Indian J. Fish., 62(2): 81-86, 2015

Note

Fisheries geographical information system for Greater Mumbai region in Maharashtra, India

S. S. GHATGE, R. S. BIRADAR, N. A. PAWAR* AND A. K. CHAUDHARY

Central Institute of fisheries Education, Fisheries University Road, Versova, Mumbai – 400 061, Maharashtra, India
**Mumbai Research centre of Central Marine Fisheries Research Institute, Mumbai - 400 061, Maharashtra, India*
e-mail: swapnilcife@gmail.com

ABSTRACT

Geographical information system (GIS) is an invaluable decision support tool, designed to address spatially related problems for management of natural resources. The power of GIS lies in its ability to visualise and relate various types of geo-referenced spatial and non-spatial data allowing users to analyse them. In India, use of GIS in fisheries management is yet to find its rightful place. An effort has been made in the present study to design and organise a fisheries spatial information system for Greater Mumbai region in Maharashtra to serve as a macro-level database for the planners and administrators, which can be used for querying, analysing and displaying datasets in the form of graphs and summarised tabular data for all the fisheries infrastructural facilities. This GIS will be of immense help to planners, managers and administrators in quick storing, retrieving and updating the required information for management of fisheries in Greater Mumbai region.

Keywords: Fisheries geographic information system, Greater Mumbai region, Remote sensing

Geographical information system (GIS) technology has been closely associated with management and mapping of natural resources, since 1960's. GIS facilitates systematic handling of spatial and non-spatial data from various sources and also provides decision criteria for decision makers or planners (Whitmore, 1990). Historically merging of information was performed by map overlaying method (Lillesand *et al*., 2007). The use of GIS permits integration of all the information contained in different ancillary map layers with classification obtained from satellite imagery and generation of new levels of information through overlay capability (Burrough, 1986).

The inital major works devoted to fisheries GIS aimed at promoting the use of remote sensing (RS) and GIS in inland fisheries and aquaculture, the one were those by Meaden and Kapetsky (1991) and Simpson (1992). Although these works were devoted largely to the use of GIS as an aid to improve fisheries, they also offered advice on GIS implementation design and stressed the importance of developing individual GIS to suit different management requirements. Chimova and Nugent, (1993) carried out some preliminary analyses of reservoir database in Zimbabwe, using both GIS and traditional database approaches and concluded that data analysis was possible only by using the GIS software. Further, Isaak and Hubert (1997) emphasised the integration of new technologies, particularly the application of GIS into fisheries science. Meaden (2000) indicated that GIS is a promising technology for fisheries science and management. Bierhuizen and Roy (1998) emphasised the use of GIS to manage fisheries taking into account the conflicts in Kanyakumari District of Tamil Nadu. Proper knowhow on the spatial distribution of resources is of great importance in the formulation of fisheries management plans.

In the context of Indian marine fisheries, majority of the GIS based work has been carried by Central Marine Fisheries Institute, Kochi and Central Institute of Fisheries Education, Mumbai. Chandrasekar *et al.* (2002) reviewed the potential of GIS and RS for coral reef ecosystem planning and management. Jayasankar (2009) discussed the usefulness of GIS for site selection issues in open sea cage culture. Jayanthi (2011) used GIS and RS for assessing and monitoring the development of aquaculture in Pichavaram mangrove area in South India and opined that for large areas both GIS and RS are useful tools with components that can be tailored for the sustainable development of aquaculture.

GIS was used for mapping the spatial distribution of demersal fishes landed by commercial trawlers at Mangalore Fishing Harbour, Karnataka (Dineshbabu *et al.,* 2012a) and in scientific cruises of Fishery Survey of India, Mumbai in the north-west coast of India (Selvaraj *et al.,* 2007). Further at Mangalore Fishing Harbour, Karnataka, GIS database was prepared for spatio-temporal

analysis and impact assessment of trawl bycatch for suggesting operation based fishery management options (Dineshbabu *et al.,* 2012b). Nair and Pillai (2012) carried out validation studies of potential fishing zone (PFZ) advisories generated using integration of chlorophyll concentration and sea surface temperatures along Kerala coast. A detailed overview of the applications of the GIS in marine fisheries management in the world and initiatives in India was given by Jayasankar *et al*. (2013).

As GIS has powerful and specially designed functions to integrate, manage and visualise spatio-temporally referenced data; it has become an important tool in fisheries management. The power of GIS lies in its ability to visualise and relate various types of geo-referenced spatial and non-spatial data allowing users to find the hidden patterns and connections between them (Pierce *et al.*, 2001). An essential requirement for scientific management of fisheries, as well as for their orderly development is that all the existing relevant information is made available and displayed in an accurate, concise and up-to-date form which is easy to read and to interpret by all concerned. The use of GIS in decision making and policy development is growing rapidly in many fields of resource management (Martin, 2004). GIS is a science as well as a problem solving tool (Wright *et al.,* 1997; Goodchild, 2003; Goodchild and Haining, 2004) which can be defined as a computer system for capturing, storing, querying, analysing and displaying geospatial data (Chang, 2007).

Data of natural resources (from satellite images, topographic maps and research), human resources (population census data) and infrastructural facilities is collected by government organisations at different time periods and in different formats (written documents, computerised files). These data sets are timely published by the respective organisations either fully or partially in annual reports, publications and census reports. However, still, the availability of all the data in a single format, on a single platform, in an easily accessible manner is questionable. Under these circumstances, GIS, RS and Global Positioning System (GPS) together provide the technology for combining the available data of fisheries natural resources, human resources and infrastructural facilities in spatial domain. This can support decision making and effective management of the fisheries sector. The present study was undertaken aimed at preparation of Fisheries Geographic Information System for the Greater Mumbai region of Maharashtra.

The study area covered Greater Mumbai region (lat. 18°53'45" N and 19°15' N and long. 72°45'E and 73°00'E). Spatial data for the study were obtained from Survey of India (SOI) topographical maps 47 A/15 (1971), 47 A/16 (1976), and 47 B/13 (1970) on 1:50,000 scale, traced from Geography Department of Mumbai University, Kalina, Mumbai. The post-monsoon, cloud free, orthorectified digital satellite image Landsat 7 Enhanced Thematic Mapper Plus (ETM+) sensor of October 2001 (path/row 148/47) were acquired from University of Maryland's Global Land Cover Facility (GLCF) website (http://glcf.umiacs.umd.edu/index.shtml). Geographical coordinates of the entities in the study were collected with the help of hand held GPS unit.

Schedules were used for the primary data (non-spatial attribute data) collection, of the following entities: Fish landing centre, co-operative societies, fisheries organisations, fish markets and fish hatcheries. Field visits were undertaken during December 2007 to May 2008 regularly to collect primary data and geographical positions (latitude and longitude) of the above mentioned entities. Wherever necessary, secondary data; from Department of Fisheries, Government of Maharashtra (2002-2007) and Maharashtra Marine fisheries census 2005 published by CMFRI, Kochi were used.

Features were extracted from Survey of India (SOI) topographical maps 47 A/15 (1971), 47 A/16 (1976), and 47 B/13 (1970) tracings on 1:50,000 scale and orthorectified Landsat 7 Enhanced Thematic Mapper Plus (ETM+) sensor 2001, (path/row 148/47) by on screen digitisation in Arc Map interface to prepare base map of the study area. The Universal Transverse Mercator (UTM) projection system was used as the projection system and World Geodetic System (WGS) 1984 was used as the geographical co-ordinate system and the WGS 84 datum. A personal geo-database named Greater Mumbai geo-dat abase was created in Arc catalog. In the Greater Mumbai geo-database, necessary Feature datasets and Feature classes were created in Arc Catalog (Map 1) and edited in the ArcMap interface. All the primary and secondary spatial data collected from the various sources, along with the geographical positions in degree-decimal format were entered in the Microsoft Excel sheets and then converted to database files (Dbf 4) format. These database files were later used in the Greater Mumbai geo-database, in ArcGIS.

A fisheries information system for the Greater Mumbai region was prepared on ArcGIS 9.2 Platform. In the Arc Catalog interface, fisheries GIS for Greater Mumbai region was designed and prepared by covering 19 landing centres, 23 fisherman villages, 30 fisheries cooperative societies, one fish hatchery, nine fisheries related organisations, 11 fish markets and the five zones of fish landing centres for depicting month-wise species-wise fish production in the Greater Mumbai region.

The landing centre point feature class gives information on craft and gear, infrastructure available, average production, population and destination details. Fig. 1 shows attribute data for a selected landing centre in Arc Map interface; such type of information is available for 19 landing centres in Greater Mumbai region.

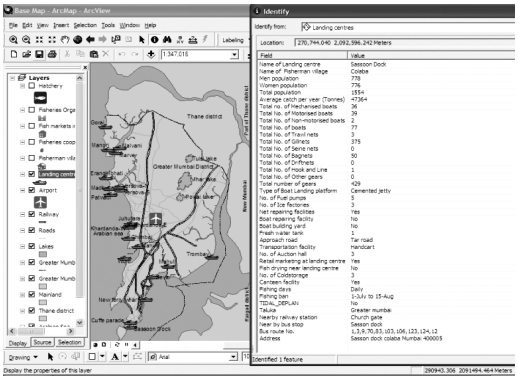

Fig. 1. Fish landing centre details in Arc Map

The fishermen villages point feature class gives information on infrastructural facilities, religion, educational profile, fishers profile, men and women occupation, craft and gear as well as destination details. Fig. 2 shows attribute data for selected fishermen village in Arc Map interface; such type of information is available for 23 fishing villages in Greater Mumbai region.

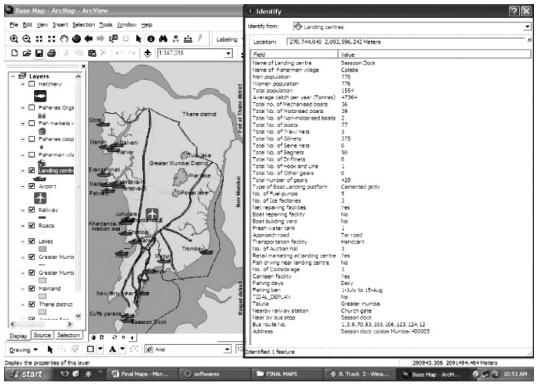

Fig. 2. Fishermen village details in Arc Map

Fisheries cooperative societies point feature class gives information on cooperative society details regarding registration date and number, year of establishment, organisation staff details, infrastructural facilities owned by society, facilities provided to fisherman and destination details. Fig. 3 shows attribute data for selected fisheries cooperative society in Arc Map interface. Such type of information is available for 30 fisheries cooperative societies in Greater Mumbai region.

The fish hatchery point feature class gives information on infrastructure facilities available, species

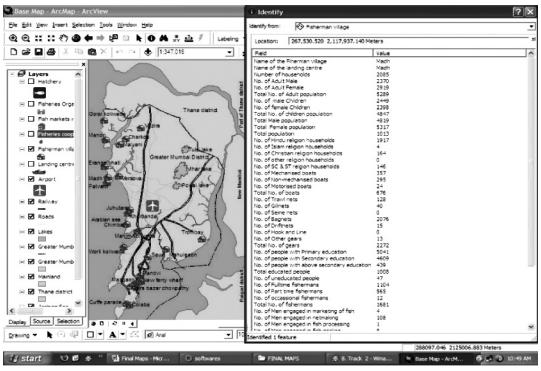

Fig. 3. Details of fisheries cooperative societies in Arc Map

used, staff details, seed production and destination details. Month-wise, species-wise, and life stage-wise fish seed availability and species-wise fish seed price were also studied. Fig. 4 shows attribute data for the Aarey Government fish seed farm located in Mumbai suburban region of Greater Mumbai.

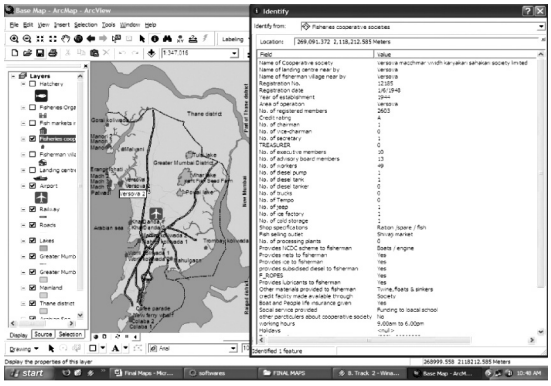

Fig. 4. Details of Aarery Government fish seed farm on in Arc Map.

Fish market point feature class gives information on the infrastructure available at fish markets, usual buyers and purchasers and destination details in a single interface for 11 fish markets in the study area. Fig. 5 shows the attribute data for selected fish market in Arc Map interface.

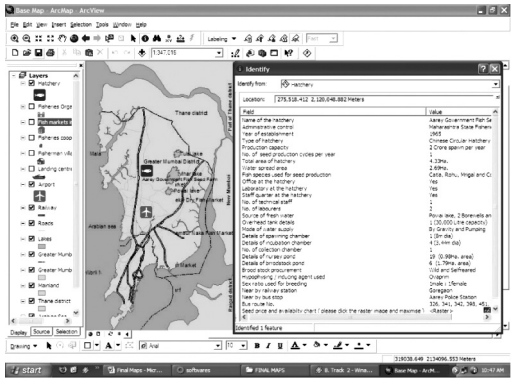

Fig. 5. Fish market details in Arc Map

Such type of information is available for 11 fish markets, which cover major wholesale and retail markets located in Greater Mumbai region.

Indicative fish prices at landing centres, whole sale and retail markets were collected during the study period. Indicative fish prices are given to have an idea of prevailing fish prices at different places during the study period. The fish prices for the dry fishes, salted fishes, retail markets and fresh water fishes are indicative as prices are likely to vary according to day, week and season, based on the fish supply and demand.

The fisheries organisations point feature class gives basic information on the State level and National level organisations including destination details of nine organisations covered in the study. Fig. 6 hows the attribute data for selected fisheries organisations in Arc Map interface and such type of information is available for nine organisations in the Greater Mumbai region.

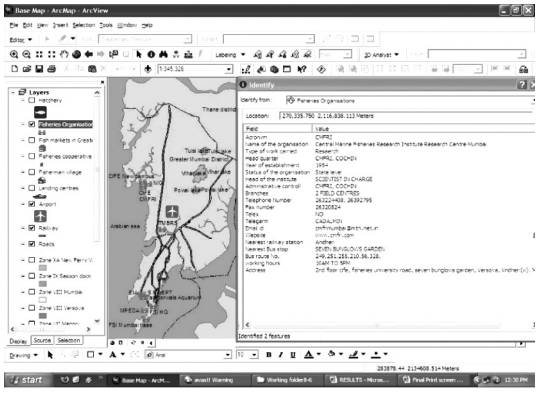

Fig. 6. Fisheries organisations details in Arc Map

On the personal geodatabase for Greater Mumbai region, queries were made and verified using Structured Query Language (SQL) in Arc Map interface; the entities which satisfy the query were highlighted on the map (Fig. 7, 8 and 9). Database query is fundamental, yet very powerful technique in GIS that allows the user to query by either location or by attribute. A social impact analysis of management initiatives is an example where such spatial queries have already informed decision-making and may become standard practice (Martin, 2004). Using Arc GIS analysis and visualisation capabilities, graphs were also prepared from the attribute tables of feature classes in the Greater Mumbai geodatabase.

Designing and organisation of fisheries spatial information system for Greater Mumbai region to serve as a macro-level database for the planners and administrators was achieved by preparing the Greater Mumbai geodatabase in the Arc Catalog interface. This was able to answer queries and analyse the data on fish

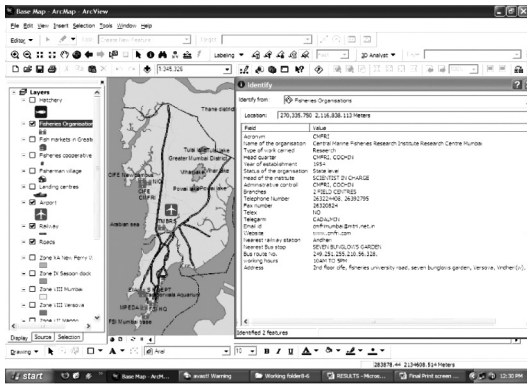

Fig. 7. Highlighted landing centres which satisfies the query (Landing centre with more than 250 bagnets and average catch above 2500 t)

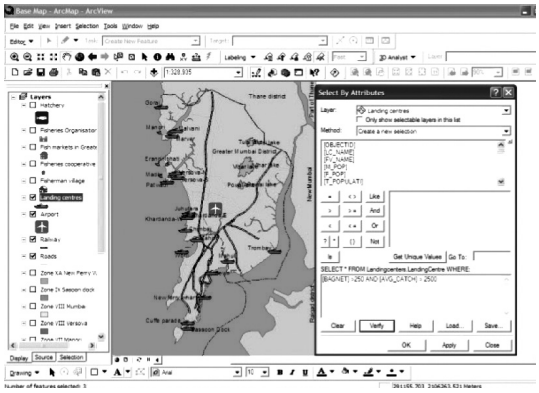

Fig. 8. Highlighted cooperative societies which satisfy the query (Cooperatives having 1 processing plant or 1 cold storage and engaged in fish marketing)

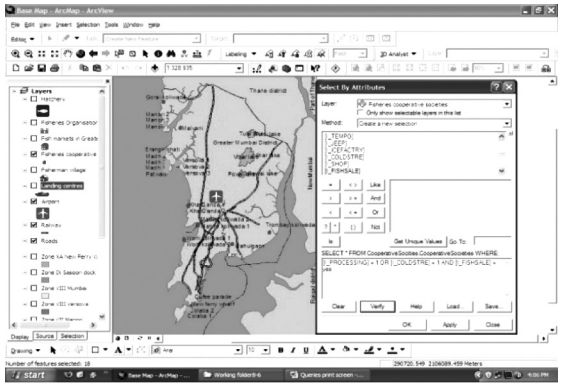

Fig. 9. Highlighted fishing villages which satisfies the query (villages with more than 500 full-time fishermen and more than 500 total nets)

landing centres, fishermen villages, fish hatchery, fisheries cooperative societies, some important fish markets and fisheries related organisations in Greater Mumbai region using spatial and non-spatial data.

The Fisheries GIS system developed on Arc GIS 9.2 platform will give the spatial distribution of the same and

assist in the decision making process. This geo-database has quick analysis and visualisation capability which will help in querying, and analysing as well as in preparation of report and graphs in time. The GIS will also help in eliminating redundancy and inconsistency of data. The near-future data updating capability of the geodatabase will be helpful in updating new data, while maintaining the features of quick analysis, visualisation, querying, analysing, preparation reports and graphs. The planners and administrators will be benefited by this system which will assist in decision making and effective management of the fisheries in Greater Mumbai region.

At present data are scattered, and available with different organisations situated in different locations. The data are available in different formats (paper, registers and computer files) along with published and unpublished literature. The process of data management can be challenging as it involves multiple management areas and hence requires GIS for assisting in decision making. The present Fisheries GIS developed is an example of how the data and information available can be brought on a single platform using GIS technology. This information system will help planners, administrators, students and public to access and utilise the data and information.

The fisheries GIS for Greater Mumbai region developed on ArcGIS 9.2 platform shows the summarised attribute information about the infrastructural facilities *viz*., 19 fish landing centres, 23 fishermen villages, one fish hatchery, 30 fisheries cooperative societies, 11 important fish markets and nine fisheries related organisations. Month-wise 5 dominant fish species available at landing centres and month-wise, species-wise and life stage-wise fish seed availability at fish hatchery, and fish market prices are also included in this geo-database.

Acknowledgements

The authors are thankful to the Director, Central Institute of Fisheries Education, Mumbai, India for co-operation and encouragement during the study.

References

Bierhuizen, B. and Roy, R. 1998. Using GIS to manage fisheries, *Bay of Bengal News*, 2 (12): 20-22.

Burrough, P. A.1986. *Principals of Geographical Information System for land resources assessment*, Oxford University Press, New York, 193 pp.

Chandrasekar, N., Victor, A. C. C., Easterson, D. C. V. and Muthiah, P. 2002. Remote sensing and GIS in coral reef environment: an overview. *Proceedings of the National Seminar on marine and coastal ecosystems : Coral and mangrove - Problems and management strategies*, 2: 132-138.

Chang Kang-tsung 2007. *Introduction to Geographical Information Systems,* 4th edn. Tata McGraw Hill publication, New Delhi, 184 pp.

Chimowa, M. and Nugent, C. 1993. A fisheries GIS for Zimbabwe: an initial analysis of the numbers, distribution and size of Zimbabwe's dams Series title: Support for rural aquaculture extension, Zimbabwe Project reports. http://www.fao.org/docrep/field/003/AB969E/AB969E00.htm

Dineshbabu, A. P., Thomas S., Radhakrishnan, E. V. and Dinesh, A. C. 2012a. Preliminary experiments on application of participatory GIS in trawl fisheries of Karnataka and its prospects in marine fisheries resource conservation and management. *Indian J. Fish.,* 59(1): 15-22.

Dineshbabu, A. P., Thomas S. and Radhakrishnan, E. V. 2012b. Spatio-temporal analysis and impact assessment of trawl bycatch of Karnataka to suggest operation based fishery management. options. *Indian J. Fish.,* 59(2) : 27-38.

Goodchild, M. F. 2003. Geographic Information Science and Systems for environmental management. *Ann. Rev. Env. Resour*., 28: 493-519.

Goodchild, M. F. and Haining, R. P. 2004. GIS and spatial data analysis: Converging perspectives, *Pap. Reg. Sci.,* 83:363-385.

Isaak, D. J. and Hubert, W. A. 1997. Integrating new technologies into fisheries science: The application of geographic information system. *Fisheries*, 22(1):6-10.

Jayasankar, J. 2009. Geographic information systems and site selection issues of open sea cage culture. In: Imelda-Joseph, Joseph, V. E. and Susmitha, V**. (**Eds**.)** *Course manual: National training on cage culture of seabass*. Central Marine Fisheries Research Institute, Kochi and National Fisheries Development Board, Hyderabad, p. 111-119.

Jayanthi, M. 2011. Monitoring brackishwater aquaculture development using multi-spectral satellite data and GIS - a case study near Pichavaram mangroves south-east coast of India. *Indian J. Fish.,* 58(1) : 85-90.

Jayasankar, J., George, G., Ambrose, T. V. and Manjeesh, R. 2013. Marine Geographic Information Systems and their application in fisheries management. In: Soam, S. K., Sreekanth, P. D. and Rao, N. H., (Eds.), *Geospatial technologies for natural resources management.* New India Publishing Agency, p. 437-449.

Lillesand, T., Kiefer, R.W. and Chipman J. 2007. *Remote sensing and image interpretation*, 6th edn. John Wiley and Sons, 804 pp.

Martin St, K. 2004. GIS in marine fisheries science and decision making, In: Fisher, W. L and Rahel, F. J. (Eds.), *GIS in fisheries*, American Fisheries Society, p. 237-258.

Meaden, G. J. and Kapetsky, J. M. 1991. Geographic information system and remote sensing in inland fisheries and

aquaculture. *FAO Fisheries Technical Paper*, No. 318, Rome, Itlay, 262 pp.

Meaden, G. J. 2000. *GIS in fisheries management*. *Geocoast*, 1(1): 82-101.

Nair, P. G. and Pillai, V. N. 2012. Satellite based potential fishing zone (PFZ) advisories - acceptance levels and benefits derived by the user community along the Kerala coast. *Indian J. Fish.*, 59(2): 69-74.

Pierce, G. J., Wang, J., Zheng, X., Bellido, J. M. and Boyle, P. R. 2001. A cephalopod fishery GIS for North-east Atlantic: development and application. *Int. J. Geogr. Inf. Sci.*, 15(8): 763-784.

Simpson, J. J. 1992. Remote sensing and Geographic Information Systems: their past, present and future use in global marine fisheries. *Fish. Ocean*., 1(2): 238-280.

Selvaraj, J. J., Biradar, R. S. and Somavanshi, V. S. 2007. Spatial and temporal patterns of demersal fish distribution in the north-west coast of India : a study using Geographic Information System. *Indian J. Fish*., 54(3): 243-249.

Wright, D. J., Goodchild, M. F. and Procter, J. D. 1997. Demystifying the persistent ambiguity of GIS as "Tool" versus "Science". *Ann. Assoc. Am. Geogr*., 87: 346-62.

Whitemore, R. A. 1990. Practical application of remote sensing technology. *NASA Contract report*, 57 pp.

Date of Receipt : 23.04.2012
Date of Acceptance : 17.11.2014