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A Study on Potential Application of Geographic Information Systems (GIS) in Fisheries and Aquaculture of Bangladesh

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Abstract: This study illustrates the potential application of geographic information systems (GIS) and spatial analysis techniques to support the fisheries management. GIS aids are familiar as an influential tool to attain this purpose in aid of a well-versed management decision system. In this context the spatial component of fisheries comes to be a main concern and the whole discipline turn into highly compatible with GIS. Harmonized with this new leaning, the objective of this paper is to demonstrate an innovative way to employ the geographic information allied with fisheries data to effectually envision and enumerate temporal and spatial data arrays in fisheries events. The core utilities of the fishery GIS are catch and effort approximation and their disparity in space and time, fishing vessel utilization, data quality control and obtaining information on the site of significant economical and endangered species. The outputs formed through the GIS aids are appositely designed for additional analysis for instance to map or quantify alteration in time by paralleling maps on different dates. The overall area, exploited by fishing activities, can be enumerated by summing the area of grid cells that have density values in the designated time frame.

Key words: GIS % Fisheries Management % Integrated Catchment Management % Conservation % EAF % EBFM % In Season Fishery Management

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INTRODUCTION

Bangladesh is a deltaic country constructed through the major Padma-Meghna-Brahmaputra River system along with a massive network of enormous rivers with their tributaries and distributaries. Immense network of water bodies of Bangladesh are very resourceful along with aquatic (fresh, brackish and marine) biodiversity exclusively with numerous fisheries resources. These fisheries resources perform an imperative role in the economy of Bangladesh and have a great potential in the economic development and poverty alleviation of the country. Its contribution to GDP is 4.43%, agricultural sector is 22.21% and its value in GNP (Present market value) is 19567.90 crore taka. Its contribution to foreign exchange earnings is 2.73%. About 12.80 lakh fishers and 42.30 lakh fish farmers are engaged in this sector. In Bangladesh, there usually exists about 260 species of freshwater fishes [1]. Fishes contribute 32.8 g of protein out of 57 g of protein required/person/day [2]. So, fish plays an important role to fulfil the demand of animal proteins of the population of Bangladesh.

As geographic information system (GIS) is a technique exercised to illustrate and portray the earth and other geographies for the rationale of visualizing and analysing geographically referenced information [3], it is an extraordinary class of information system that possesses all the features of information system. An elementary characteristic of a GIS is its aptitude to conduct spatial data i.e., the location of objects in a geographic space and allied traits [4]. Since, GIS is one of the most influential of all information technologies because it spotlights on integrating knowledge from numerous sources (for example, as layers within a map) and constructs a crosscutting environment for collaboration as stipulated by many eager ones. Besides, GIS is appealing to most people who encounter it because it is both intuitive and cognitive. It merges an influential visualization environment using maps to

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commune and envisage with a sturdy analytic and modeling framework that is rooted in the science of geography [3]. This combination has resulted in a technology that is science based, trusted and easily communicated using maps and other geographic views [3].

Fisheries management and planning comprises numerous spatial constituents (e.g. movements and migrations of resources, definition of fishing grounds, transportation networks, markets) and several solemn concerns resembling habitat destruction and ecological deterioration encompasses spatial dimensions, consequently fisheries biologists, aquatic resource managers and decision makers need to tackle matters of great intricacy. By the way, GIS is a skill that can assist to elucidate the concerns and proceed to solutions through considering numerous spatial constituents concurrently. Nevertheless, several persons are yet ignorant or scared of this skill and its capability of fisheries management.

Presently, GIS is fetching progressively more integral constituent of natural resource management activities worldwide [5]. These days, it is the underlying element of water quality modeling and elementary database formation. Sustainable Hilsha fishery management necessitates inclusive data on physical resources and synoptic incorporation of and scrutiny of these resources. GIS's capacity for dynamically modeling environmental parameters [6] as well as its cartographic spatial competence can be inestimable for water quality modeling and associated study. GIS is used as a verdict support-system linking incorporation of spatially referenced data in a problem-solving ambiance. GIS can be considered as a database management system having a noteworthy role in planning and management progression of natural habitat and helps in assimilating multi-parameter spatial information for modeling. Usage of GIS is advantageous as it is time and cost effective also aids in accomplishing added thoroughgoing and integrated basic databases, which is complicated through orthodox practices alone. A GIS, however, is not automated decision making system but a tool to query, analyze and produce map in support of the decision making process [7, 8].

GIS has been paralleled by an enormous augment in low-cost computing power with the consequence which is very comprehensive utensil for handling of spatial data are currently existing to a wide assortment of clients. It is predominantly apt for natural resource management and archiving practice of unparalleled suppleness. Many assorted data sources and types can be exploited concurrently and cartographic output is usually outstanding. Remote sensing and GPS are splendid data assortment schemes, but GIS provides an incredible modeling tool for environmental concerns. Models are goal-oriented and can use the same database to address different issue and this united with the competence to accomplish time-series analysis and predict future circumstances. That means that GIS is rapidly becoming an invaluable tool in all natural resource disciplines.

Combined works between NOAA's National Ocean Service (NOS) and National Marine Fisheries Service (NMFS) and four regional Fishery Management Councils (2004) used a GIS tool to inspect how Geographic Information Systems (GIS), marine data and custom analysis tools can better aid to permit fisheries scientists and managers to adopt Ecosystem Approaches to Fisheries Management (EAFM). In addition, GIS tools are used in New England Fishery Management Plans for spatial/temporal management, current GIS applications, Ecosystem Approaches to Fisheries (EAF) Considerations for North-eastern multi-species (ground fish), Atlantic Sea Scallops, Monkfish, Red Crab, Atlantic Herring, Skates, Atlantic salmon.

In Bangladesh, it is yet a new method to apply GIS in fisheries planning and management. Application of GIS is started only a few years ago, in the early 90s. It is now being used in this country as obligatory part equally for physical and human resource planning and development. Its usage and application is lengthening steadily and in near future it will be the most steadfast technique of information system. Nonetheless in Bangladesh, it is a fact that GIS is essential and the decision makers at the national/regional levels are paying awareness to obtain the expertise [9]. A GIS scrutinize is undertaken by EGIS [10] for floodplain fish habitat study and monitoring in Tangail district, Bangladesh, principally based on database query in ArcView. GIS would be a suitable method for preparing future generations of natural resource specialists which could noticeably influence the future verdict of the people of Bangladesh [11].

Main purpose of the study is to illustrate the potential use of GIS in fisheries and aquaculture for the better and sustainable management planning, strategy and decision making.

MATERIALS AND METHODS

The data is collected over six months from 1st November to 30th April, 2011 and for the congregation of data, amalgamation of numerous survey techniques is adopted.

Secondary Data Collection: From apposite government and non-government organizations such as Department of Fisheries (DoF), International Union for Conservation of Nature and Natural Resources (IUCN), Asiatic Society of Bangladesh, Geographical Solutions Research Centre Ltd. (GSRC) and Environment and GIS Support Project for Water Sector Planning (EGIS-II), all secondary data about GIS and its application are congregated.

Primary Data Collection: Field surveys and direct observation are used for the collection of primary data. For the confirmation of the secondary data, primary data is used also.

Questionnaire Survey: 100 experts, fishers, fish farmers and general people are very cautiously selected by their appropriateness in the study through careful inspection for the questionnaire interviews. Questionnaire is examined in the field before interviews. All experts, fishers, fish farmers and general people are interviewed through a formal conversation for this purpose. Information about GIS and its application in fisheries is the consequence of the interviews.

Data Processing and Analysis: With the help of Microsoft Excel software, data from different appropriate sources are coded and recorded into a database system. For the accuracy of the data recorded at every sources of the survey, correspondence between elementary data sheets and the original coding sheets are considered; accuracy and quality of the data are inspected up, edited and coded at the field level.

RESULT AND DISCUSSION

Management of fisheries is, to a prodigious range, a space-oriented problem. Mapping and representing a fishery and the associated resources should be surrounded by the precedence responsibilities while scheduling for fisheries management and should not be adjourned up to "comprehensive" information is accessible, meanwhile dismissals or gaps in the information base will more enthusiastically appear in the procedure of amplification.

Monitoring and analysis of spatially-distributed factors for example resources richness and structure, feeding and reproduction, nurseries, fishing efforts, harvest, tagging and recaptures, trade flows, recruitment, regulatory zoning, control and surveillance, conflicts between gear and fleets, ecosystem conditions, etc. impose major operational and management challenges to fisheries. As previously established in additional grounds where spatially-related problems appear, Geographical Information Systems (GIS), collectively with supplementary analytical aids and models, permit for upgraded spatial monitoring and analysis and, ultimately, superior and more operative management practices. Geographical Information Systems are fundamentally incorporated computer-based systems which consent the input of digital geo-referenced data to yield maps plus other textual, graphical and tabular output. The indispensable usefulness of GIS conversely, relies in its aptitude to operate and overlay data in an enormous number of techniques and to implement numerous analytical utilities in an attempt to yield outputs that may perhaps add to a quicker and more competent decision making process in fisheries.

Beforehand a GIS is applied into a fisheries management program, two most important concerns must be made regarding:

- The probable use of GIS as a management tool and
- The paramount technique to implement a sustainable fisheries GIS given the limited resources accessible by means of all the guidance and support that can be acquired.

FAO has lately released a web-based portal, GIS Fish, from which to find the worldwide skill on Geographic Information Systems (GIS), Remote Sensing and Mapping for instance practiced to Aquaculture and Inland fisheries. GIS applications can be generally assembled into three multiplicities: remote sensing of phenomena or patterns as of far afield, the spatial representation of data and participatory GIS, that encompasses questioning investors and their views with regard to the site of accomplishments.

GIS and Fishing Catch-Effort Analysis: GIS are frequently used in Fishing Catch and Effort Analysis. It enables to illustrate and visualize the fact of Where, when and how do fisheries function and control inside a specified region and impact of regulatory alterations and modifications on fisheries. Time and area summarized maps of fishing effort and catch from record, spectator, or fishery-independent survey data arrays can be created through GIS. The tool can allow an operator to enquire the elected source of data using species and gear, specify a time frame and time step, arrange spatial summary and designate the variable to summarize (catch, discards, effort) [12].

GIS and Area Characterization: GIS are commonly used as a tool for area characterization. It allows clarification and visualization of the physical parameters (e.g. water quality, sediment type), biological parameters (e.g. species abundance) and regulatory framework inside a designated region. GIS enlightens an extent for regulatory, project discussion, or research purposes and to portray that area in the field of Essential Fish Habitat (EFH), Habitat Areas of Particular Concern (HAPCs), critical habitat, fishing fleet characteristics and species richness and life stage distribution [12].

GIS and Bycatch Analysis: GIS are customarily practiced as an aid for bycatch analysis. It aids to explain and envision the trends in bycatch among different fisheries and gear types, geographic areas, time periods, depth ranges and habitat types. Bycatch and discards are accrued as a consequence of the defective methods of fish capture, the imperfect selectivity of certain fishing gear, the behaviour and distribution of fish and the structure of management programs. Time/area closures are one of the management measures which are applied to make an effort to lessen bycatch and discards when location and time are the primary causative influences (NOAA/NMFS 2004). GIS analyses harvest data to discover locations and time periods where excessive quantity of bycatch and discards exist. When these areas are recognized, the fundamental reasons can be studied, for example species migrations or shared habitat between commercially valued species and non-target species. Stated an area or series of areas and catch locations from survey and observer data, this aid would produce maps and reports summarizing bycatch and discards. Maps and reports could be created within definite time periods, depth ranges, habitat types, or other additional variables. This aid would be applied for overall assessment of spatial or statistical patterns in the data and could be practiced for elementary discard distribution/density analysis [12].

GIS and Habitat Interactions: GIS are recurrently applied as an essential aid for habitat interactions analysis. It makes possible to establish and visualize the natures, varieties and amount of habitats have been exploited by means of bottom-tending gear. So as to reveal the actual fact of interactions among bottom-tending fishing gears (e.g. trawl nets or scallop dredge) and benthic habitats, fishery managers requirement is to quantify the types and amount of habitat that has been exploited. A *Fishery/Habitat Interaction* tool enables to map these interactions through conjoining habitat data with fishery-dependent data such as vessel records or observed data and Vessel Monitoring System (VMS) data depending on obtainability. By means of VMS data alone, the aid would require to screen out fishing activity (i.e. time of fishing gear deployment) from transit time to and from port. Register or observed data could be exercised, either alone or with VMS data, to recognize fishing activity tracks. Records, observed and VMS data are mostly confidential; consequently the aid would require safeguarding the security of these data [12].

GIS in Decision-Making and Policy Development: Application of Geographic Information Systems (GIS) in decision-making and policy development is emerging speedily in numerous grounds of resource management. GIS is exercised as a mandatory tool for decision-making, situation testing, site appropriateness analysis, or socio-economic analysis has previously to be established in marine fisheries management [13]. The gradual development of the use of GIS in marine fisheries is somewhat owing to the exclusive and intrinsic features of fisheries resources which cause their representation and analysis problematic using GIS (e.g. the mobility of fish stocks and the three dimensionality of the ocean environment; [14].

Fisheries science and management are governed by two general classes of data gathering: biological surveys to quantify amounts of fish in the sea and landings/catch tallies to quantify fishing effort and fishing mortality [15]. Biological surveys of fish stocks are performed using sampling techniques that rely upon explicit mappings of the ocean (e.g. a regular grid or zonation modified by bathymetry) intended to precisely assess the levels of fish population at the context of the management area [16]. To evaluate the effect of an area closure, vessel trip report data delivers information nigh on individual fishing trips by boats carrying federal fishing permits. The information comprises species and quantity caught number of crew members, as well as, significantly, the trip location. These analyses enquire the trip report data for all earlier fishing trips in the region to be closed and then characterize the features of those trips (e.g. species caught, quantity, length of trip, etc.) and the boats engaged (e.g. gear type, average size and, prominently, port association which delivers the connection between offshore trip location and onshore community). The outcome is a array of tables and maps typifying the fishing activity in the potentially closed area and the reliance of ports on that area [13].

GIS and Modelling: GIS is applied in Modelling of the association between species richness and the physical environment, establishing predator-prey relationships, monitoring issues concerning the pilot fishing programs, Studying spatial changeability in fish community structure, examining associations between bottom ecology and trawl tow lines, choosing sites for marine stock enhancement, evaluating the performance of catch or of effort quotas, recognizing ideal habitats or areas for marine conservation, modelling of the probable fish mortality, biomass distribution, anticipated catch densities(e.g. throughout the years of high, average and low population abundance) etc.

GIS and Integrated Catchment Management: GIS helps in integrated catchment management through a particular emphasis on the freshwater, marine and brackish water single or multi-species fishery combined with topographic, geology and land use data, in common with derivatives of these and other data sets, such as water-quality monitoring data and ecological field survey information. The GIS aid assimilates stream slope and width estimates with stream locations, electrofishing survey data and local information to describe manageable and unapproachable stream areas for fish (arranging survey determinations, assessing natural spawning distribution and classifying suitable areas for stocking with eggs or fry) [17].

GIS and Conservation: GIS is frequently employed in establishment of marine protected areas, closed areas, seasonal closure, habitat closure (e.g. all mobile, bottom-tending gears), management areas. It can be used to represent resource shearing, abundance at different life stages, fishing impact mapping, coastal communities interactive mapping (Fisheries and census data synthesis), Country business patterns and Network analysis–from fish-in-the-net to market to end-user, employment, regional impact, multi-fishery impacts etc.

GIS and Ecosystem Approaches to Fisheries (EAF): GIS aids in mapping and analysing species & stock distribution data from scientific surveys, larval, juvenile & adult life stages data, spatial presence within water column, benthic habit information-sediment type, depth contours; oceanographic information-current dynamics, salinity, temperature, larval transport; food web-geographic/seasonal information on predator-prey interactions, location of phyto and zooplankton blooms (primary production/producer), fisheries catch information, fisheries effort information, designated areas-fishery management areas, marine sanctuaries, jurisdictional/political boundaries, disposal sites, shipping lanes, valuable cultural sites, non-fishing activities-all fluid discharge sites, all watersheds, non-fluid disposal sites, water transportation facilities and patterns, concentrations of non-point source discharge, locations of other activities that affect the marine environment, economic /social-location of fishing communities, geographic characterization of economic dependence on fishing, activities (including non-consumptive uses), location of major support infrastructure, market distribution system, areas where stakeholders reside, population areas mapping which are indispensible constituents of ecosystem approaches to fisheries (EAF).

GIS and Ecosystem Based Fishery Management (EBFM): From the viewpoint of ecosystem based fishery management (EBFM), the accessibility of georeferenced data related to habitat, resource distribution and fishing effort and the progressively complicated approaches accessible in GIS for envisioning and processing these data make it possible to develop spatial indicators of fishing impact. Suitable spatial analyses comprise: (i) interpolation of point or line data to foster comprehensive contour diagrams; (ii) overlaying data layers for quantify spatial overlap; (iii) buffering closed areas and other spatial topographies; and (iv) attributing data on bathymetry and slope from maps to sampling stations [19]. This make one available to enquire questions which cannot be dealt with simple measures of space centred on statistical areas, for instance the effect of distance from a closed-area boundary on catch per unit effort (CPUE) or bathymetric and oceanographic circumstances allied with each species in the catch [20].

GIS and additional categories of spatial analysis have been employed in combination with population dynamics modelling and for example a decision-support aid in management. Valavanis *et al.* [21] established a GIS of the cephalopod fishery in the eastern Mediterranean that comprised habitat and oceanographic data along with geo-referenced fishery data. Maury and Gascuel [22] arisen a GIS-based simulation model to assess the effect of an MPA specified seasonal migration of fish. Lindholm

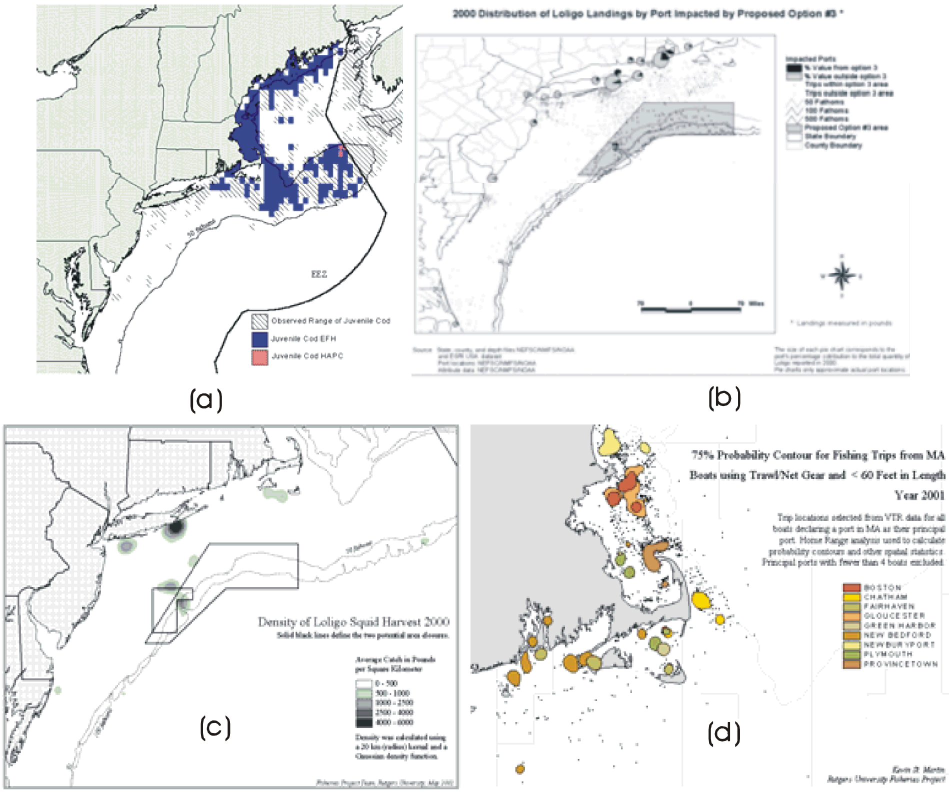

Fig. 1: Current application of GIS, a) Essential Fish Habitat (EFH) and Habitat Areas of Particular Concern (HAPC) for Cod within the Exclusive Economic Zone (EEZ) of the Northeast United States. Data expressed in terms of 30' squares. Source: New England Fisheries Management Council web site (http://www.nefmc.org/). b) Communities/ports potentially impacted by a proposed closure (option 3) of fishing grounds to Loligo squid and other fishing. Analysis based on vessel trip report data [18]. Density surface produced using a density analysis of vessel trip report data for all boats catching Loligo squid. Source: Rutgers University Fisheries Project. d) Home Range analysis of inshore trawl boats whose principal port is located in Massachusetts. Ports with fewer than 4 boats excluded. Source: Rutgers University Fisheries Project.

et al. [23] applied a dynamic model to discover the relationship between survivorship of post settlement juvenile cod and spatial variation in habitat complexity. The model used for simulated habitat alterations centred on fishing activities and is employed to assess the capability of an MPA to boost up recruitment success. Ault *et al*. [24] utilised fostered a spatial multi-stock model of fish and shrimp population dynamics which encompassed a hydrodynamic circulation model in addition to habitat information. Likewise, spatial modelling techniques have been adopted to inspect economic and social questions concerning fisheries. Scholz [25] raised a GIS of fishing locations cross-referenced with the port of origin to resolve the economic effect of recommended closed areas upon fishing communities adjacent to the coast.

GIS and Evaluation of Fish Habitat: Habitat evaluation encompasses the succeeding data classes: (a) vegetation percent by class; (b) vegetation percent by class inside response channel buffers; (c) response, transport and source channel density; (d) road density; and (e) landscape slope. Summary graphics comprise drainage density by channel type and forest coverage articulated as a percent of total watershed and percent area inside buffers around response aches. These data can aid the speedy interpretation of general stream-side environments and capacity for LWD recruitment. Furthermore, road density and slope data deliver particular awareness to the aptitude for sedimentation effects contained by a specified hydrologic unit. GIS-based analytical approaches offered an instant, objective and cost-effective aid to support in highlighting locations of fish habitat preservation and restoration efforts [26].

Table 1: Applications of GIS in Bangladesh

Type of Study	Application	Data acquisition	Case in point
Remote sensing	Marine productivity hotspots, Aquaculture site selection, Population dynamics Land cover changes Mapping of aquaculture ponds	Airborne sensors, Space-based sensors, Radar, Underwater sensors, Aerial photography	Islam *et al.*, 2009 [27] EGIS, 2000 [28]
Spatial visualization	Macro: national fisheries status Fisheries statistical yearbook Consumption by country Production by country Regional: Permitted vessel by country Registered vessels by size Landed value by county Poverty rates by county Fishing effort by state Value by place Landings by port Kemp and Fishing activity Effects of closures on behaviour Fish movement tracking Stakeholder conflict mapping	DoF statistics BBS Permit data Landings data Census data Vessel logbooks Tag returns/reports Location databases	Statistical Yearbooks (Department of Fisheries, Ministry of Fisheries and Livestock) BFRI, 2012 [29]
Participatory GIS	Delineation of fishing grounds Local ecological knowledge	Surveys Interviews	DoF, 2008 [30]
Modelling	Water quality monitoring Rapid Fish Biodiversity appraisal	GPS Laboratory analysis Field survey	Yasmin, 2012 [31] Islam, 2012 [32] EGIS, 2000 [28]
Open water Fisheries management	Water quality monitoring Local ecological knowledge Socio-economic condition Larval fish densities in the major rivers	GPS Laboratory analysis Field survey Interviews	IUCN(Ecosystem for Life: A Bangladesh-India Initiative Project) EGIS, 2000 [28]
Floodplain Fisheries monitoring	Habitat stratified monitoring Land types Determination of catch per unit of area Determination of monthly inundated areas or monthly flood maps Fish catch in the CPP for two scenarios	Surveys Interviews	EGIS, 2000 [28]
Marine fisheries	Shrimp fisheries by Estuarine Set Bag nets in the coastal zone Shrimp and fish trawling in the off shore waters of the Bay of Bengal Cephalopod catches Fish biomass distribution in the BoB in relation to Water depth	Surveys Interviews	EGIS, 2000 [28]

GIS and Land-Sea Connection: Geographic Information Systems can aid to enhance, upgrade Ocean learning and up-to-date our understanding about the human dimensions of marine resource utilisation. This paper portrays the application of GIS where it is applied to demonstrate the relations between fish stocks and the social, cultural and economic constituents of the fishery on land. This technique of presenting and merging qualitative and quantitative data exemplifies a contemporary tactic to aid fishery managers, participants, policy-makers and other stakeholders in envisioning a frequently confounding and scantily understood network of interactions. The Atlantic herring fishery which assists the role of a case study and maps from this pilot project are presented and methods studied [33].

GIS and the Human Dimensions of Marine Ecosystems: GIS has been familiar with the study of an extensive variety of issues relevant to fisheries and their management. Issues recurrently incorporated in the literature comprise habitat assessment and management, aquaculture and mariculture site selection, mapping oceanographic features and population dynamics, abundance and spatial distribution mapping, as well as movement tracking, migration patterns etc. The increasing quantity of tagging projects and amplified funding for habitat mapping reveals the intensifying pervasiveness of these functions. Usages of GIS for apprehending the human dimensions of marine ecosystems, conversely, have just commenced to develop [33].

GIS and Inseason Fishery Management: By means of geographic information systems (GIS), we can evolve spatially unequivocal models to guesstimate inter annual inconsistency of three explicit traits of spawning events: (1) spawning timing, (2) spawning locations, (3) roe content and (4) migration dynamics. Migration dynamics of pre-spawning migration is supposed as an equally essential aspect governing inter-annual unpredictability in those features. Spatial and temporal analytical tactics with aids, for example Geographic Information Systems (GIS), accepted for envision of the potential mechanisms following the timing of migration and spawning [34].

GIS and Floodplain Fisheries Monitoring: Fisheries are conventionally scrutinised by means of so-called “Catch and Effort” monitoring systems wherein “effort” is the total of fishers or fishing aids (e.g. gears, spears, traps, hooks and lines, trawls) functioned in a water body and “catch” is the amount of fishes taken on a daily basis by the fishers or fishing aids. The total amount of catch is attained through multiplying the catch per fishermen per fishing aids with the total fishers or fishing aids. A precondition for the “Catch and Effort” monitoring system is the total effort, the total number of fishermen or devices functioned is experienced. Floodplain fisheries of Bangladesh are meant for an extremely huge number of family units that must be required to follow all-over the year round, since, the great number of subsistence fishing families. If a customary Catch and Effort monitoring system is employed, this is virtually irresolvable. This denotes, the monitoring procedure needs to split including numerous demonstrative smaller fractions as the fisheries can be monitored for each fragment, besides, as a final point, the inclusive portray is attained by totalling the outcomes of all the small portions concurrently. The assessment of the overall catch goes along three steps:

- The Catch per Unit of Area (CPUA) for each type of water body is estimated in traditional way.
- The total flooded region for all type of water body is estimated by means of GIS.
- The total catch per type of water body is estimated by multiplying the catch per unit of area with the total quantity of area.

Floodplain Fisheries Monitoring system, which is centred on conventional Catch and Effort data documenting, is merged with hydrological developments and the outcomes are analysed in a Geographical Information Systems (GIS) milieu.

GIS and Rapid Fish Bio-Diversity Appraisal: Ordinarily, within over-exploited floodplains having a high fishing pressure, comparatively large, slow-developing fish species which breed in every two to three years are supplanted by fast-developing and rapid-reproducing fish species. This may perhaps be one of the main reasons, aligned with the obstruction of migration routes and declining breeding areas owing to flood control projects. Data derived from the survey or research can be analysed in GIS with a "surface plot" of the species composition in the area and the conclusions are drawn about the areas which seem to be negligibly affected and those areas which seem to be deteriorating as the species composition changes from the resident species toward a more dominant r-selected species, more or less flooded areas, areas of higher or lower population densities, areas of lower or higher fishing pressure. Another factor could be the construction of the railway and the by-pass road in within a fish habitat. The Bio-diversity Index and its use in a GIS environment visualises distinctly the patterns, however it will help us to understand the patterns after an alteration has been taken place and whether we are in presumably the situation of too late to converse the process or characterization of “clear criteria” for a “healthy system", will be desirable so as to identify alterations beforehand.

GIS and Fisheries Survey: GIS can be employed in the survey of World fisheries, consumption by country, production by country, permitted vessel by country, registered vessels by size, landed value by country, poverty rates by country, fishing effort by state, value by place, landings by port Kemp and fishing activity, effects of closures on behaviour, fish movement tracking, stakeholder conflict mapping [33].

GIS in River Basin Management and Water Quality Monitoring: GIS and GIS-based Models can be used for River Basin Management Tasks and Water Management of Rural and urban areas. Precipitation time series, calculated CN (curve numbers), average and peak flows under different weather conditions including an array of inorganic and organic water quality parameters, can be employed intended for representing the outcomes in the GIS applications [35].

GIS can be applied for investigation and modelling of water quality in rivers, fish habitats, national and international protected areas and sanctuaries to assess the suitability of the environment. The contents of every pollutant in surface waters can be determined for different seasons and by means of these data, a Geographic Information System (GIS) has been raised by using different kinds of GIS software. From the photometric heavy metal, pesticides, insecticides, fungicides, rodenticides, fertilizers and other water quality parameter analysis through GIS, it can be concluded that what are the reasons of undesirable quality for drinking purposes or for fish habitat deterioration or destruction. The source of excess concentration of various heavy metals pesticides, insecticides, fungicides, rodenticides, fertilizers and other water quality parameter can be identified whether it is from the agricultural activities and fertilizers or industrial wastes or leaching from the sediments. It can be determined in all periods that how the heavy metals and other pollutants in the fertilizers and pesticides are transported to river water with irrigation return flow. The increasing or decreasing trends of organic pollutants, including COD, BOD, NH_3 and NO_3 can also be determined [36].

Advantages of GIS: GIS currently offers diverse range of suitability and thus should be regarded as the principle tool. The main feature of its aptness is as follows [14]:

- GIS allows for the display of spatially associated data in a way that is straightforwardly lucid for most people;
- Once maps are digital format originated, it is an effortless task to revise them, to change them, or to merge them with added maps in order to creating new maps;
- GIS allows for the affluent and instantaneous incorporation of other large data sets, i.e. aiding technologies of, for instance, GIS and remote sensing, or GIS and radar, to be instantly mutual;
- GIS offers a consistent flow of spatially allied information in a consistent format. This may perhaps be for a bequeathed time series in which all maps are constructed collectively, or it might mean that intermittently a new version of the identical map could be generated.

CONCLUSION

The study retro, both research and analysis in fishery management strategies could be categorized into three extents: biological, social and economic. On average, evidence in each region is separately analysed, bestowing an artificial disaggregation of related information. For enhancing our perception about social, economic and ecological relations, it is crucial to involving people to the fisheries environment and realising the responsibilities of humans and human communities concerning ecosystem-based management. Single species management approach has created these separations even further articulated as it is solely pertained to one specific species or a group of species. Fisheries management could be fostered from an enhanced aptitude to envisage these acquaintances, since social and economic influences of regulatory transformations can then be more rapidly analysed and convenient to a wide-ranging audience. GIS maps can depict a measure of knowledge otherwise unreachable accompanied by horizons of information elucidating social and ecological associations that are ailing cognised. Collaborative web-based tools should enhance the efficiency of this attitude since these will allocate for enhanced layering, options and superior assimilation of qualitative and quantitative data [33].

Ironically, although GIS could be considered as a potent analytical tool, it incorporates few data inadequacies. GIS maps are merely almost analogous to the information that energizes them. Since this tactic thriving for the herring fishery, it may be suitable to be adapted to work for other fisheries containing with dissimilar appearances. For instance, harnessing this approach for a fishery alike the northeast ground fish fishery may be tortuous since the substantial amount of vessels partaking in the fishery are progressively being coped nevertheless numerous different access privileges (i.e. days-at-sea, special access and sector quotas). The huge sum of vessels implicated may pose challenges for this tactic, as some aggregation of vessels by size class, gear type, or homeport will be indispensable for the maps to be comprehensible [33].

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