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Uncovering the emerging concerns in monitoring and management of *Nematopalaemon tenuipes* Aramang fisheries: Towards the design, development and implementation of an IT solution

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Abstract

Fishers and locals' knowledge along abundance and catch areas of the endemic specie, *Nematopalaemon tenuipes*, is very limited, hence affecting production and economic stability in the area considering weather and water parameters, and pricing. This study focused on uncovering the emerging concerns in monitoring the fishing practices towards the design, implementation and testing of a Geographic Information System (GIS)-Based Mapping and Prediction for *Nematopalaemon tenuipes* Aramang Fisheries with Decision Tree Algorithm. Conducted in Aparri Philippines, descriptive data was obtained thru a validated 5-point Likert survey-questionnaire among 40 participants composed of IT experts, Fisheries and Marine Sciences experts, agriculture office staff, and members of the Aparri Aramang Fishers' Association. Additionally, interview guide and documentary analysis elicited additional data. Findings presented a varying concern along the management, operations, and monitoring of catch and production of the endemic Aramang both among fishers and concerned office. Further, results showed a need to implementing an information system embedding decision support system with prediction and the provision of GIS-based catch maps necessary to providing meaningful information to fishers saving their fuel resources, time, and cost in fishing. While Aramang fishing greatly aids in economic development, production trend data tends to reveal overfishing, posing challenges on conservation and management of the specie and sustainability of livelihood to fishers' families. The design, implementation and utilization by the local agriculture office of a viable system will serve as decision-support and IEC tool for reconsidering the open and closed season of Aramang catch aiding to conservation and management towards sustainability.

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Introduction

Over the years, the number of varying studies evaluating the practical implementation and integration of electronic systems in the field of agriculture, food security, conservation and management of resources has steadily grown (Alagappan, Kumaran, 2013; Alum-Udensi, Egesi, Uka, 2016; Bjorn Magnus Mathisen, 2016). With rapidly growing population, food security, monitoring, and management of natural resources benefiting the populace has become a pivotal area of concern to scholars, management leaders, and policy-makers in the different facets of the globe. With the bulk of data, decision-support systems aid to increasing sustainable productivity on fishery agro-industry supply chain (Teniwut Y.K. and Marimin, 2013; Nath, J. P.M, 2000). These concerns are critical parameters of a country or a region in its mechanism to improve human and societal development.

Ensuring food security, alleviating poverty reduction, and management and conservation of resources is a global imperative as reflected in the compelling Millennium Development Goals (MDG) which seeks to provide accelerated interventions for poverty reduction and environmental needs. It is clear that if success is to be achieved, collaborative efforts from various institutions need to be furthered, scaling up and mobilizing efficiently existing resources, stronger advocacy, and technical capacity development at the local level (United Nations Development Programme Philippines, 2012).

Scientifically known as *Nematopalaemon tenuipes* according to the World of Register of Marine Species (2018), "Aramang" is an exotic, palatable soft-shelled shrimp and only endemic species in the Northern Cagayan Philippines, particularly in Aparri (Molina L. P., *et al.,* 2013). The term aramang (Ilocano for Alamang) is always associated to Aparri, Cagayan in the Northern part of the Philippines (18.3551 N, 121.6420 E), which nature has uniquely blessed with the soft-shelled pink shrimp species or spider shrimp (Rodriguez, 2014). Aramang fishing becomes one of the major sources of income, forming almost 100 percent among the catch by drift filter nets in the Aparri Cagayan River Estuary (ACRE) Northern Philippines. Aramang is an indispensable condiment in most Iloco dishes that have brought fortune to fishers and traders as well. Remarkably, there's an increased demand for aramang primarily due to its gustatory taste (Culasing, Molina, Layugan, Rabanal, Jr., & Amog, 2013).

Meanwhile, production data as reported by the local agriculture office and the Bureau of Fisheries and Aquatic Resources - National Stock Assessment Program presents a changing and unstable production trend of aramang. The fluctuating production of aramang increased from 1996 to 2008 posing issues on overfishing or overharvesting (Municipal Committee of Fisheries and Agriculture, 2015). However, production slowly decreased in 2012 until 2018 (PSA, 2018).

This evident decreasing trend, according to the local government fisheries in-charge, was attributed to the implementation of the local ordinance on catch or aramang. However, fisheries experts (Layugan, 2018) asserts that the decreasing aramang production is due to unforeseen overfishing which calls an immediate management action to keenly monitoring catch and production among fishers. However, local officials are unable to directly make actions to permanently imposing the ordinance due to the difficulty in unlocking the real issues and problems. More so, there exists no standard mechanism to monitoring catch and production because local agriculture office only relies on the by-word declaration of few fishers and small-scale businessman in the locality.

With the call for conservation of marine species, climate change, and sustainability of available resources to sustain livelihood, the study came in to uncover the problems or issues, practices and challenges posed mainly by the fishers, and to uncover possible solution in the monitoring, conservation and management of the *Nematopalaemon tenuipes* or Aramang aiding the local government unit.

Statement of the Problem

This study generally aimed to uncover the problems or issues, practices and challenges in Aramang fishing towards the analysis, design, development, implementation and evaluation an operational system, "Geographic Information System (GIS)- based Mapping and Prediction for *Nematopalaemon tenuipes* Aramang Fisheries" for the local government unit of Aparri Philippines as a means of providing management support tool for aramang fisheries management, conservation, and possible policy development.

Specifically, this study aimed to provide answers to the following problems:

1. What are the current management practices and processes involved to monitor the *Nematopalaemon tenuipes* (Aramang) in terms of its catch or yield, and production?
2. What are the issues or problems encountered as regards the monitoring, operations, and management of *Nematopalaemon tenuipes* (Aramang) fisheries?
3. What practical IT solution could ease the problem or issues uncovered in the study?

Materials and methods

Research Design

The study utilized the descriptive research design as well as integrating the system analysis, design, and development iterative process. Descriptive-qualitative inquiry was conducted to unlocking the issues as supplemented by an interview, documentary analysis and actual fishing observation.

Participants

Implementing the purposive sampling technique to meet the inclusion and exclusion criteria, the participants of this study, presented in table 1, were categorized into two groups namely: (a) the IT experts, composed of IT faculty members and industry practitioners with relevant prior knowledge on field of study as well marine and science faculty-researchers with sterling research performance, and (b) the of the system composed of the staff of the municipal agricultural office (MAO) LGU Aparri, faculty of fisheries and marine science, researchers, and students in the academe or research institutes, and the fishers and fishery organizations highly engaged in Aramang fisheries.

Locale

The study was conducted in the coastal areas of Aparri Cagayan Northern Philippines, particularly along the Aparri Cagayan River Estuarine and the Babuyan Marine Corridor. Bounded in the east are coastal towns of Buguey, Calayan Group of Islands and Batanes in the far north, Ballesteros in the West, and Camalaniugan in the South.

Instrumentation and Data Gathering

The study employed a survey-questionnaire adopted and in accordance with what has been acceptable by the International Standards Organization (ISO). The ISO/IEC 25010 software characteristics software assessment tool consisted of the three parts. With a formal consent form, the questionnaire was explained to the respondents in vernaculars, before the same was used to assess the system or processes of monitoring, management and operation of *Nematopalaemon tenuipes* Aramang Fisheries.

An interview guide assisted the researcher to elicit the participants' views, issues, and problems relative to Aramang fishing, operations, and management.

Table 1. Distribution of Study Participants.

Participants	Sector	n	%
Experts	Academe IT Experts	5	12.5
	Industry IT Experts	5	12.5
	Fisheries and Marine Science Faculty-Researchers	5	12.5
Users/Frontline	Agriculture Office Staff	5	12.5
	Fishers (Aparri Aramang Fishers Association)	20	50.0
	Total	40	100.00

A Reliability test was carried out via test-retest method using both Spearman-Brown coefficient and Guttmann split-half coefficient. Scheduled formal interview was done to elicit additional information from the participants specifically the fishers, MAO staff, LGU officials, experts or researchers in the fisheries and marine sciences, Cagayan State University at Aparri, Philippines.

More often, the researcher conducted interviews and observation at the landing site, working or meeting sites, and on-board during actual Aramang fishing. Acknowledging the provisions of the Philippine Data Privacy Act, data sets and information along Aramang production, catch, and landing sites was taken through documentary analysis.

Through formal communications, datasets and documents or reports was taken basically from the office of the municipal agriculturist, LGU Aparri, supplemental data from the Philippine Statistics Authority website, Provincial and Regional Fisheries and Aquatic Resources.

Data Analysis

To analyse the data gathered, weighted means was used to analyze the issues and problems along monitoring, operations, and management of the *Nematopalaemon tenuipes* Aramang fisheries using a validated 5-point Likert scale survey-questionnaire. Thematic analysis was used to analyze the responses based on interviews following an interview guide.

Results and discussions

Profile of the Respondents. Table 2 presented the profile of the users including the assessment of the Municipal Agriculture Office Staff (5), Faculty of Fisheries and Marine Sciences (5), and the fishers belonging to the Aparri Aramang Fishers Association (20).

Table 2. Profile of the agriculture office staff, fishers, fisheries faculty-researchers.

Variable	Sample Composition	Male	%	Female	%	N (30)	%
Category							
	Fishers	20.00	90.91	-	-	20.00	66.67
	Non-Fishers	2.00	9.09	8.00	100.00	10.00	33.33
	Total	22.00	100.00	8.00	100.00	30.00	100.00
Age							
	30 to 40	7.00	31.82	3.00	37.50	10.00	33.33
	41 to 50	7.00	31.82	1.00	12.50	8.00	26.67
	51 to 60	8.00	36.36	4.00	50.00	12.00	40.00
	Total	22.00	100.00	8.00	100.00	30.00	100.00
Highest Education Attained							
	Elem. Level	13.00	59.09	-	-	13.00	43.33
	Elem. Grad	4.00	18.18	-	-	4.00	13.33
	High School Level	3.00	13.64	-	-	3.00	10.00
	High School Grad	-	-	-	-	-	-
	College Level	-	-	-	-	-	-
	College Grad	1.00	4.55	-	-	1.00	3.33
	Masters	1.00	4.55	6.00	75.00	7.00	23.33
	Doctorate	-	-	2.00	25.00	2.00	6.67
	Total	22.00		8.00		30.00	100.00
Years of Experience							
	below 15	2.00	9.09	4.00	50.00	6.00	20.00
	15 to 20	10.00	45.45	-	-	10.00	33.33
	21 to 25	6.00	27.27	1.00	12.50	7.00	23.33
	26 to 30	3.00	13.64	3.00	37.50	6.00	20.00
	above 30	1.00	4.55	-	-	1.00	3.33
	Total	22.00	100.00	8.00	100.00	30.00	100.00

Majority of the user-respondents were male (80.0%), in contrast with their female counterpart. With a mean age of 46.47, most of the user-respondents were between 51 to 60 years old, majority of were male (36.36%). The highest education attained differ from the 2 groups of users: majority of the fishers did not complete elementary (59.09%), while most of the non-fishers (MAO, Faculty Members) or 7 respondents were able to complete their relevant master's degree. In terms of the years of experience, majority of the non-fishers (MAO, Faculty Members) has been in the service between 15 to 20 years with a mean of 17.4 years. With a mean of 22.05 years, most of the fishers have been into Aramang fishing between 21 to 25 years, while some reported having into Aramang fishing over 30 years already. Most of the IT Experts who served as respondents in this study were male (70.0%) outnumbering their female

counterparts. As presented in table 3, majority has been in the academe (60.0%) at a mean of 11.83 years as compared to the 4 working in the industry for a mean of 12.25 years. A substantial percentage (90%) were masters' degree holder in the relevant IT education, while only 10 percent with doctorate degree.

Table 3. Profile of the IT Experts.

Variable	Sample Composition	Male	%	Female	%	N (10)	%
Category							
	Academe	3	42.86	3	100.00	6	60.00
	Industry	4	57.14	0	-	4	40.00
	Total	7	100.00	3	100.00	10	100.00
Age							
	below 30	2	28.57	0	-	2	20.00
	30 to 40	5	71.43	2	66.67	7	70.00
	40 to 50	0	-	1	33.33	1	10.00
	50 to 60	0	-	0	-	0	-
	Total	7	100.00	3	100.00	10	100.00
Highest Education Attainment							
	Bachelor	0	-	0	-	0	-
	Masters	7	100.00	2	66.67	9	90.00
	Doctorate	0	-	1	33.33	1	10.00
	Total	7	100.00	3	100.00	10	100.00
Years of Experience							
	below 15	5	71.43	2	66.67	7	70.00
	15 to 20	2	28.57		-	2	20.00
	20 to 25	0	-	1	33.33	1	10.00
	above 25	0	-		-	0	-
	Total	7	100.00	3	100.00	10	100.00

Current Practices in Nematopalaemon tenuipes Aramang Fishing, Monitoring, and Management

The current practices along monitoring catch, production, and yield of Aramang are herein presented. The monitoring and management of Aramang fishing is in close coordination with the Maritime group, Philippine Coast Guard, Philippine Navy, Bureau of Fisheries and Aquatic Resources, and the Local Government Unit of Aparri.

1. Since 2015, members of the Aparri Aramang Fishers Association are guided with the Gentleman's Agreement (Municipal Ordinance 151 series of 2015) along which hauling, schedule of fishing, allowable catch, and pricing were stipulated.
2. The monitoring of Aramang catch starts from the landing sites established by the Local Government Unit of Aparri through an assigned Municipal Agriculture Office staff, particularly the in-charge in fisheries and aquaculture.
3. The total catch in kilos are manually recorded, the number of hauls is declared by the fishers, and the pricing per kilo are declared in accordance to the purchasing power.
4. The wet catch are either be sun-dried or directly sold fresh in the public market of Aparri. Sun-drying is normally made in direct sunlight, conspicuous areas, safe from dust, and in boxed drying nets elevated from the ground. However, most of the drying, as observed, was into clean pavements, in long-thin fine nets along public roadsides, and along the stretches of the coastlines.
5. Commissioned gatherers sun-dry fresh-caught Aramang segregating export quality Aramang. These are monitored in warehouses where traders normally transport for export.
6. The MAO staff makes consolidated report for the office and relevant information-seeking organizations. These reports are filed in piles of folders and safe-keeping file cabinets which may be exposed to data breach or loss.
7. The report of the BFAR including those in the National Stock Assessment Program comes from the report of the Local Government Unit in an Excel-formatted template which are transmitted to the BFAR.

Table 4. Assessment of the current monitoring and management practices on Aramang fishing by the fishers, mao staff and fisheries experts.

Assessment Statements for Fishers, MAO Staff and Fisheries Experts	Weighted Mean	Description
Monitoring of catch is done regularly by the local agriculture office staff	2.60	Disagree
Catch are recorded manually on record books	3.30	Uncertain
Aramang pricing is dependent on the traders not the local government authorities (MAO, Market Supervisors)	3.10	Uncertain
Aramang fishers are updated on the local ordinance for Open and Closed Catch and related laws	2.90	Uncertain
Aramang fishers are guided with the applicable filter nets/gear for fishing and proper fishing practices.	2.70	Uncertain
Landing sites are available for actual monitoring of Aramang catch conspicuous and accessible.	2.40	Disagree
Fishers are informed of the catch points saving time and resources thru generated maps.	2.10	Disagree
Fishers are well-informed of abundance of Aramang eventually saving time, costs, and resources.	2.20	Disagree
The local agriculture office provides informative and relevant IEC materials for Aramang fishing, and its conservation management.	2.50	Disagree
The local agriculture office – fisheries in-charge and Aramang fishers are forecasted regularly on Aramang fishing updates, weather and water parameters.	2.56	Disagree
Catch points are provided for safer and efficient fishing as well as monitoring.	2.00	Disagree
Water parameters are known to fishers by the local agriculture office prior Aramang fishing.	1.70	Strongly Disagree
Local ordinance is made known and well-understood to fishers by the local government and concerned offices.	2.90	Uncertain
Fishers are oriented on the allowable number of hauling and allowable catch limits.	2.80	Uncertain
Fishers are apprehended if are not compliant to the imposed local ordinance.	2.60	Disagree
Meeting and coordination with concerned agencies and fishers are initiated by the local agriculture office-fisheries in-charge.	3.30	Uncertain
Local agriculture office staff and relevant government agencies are on-field to secure and monitor regularly.	2.80	Uncertain

The fishers, MAO staff, and fisheries experts have revealed, through the assessment, (table 4) varying and impending issues, problems, and emerging concerns that confronts monitoring, management, and conservation of the Aramang. This tends to suggest a greater role for the local agriculture office towards the proper imposition of the local ordinance, dissemination of relevant information and updates that may assists in proper monitoring, management, and operations in Aramang fishing, and the need to closely work with relevant agencies towards sustaining livelihood development for the fishers and their families. Meanwhile, the assessment of the IT experts revealed an existing issue along the monitoring and preparation of reports on Aramang catch and production (table 5) congruent with the assessment by the fishers.

Further, while formats are made available, discrepancies and data integrity emerged as an issue. The manual way of monitoring, preparation, and security of Aramang catch and production brings forth a greater need to systematize and instigate a user-friendly, resource-efficient, and management-effective tool through the development of a system.

Issues and Problems along Current Monitoring Practices

One of the end goals of the study is the design, development, and implementation of a GIS-Based Mapping and Prediction for *Nematopalaemon tenuipes* Aramang Fisheries which hopes to consolidate the different features of the current system practices and procedures thereby providing a practical IT solution that supports decision-support

system, improved processes in the local agriculture office, and improve fishing practices and support to Aramang fishers. Hence, to guide the researcher in this goal, the IT experts were asked to provide their assessment on the current monitoring and management practices for Aramang fisheries. After a 2-session office and field observation, analysis of the current practices, and review of documents, the assessment was made using a questionnaire. Results revealed a majority of disagreements in the statements pertaining to the monitoring, operations and management of Aramang fisheries though with uncertain overall remark (mean=2.65).

Nonetheless, the statements reflect the greater need to improving the system processes and procedures which integrates the power of ICT as the need is critical to the local government, more particularly the fishers.

Table 5. Assessment of the IT Experts on the Current Monitoring and Management Practices for *Nematopalaemon tenuipes* Aramang Fisheries.

Assessment Statements	W. Mean	Desc. Rating
Aramang records are stored in loose sheets and computer terminals.	3.70	Agree
Needed report on a timely manner are prepared by the MAO staff.	2.20	Disagree
Production report on Aramang are prepared for management purposes.	2.50	Disagree
Aramang production are known to fishers for them to benchmark on their catch thru dissemination.	2.50	Disagree
Monitoring of Catch is done regularly by the MAO staff	2.50	Disagree
Catch are recorded manually on record books	3.50	Agree
Fishers are informed of the catch points saving time and resources thru generated maps.	2.70	Uncertain
The MAO office provides IEC materials for Aramang fishing.	2.20	Disagree
MAO and Aramang fishers are forecasted regularly on Aramang fishing.	2.70	Uncertain
Catch points are provided for safer and efficient fishing as well as monitoring.	1.80	Strongly Disagree
Monitoring of Aramang production are documented thru forms	2.70	Uncertain
Formats in monitoring Aramang catch and production are based on standard BFAR templates.	2.80	Uncertain
There is a systematic way of providing information to the local agriculture office along weather parameters for dissemination to fishers	1.40	Strongly Disagree
There is a way to produce needed reports and locate these reports for decision making purposes.	1.40	Strongly Disagree
A database to store Aramang-related data is in-place.	1.20	Strongly Disagree
Overall Weighted Mean	2.65	Uncertain

Based on the interview responses of the participants, the following were issues and problems deduced.

1. Inaccuracies and inefficiency in reporting along Aramang catch or production due to varying inconsistencies such as missing monthly records, unconsolidated and uncategorized data, and unsafe cabinet-records keeping;
2. Difficulty in the actual monitoring of catch and production in the different landing sites is associated to the varying time to dock by the fishers, risks in crossing the Babuyan Marine Corridor (BMC) and Aparri Cagayan River Estuarine (ACRE) Aparri Philippines, and non-reporting of fishers on actual catch or total production especially when peak season where traders directly buys fresh catch aboard;
3. Discrepancies in the reports available in the National Stock Assessment Program (NSAP) of the Bureau of Fisheries and Aquatic Resources and the reports of the local agriculture office along Aramang catch and production;
4. Fluctuating prices of Aramang could be associated to the monopoly by some traders, uncontrolled market pricing, and inability of the local government and local agriculture office to properly regulate pricing of Aramang;
5. Aramang fishers reported that they are unable to control catch and usually exceeds the catch limits indicated in the Gentleman's agreement especially during peak season and there is a greater need for the return of investment in the catch;

6. Unavailability of safe, secured, and sanitary drying pavement or facilities for drying export-quality Aramang in the locality affecting production of sanitary, safe, and world-class dried Aramang for export;
7. While a Gentleman's Agreement is enforced with the local government of Aparri, relevant and concerned government agencies (such as DENR and BFAR, Maritime, Navy, and Coast Guard), fishers' fully disclosed issues on the ordinance needing review addressing food security among its residents and their livelihood, Aramang management and conservation, and local economy of Aparri;
8. Aramang fishers find issues or problem regarding when to catch due to unavailability of scientific mechanism or decision-support system aiding fast, accurate, and cost-effective information dissemination along catch schedules to fishers by the local agriculture office. These according to most fishers hinders their ease of Aramang fishing, affecting their livelihood; and
9. Live weather and sea updates are crucial to fishers. However, due to lack of real-time forecasting on weather and sea currents, fishers are constrained to go fishing which greatly affects supply market chain of wet and dry Aramang as well as export-quality sun-dried Aramang.

Integrating the best features of data mining, geographic information systems (GIS), decision tree algorithm, and relevant ICT tools, the design, development, and implementation of a viable IT solution through the Geographic Information System (GIS)-Based Mapping and Prediction for *Nematopalaemon tenuipes* Aramang Fisheries is herein proposed. While cost-benefit analysis is not presented herein, many literatures has proven the edge of system application over manual systems practices. Features to be contained may include live weather notification to add safe, secured, and cost-effective Aramang fishing via SMS notification updates to Aramang Fishers, condition prediction for Aramang fishing using Decision Tree Algorithm with the integration of live weather and sea maps, Google maps, and production data, mobile-friendly IEC tool for researchers, students, and the community, and data consolidation with the National Stock Assessment Program of the Bureau of Fisheries and Aquatic Resources. Systems such as GISMaPNeT serving as an IEC too is infact proving access to appropriate 'information' which has been outlined as comprising a vital component of the coastal management process according to Nicholls, Dawson, and Day (2015) and further supported by the studies of Supriatna A. K., *et al* (2016) and St. Martin K (2009). Such technologies have been found essential in providing decision support to stakeholders (Javier, 2019).

Conclusions

As reflected in the results, issues and problems affects the catch, production, and yield of the *Nematopalaemon tenuipes* Aramang Fisheries which redounds to the economic instability among fishers and the local government in general. The need to regulate catch through proper and systematic monitoring of catch, provision of GIS-based catch maps through ICT tools, and development and implementation of a viable IT solution maximizing its solution is herein eminent based on the issues and problems uncovered.

The analysis, design, development and testing of the Geographic Information System (GIS)-Based Mapping and Prediction for *Nematopalaemon tenuipes* Aramang Fisheries as a management tool to the local government of Aparri, as a decision - support tool for the local agriculture office, and as a critical informative tool to fishers and the community, needs to be in place towards the provision of appropriate policies, updates, or even ordinances towards the conservation and management of *Nematopalaemon tenuipes* or Aramang only endemic in Aparri Cagayan-Babuyan Marine Corridor. Further cyclic studies to include water current in the area and depth of catch areas which is still uncovered through research due to strong currents underneath may be collaboratively made towards mapping. The Municipal Agriculture Office may require all Aramang fisher to be included in the

database for faster monitoring and top-level decision making once an IT solution is in-place. A multi-sectoral review of the local ordinance may be made since fishers complain of obtaining source of income during closed season which according to them, seasons have change due to climate change.

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