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Development of web application, "Lank fish" to sustain consumption of marine food fish species in Sri Lanka

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Abstract
The demand of fishery for diverse fish species is determined by the fishermen, consumers, and their catching or purchasing decision respectively. Knowledge on precious identification and exploitation level of the fish species is significant to make a correct decision considering sustainability and conservation status. Hence this study intended to provide a computer based fisheries management tool as fulfilling above requirements by making an attitudinal change of the stakeholders. Diagnostic characters of each fish were confirmed by the in-situ morphological study using photographs and visual observation. A user-friendly scale including five colors of sustainability rating was generated by combining Indian Ocean Tuna Commission (IOTC) stock status and International Union for Conservation of Nature (IUCN) conservation data. A traffic light system was developed using above sustainability rating of the fish as displaying consumer advices; "avoid" (red color), "suit" (green color) or "think" (yellow color). Out of 22 selected fish species three, five and fourteen number of species were categorized under the Lanka Fish ranking of "avoid", "suit" and "think" respectively. Most of the shark and billfish species were categorized under the "Not entirely sustainable" and "Fish to be assessed" due to data deficiency, therefore this study highly recommends comprehensive scientific studies on target species. The developed Lanka fish web application (http://www.uwu.ac.lk/lankafish/) act as a user-friendly fisheries management tool while demonstrating the consumer advice for each species to sustain utilization of marine food fish species in Sri Lanka.

Keywords: Sustainability, fishery, Indian Ocean, Lanka fish, exploitation, conservation

1. Introduction
The fish production plays an imperative part in human nutrition as well as economic point of view. Fish is one of the most important sources of animal protein available all over the world for human consumption [1]. There are two main categories of fish production under capture fishery (fresh water and marine water fish production) in Sri Lanka. Among them, coastal fish production is the most prominent under the marine fish production category [2]. Fisheries statistics data demonstrated that the contribution of coastal fisheries is always exceeding the deep sea/offshore production during last four years. Further, fisheries sector in Sri Lanka accounts for 1.8% of GDP at the current market prices and 1.3% at constant prices in 2014 [2]. There are approximately four major commercial food fish groups which carry 22 fish species found in the sea of Sri Lanka which were impacted by fishery according to Indian Ocean Tuna Commission (IOTC) documents [3]. Still, the off-shore and high sea fish production is dominant by tuna and tuna-like species according to above documents.
The high demand for marine fish production leads to overexploitation of demanded food fish species in the Sea of Sri Lanka, Indian Ocean [4, 5] and also, it will be a threat to other marine wildlife and habitats. There are few other reasonable gaps in the conservational sector. Consumers have no idea about the conservational status and threat level (infections favor to occur) of the species that they consume. If they know the sustainability level (in a user-friendly manner) of the food fish that they consume, it will definitely help to reduce the consumption of overfished species. Every day marine capture fishery taking out too much fish more than our ocean can reproduce [6]. Hence, the future of fish stock cannot be guaranteed by any authority in the Indian Ocean. Fisheries resources are very assorted and depended on responsible management decisions where practices need for their sustainable development [7]. One way of management of fishery resources is to reduce the demand for those unsustainable food fish stocks.

For that, there is an urgent requirement for a user friendly sustainable fish guide to reduce the consumption of fish which were susceptible for overfishing via attitudinal changes of the consumers while reflecting the level of sustainability in the particular fish species and their stocks. There are several ways like television or radio news, newspapers, public awareness programs to advise consumers, however internet usage has increased tremendously in the past decade. Thus, websites have become the most important public communication portal mostly and also for businesses and organizations [8].

As a pre-requirement of the sustainable food fish guide, foremostly need to identify major commercial food fish species, their sustainable level and which fish species need to conserve are important in Sri Lanka. Though Sri Lanka has high level of consumers for marine food fish, still there are very limited user-friendly sustainable fish guides which could aware the consumer about current status of the available fish stocks. As fulfilling above gaps, this research is focused on providing necessary awareness to the consumers about sustainable consumption. A proper tool will act as a user-friendly website, to the consumer with ability to use in the fish market when purchasing fish. MySQL database preparation is a freely available open source database management system for its user friendly and sustained for almost every technology which can be used for the purpose of repossessing data [9].

Accordingly, major objective of this study is to develop a reliable marine food fish database/tool to improve the consumer awareness and sustainable use of marine food fish in Sri Lanka. This tool will act as a consumer guide for the local fish market as well as a fisheries management tool which helps to sustain sea food industry in the country.

2. Materials and methods

Fishery impacted marine food fish species were selected using IOTC as a referring material. Twenty-two species has been categorized under 4 major marine food fish groups (Neritic tunas and mackerels (seer fishes), Sharks, Billfish and Temperate and Tropical tunas) and it has further recorded the current stock status of the particular species in the Indian Ocean. Additionally, reliable secondary data (FAO, FISHBASE) were used to confirm common names, scientific names and local names of each species respectively.

Peliyagoda fish market and the Mirissa fisheries harbor area were selected as the survey sites for morphological identification. Diagnostic body characters (position, color & structure of fins, body color & shape, mouth position, shape of the lateral line, etc.) of the selected 22 species were observed and recorded for trustworthy and user-friendly identification. Most of the images of above 22 species were captured and rest of the images were taken from reliable literature materials while acknowledging the photojournalist. Diagnostic features, stock status, conservation status, threat to human and image of the species were demonstrated in the database.

MySQL Database Management System (DBMS) software was used for the storage of data in a user-friendly manner. For the purpose of retrieving data, this study was continued with developing a web application which later called "Lanka Fish" integrated with the main website of Uva Wellassa University of Sri Lanka. Stock status of each species in the Indian Ocean and conservation status for every 22 species were given by IOTC and IUCN respectively. Three color codes were developed to display the IUCN conservation status of the selected species. Red color used every species which mentioned the conservation status as "Endangered/Near Threatened/Vulnerable". Yellow color was used to show the data deficient categorical species and green color was used to display the category of least concern species (Table 1). Combination of IOTC color codes and developed conservation color codes were used to illustrate the Lanka Fish rating for the designated 22 species and consumer advice was created using above rating system.

All the collected research data were inserted to Microsoft excel data sheet and then that data sheet was exported to MySQL Database Management System. Then the MySQL database was connected to the "Lanka Fish" website by using LAMP technology and finally the prepared web application was connected to the Uva Wellassa University Website. www.uwu.ac.lk/lankafish link was directed to the "Lanka Fish" web application and it was demonstrated the complete database of above mentioned 22 species including consumer advice and Lanka Fish rating (Fig. 1).

Uva Wellassa University of Sri Lanka was subjected as the hosting partner of the "Lanka Fish" web application. It was developed as an attractive web application followed by species fact sheets for mainly giving consumer advices at purchasing (Fig. 2). Different user-friendly characters were incorporated in this web application using key design elements, such as scannability, readability, learnability, efficiency, memorability and visual aesthetics.

3. Results and Discussion

Current study has used fisheries affected 22 marine food fish species under the guidelines of IOTC, which was identified as the only organization having reliable marine food fish stock data in the Indian Ocean region. Table 1 shows IUCN conservation status in the code of three different colors for this selected 22 species. The "Lanka Fish" rating has implemented by concerning all the available IOTC stock status and IUCN conservation status data (Table 2).

However, the status of most of Indian Ocean fish species consider as "unknown," due to inaccurate reporting or lack of reporting [10]. Therefore, collection of information and dissemination of current status of these marine food fish species is an urgent need in the Indian Ocean region. The "Lanka Fish" web application is the first computer based intelligible database which has been prepared considering several key characteristics of each species for accurate identification and to aware the consumers on selecting the proper purchasing decisions. Also, it provides necessary information on consumption pattern and current status of the fish.

The prepared five color codes and legends are specified in the table 3. Even there are five color codes for "Lanka Fish" rating, the final advice for consumers is given by three color codes. The Near Threatened, Vulnerable and Endangered species has considered under one color code; "red" for avoiding the purchase. The Data Deficient fish species has categorized under the "yellow" code for thinking again when catching and purchasing. The "green" color code has reflected Least Concern species, which are suitable for sustainably catching and consumption.

Three colored consumer advices act as a user-friendly traffic light system for quick, effective and convenient selection either taking the purchasing decision or selective fishing. Hence, the accurate decisions of above stakeholders assure

sustainable utilization and management of those fish species. The Marine Conservation Society in Scotland has also used this kind of web portal to protect the UK's seas, shores and wildlife focusing on implementation of site-specific management measures [11]. Therefore, web application systems signify novel approach in conservation, protection and management of several ecosystems.

The generated consumer advice codes were consisted with three species to "Avoid", five species to "Suit" and fourteen species to "Think" before take the purchasing decision (Table 3). According to the Lanka Fish rating system, there were three most sustainable species, two sustainable species, four not entirely sustainable species, three avoidable species respectively with ten fish species need to be assessed in near future.

Tuna and tuna-like species significantly contribute for the large pelagic fisheries sector in Sri Lanka [12]. This database has also mainly concerned tuna or tuna-like species for sustainable management. Based on the results, yellowfin tuna has reached the overexploitation level due to significant growth in marine food fish consumption with rising human population all over the world. Higher marine fish production of yellow fin tuna has recorded due to usage of high technology and increasing trend of catch per unit effort in Sri Lanka during past two decades [12, 13]. This would be a possible reason to exceed the yellow fin tuna production over the maximum sustainable yield. Total capture production in marine waters was 81.5 million tonnes in 2014 while total catches of tuna and tuna-like species were almost 7.7 million tonnes [14]. According to FAO data, 47 fish species in Indian Ocean have recorded with sufficient available data to evaluate the current condition of those wild fish stocks. Moreover, 41 species out of 47 were either "moderate-full" exploited or "full-overexploited" which included as avoidable species in the Lanka Fish consumer advice guideline confirming the results of this study.

The silky shark (*Carcharhinus falciformis*), Whitetip shark (*Carcharhinus longimanus*) and Hammerhead shark (*Sphyrna sp.*) were considered as most abundant sharks groups in the offshore regions [15] while blue shark (*Isurus oxyrinchus*), shortfin mako shark (*Isurus oxyrinchus*) and thresher shark (*Alopias sp.*) are mainly found in sub-surface sea waters of Sri Lanka [16]. Significant number of shark species have categorized under "Fish to be assessed" and "Think" due to the deficiency and lacking of the secondary information for assessment of conservation and stock status. In the case of sharks, stock status was not available at least for a single shark species. As shark is a restricted group of fish for catching, legal issues would arise for responsible authorities with publishing the data of shark stocks in Indian Ocean.

Several billfish species like black marlin (*Makaira indica*), blue marlin (*Makaira nigricans*), striped marlin (*Tetrapturus audax*), sailfish (*Istiophorus platypterus*) and swordfish (*Xiphias gladius*) have been recorded in Sri Lankan Sea and documented by Samaraweera and Amarasiri [17]. Among them, Striped marlin has highlighted as one of fish species to be avoided when purchasing or fishing according to the Lanka Fish ranking, because their harvest could be reached to the overexploitation level by high demand. Sword fish has been identified as the most sustainably produced group which is suited for consumption according to the Lanka Fish ranking. Billfish capture industry has not largely expanded until 1980 [18], accordingly still the swordfish harvest would not exceed the maximum sustainable yield during last few decades. Most of other billfish species considered in this guide has categorized under the "Not Entirely Sustainable" and "Fish to be Assessed" which leads to think when taking the consumer decision. As Maldeniya *et al*. [18] revealed, landing and catch data of billfish species around Sri Lanka were underestimated and limited scientific studies are recorded. As well as, the biology and taxonomic studies on billfish group inadequately addressed which leads to misidentification of the target fish [19]. These factors significantly effect on the consumption status and fisheries management regime of the billfish industry. Further, this web-based application provides appropriate guidance to identify the target species correctly using morphological characters. Thus, this tool would be useful to mitigate issues related with the misidentification of billfish varieties.

However, deficiency of data will affect severely on fishery management systems of target fishery according to the findings of this study. Hence, the current study suggests a thorough scientific investigation on those fish stocks in the Sri Lankan sea, Indian Ocean for implementing a sustainable fishery management system. Marine sea food consumers are recommended to use this web application during the decision-making time of fish purchasing or harvesting. This web application opens novel approach in sustainable marine fisheries management sector of Sri Lanka in near future. Further, this application would be developed into a mobile app to promote the usage among consumers.

Table 1: Ranked IUCN conservation status color codes

Color Code	Conservation Status	Number of Species
Red	Near Threatened/Vulnerable/Endangered	13
Yellow	Data Deficient	3
Green	Least Concern	6

Table 2: Different codes of Lanka Fish rating and consumer advice for selected species

IOTC Stock status	Conservation status	Lanka Fish rating	Consumer Advice
Red	Red	Red	Red for Avoid
Orange	Red	Orange	Yellow for Think
Yellow	Red	Orange	Yellow for Think
Gray	Red	Blue	Yellow for Think
Green	Red	Green	Green for Suit
Gray	Yellow	Blue	Yellow for Think
Orange	Yellow	Orange	Yellow for Think
Gray	Green	Blue	Yellow for Think
Orange	Green	Orange	Yellow for Think
Green	Green	Dark Green	Green for Suit

Table 3: Species categories under the Lanka Fish rating

Lanka Fish Rating	Description	Name of the species	Consumer advice
Dark green	Most sustainably produced	Kawakawa, Swordfish, Skipjack tuna	Green for Suite
Light green	Sustainably produce	Albacore, Bigeye tuna	Yellow for Think
Orange	Not entirely sustainable	Longtail tuna, Black marlin, Blue marlin, Indo-Pacific sailfish	
Blue	Fish to be assessed	Indo-Pacific king mackerel, Frigate tuna, Bullet tuna, Blue shark, Oceanic whitetip shark, Scalloped hammerhead shark, Shortfin mako shark, Silky shark, Bigeye thresher shark, Pelagic thresher shark	
Red	Fish to be avoided	Narrow-barred Spanish mackerel, Striped marlin, Yellowfin tuna	Red for Avoid

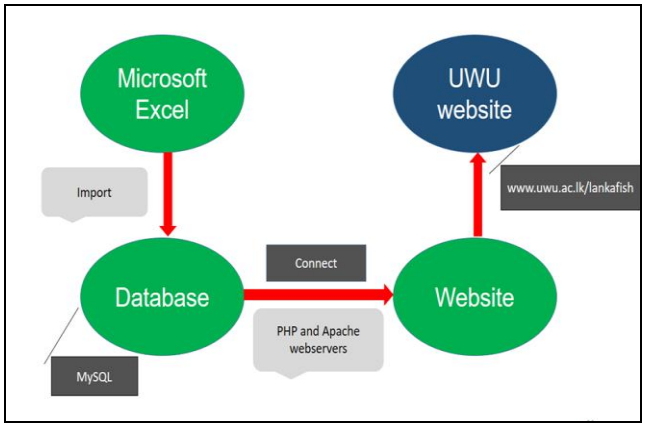

Fig 1: Web application development process by MySQL database tool

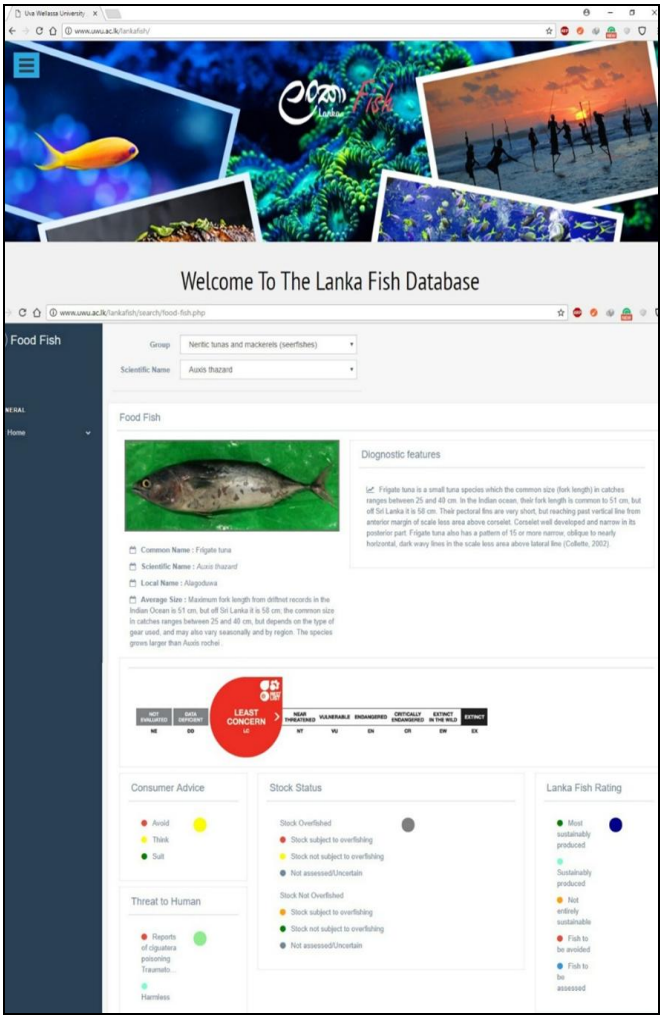

Fig 2: Lanka Fish web application home page and species fact sheet

4. Conclusion

The "Lanka Fish" web application act as a fisheries management tool to sustain the commercial capture fishery with the available data such as morphological identification features, stock status, conservation status and consumer advices. Mainly this tool has identified three commercially important fish groups (Tuna, Sharks and Billfish) in marine fishery sector.

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