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Conservation oriented habitat classification scheming and mapping of Egypt

Khaled Allam Harhash, Mohmmed Talaat El-Henawy, Haitham Farouk Abdel Fattah* and Mohammed Sameh Antar

Abstract

Background: "habitat classification models" are invaluable tools for species conservation, land-use planning, reserve design, and meta-population assessments, particularly at broad spatial scales". Globally, there are at least 23 schemes developed for habitat classification schemes. The pioneer attempts in Egypt for classifying habitats were started by the series of Kassas giving a concern about dry lands and desertification problems. The main purpose of this paper is to: 1) present a suitable model for large scale planning to support the decision making process towards the natural resources in Egypt, 2) standardize data collection on habitats which will assist in management and conservation of the Egypt's natural heritage.

Results: This paper presents new GIS-based habitat classification hierarchy that contains 5 main habitat systems, 12 habitat sub-system and 36 habitat classes. One of the major outputs of this present scheme is to define the boundaries of the three classes (epipelagic – mesopelagic – bathypelagic) of the pelagic sub-system.

Conclusion: This hierarchy represents a new GIS-based standardized habitats scheming for Egypt. It was designed to support the current efforts to define the key biodiversity hotspots as well as long term planning of biodiversity at the national level. This new habitat mapping/scheming, has considerable potential utility for conservation priority setting for Egypt; it could be used to design and update the existing protected areas network; it could be used to evaluate the protected areas system representativeness, and climate change impacts studies. It is recommended to link habitat classification and mapping efforts in Egypt to regional and global approaches.

Keywords: Egypt; Habitat Classification; Scheming; GIS-Mapping; Conservation; Ecosystem; Resource Management

Background

"Habitat classification models (HCMs) are invaluable tools for species conservation, land-use planning, reserve design, and metapopulation assessments, particularly at broad spatial scales" (Jacob, *et al.* 2013). Two basic questions must be answered before planning to conserve biodiversity: (1) what to conserve and (2) where? With regard to what to conserve, there is still considerable debate on appropriate measures of biodiversity for conservation planning. Much attention has been given to the importance of taxonomic rank and character differences between species (Vane-Wright *et al.* 1991; Faith 1994). Use of a common habitat classification scheme serves as a foundation to communicate about resources and issues between multiple stakeholders and management groups in a common language.

In accordance with the global biodiversity strategic plan (2011 – 2020) developed by CBD and named AICHI biodiversity targets. Middle age professionals from the Nature Conservation Sector (NCS) within the Egyptian Environmental Affairs Agency (EEAA) work to develop a new approach toward strategic conservation oriented views to manage the natural resources in Egypt. The applied methodology that are used for habitat description – classification was based on broad scale GIS of the Egyptian lands.

Globally, there are at least 23 schemes developed for habitat classification schemes listed in Madden and Grossman (2004). Many approaches have been developed with a particular geographic focus (Dethier 1992 for coastal Washington; Valentine *et al.* 2005 for the Gulf

* Correspondence: HaithamFarouk@yahoo.com
Nature Conservation Sector, Egyptian Environmental Affairs Agency, Ministry of Environment, Cairo, Egypt

of Maine region; Greene *et al.* 1999 for seafloor habitats off California; Auster *et al.* 2005 for North Atlantic seamounts) with detailed discussion on global applicability (Auster *et al.* 2009).

In its global habitats classification hierarchy, IUCN has identified three levels of habitat hierarchy, which use familiar terms consider biogeography, latitudinal zonation and depth in marine systems. The IUCN classes include 18 classes, 100 subclasses and 8 sub-sub classes which describe the major habitat/s in which taxa occur.

The habitat classification forms an integral part of the European Nature Information System (EUNIS), developed and managed by the European Topic Centre for Nature Protection and Biodiversity (ETC/NPB in Paris) (Davies and Moss 2004. It is a comprehensive system covering the terrestrial and marine habitat types of the European land mass and its surrounding seas. It is hierarchical in structure and includes a key with criteria for identification of habitats at the first three levels, (EEA 2008). This has been achieved after a series of works for Davies and Moss (1998), Davies and Moss 1999, Davies and Moss 2002, and Davies and Moss 2004.

Rodwell *et al.* (2013) reported about individual European countries who have often devised several habitat classifications dependent on particular policy requirements and these are not always compatible. In the UK, for example, the Phase I Habitat Classification, the Countryside Survey reporting categories (Barr *et al.* 1993) and the Biodiversity Action Plan Priority Habitats (UK Biodiversity Steering Group 1995) use different criteria for habitat definition. So their units do not bear a simple or consistent relationship to one another, nor to the standard classification of vegetation types in use in the country. In addition, the classifications of freshwater rivers (Holmes *et al.* 1999) and open waters (Duigan *et al.* 2006) have used different criteria for defining habitats, partly by hydrological characteristics and partly by vegetation.

In his review, Rodwell *et al.* (2013) introduced examples of national marine classification schemes of habitats/biotopes that are used by European countries which include those developed by France, the Netherlands, the UK and Ireland. In France, classifications of biocenoses (the ZNIEFF-MER classification) provides a detailed typology based on the CORINE biotopes list for the metropolitan French coast and developed from the work of Pérès and Picard (1964) and Dauvin *et al.* (1994). The Marine Habitat Classification for Britain and Ireland Connor *et al.* (1997a), Connor *et al.* 2004) has five levels covering broad habitat types, habitat complexes, biotope complexes, biotopes and sub-biotopes. In the Netherlands, the Dutch Ecotope System for Coastal waters (Bouma *et al.* 2005) uses salinity, substratum, depth and hydrodynamics in a six-level system of classification. Other studies were dealt with separate issues such as: Tropics (WCMC); Wetlands (SANPI).

The pioneer attempts in Egypt for classifying habitats were started by the series of Kassas: HABITAT AND PLANT COMMUNITIES IN THE EGYPTIAN DESERT: I. Main classes of desert habitats on 1952, II; The features of a desert community on 1953; III. The wadi bed ecosystem on 1954 and IV; The units of a desert ecosystem on 1965. Kassas has giving a concern about dry lands and desertification problems as one of the generally recognized global problems which translated in his efforts towards the classification of habitats in Egypt (Kassas 1999).

Vanderstraete *et al.* (2004) used the Remote Sensing (RS) techniques for mapping different bottom types occurring on the reef systems in the Red Sea. They calculated the 'Depth-invariant bottom indices' and form the basis for classification, besides the bottom type as an ecological classification, also a geomorphological classification is made. After contextual editing they developed an open-ended hierarchical classification scheme.

The challenge being faced for implementing any individual habitat classification approach is to develop the set of "habitat classes" that are appropriate and applicable for Egypt, then, if applicable, is to integrate these classes into a particular classification scheme. This integration step requires at least two critical decisions: The first is whether the scheme allows data aggregation within and between classification levels to meet the goals of users. The second is whether the classification scheme, if applied locally, needs to be integrated to a regional or national classification and mapping effort. These decisions will dictate which classification scheme is used and the structure of the resulting scheme for local application (Auster *et al.* 2009).

The habitat classification models presented in this work was derived from several sources (e.g., British Oceanographic Data Centre (BODC – NASA – FAO - Consortium for Spatial Information – WCMC – etc.). The main purpose of this paper is to: 1) present a suitable model for large scale planning to support the decision making process towards the natural resources in Egypt, 2) standardize data collection on habitats which will assist in management and conservation of the Egypt's natural heritage.

Results and discussion

The results of the mapping for the finest hierarchical level of habitats (classes) are shown in the following figures. A total of 5 main habitat systems, 12 habitat sub-system and 36 habitat classes were identified and described. Detailed analysis of the input GIS layer indicated that 4 habitat classes were described but not mapped because of their occurrences were too small to be mapped (Seasonal/Intermittent Freshwater Marshes/Pools – Oasis and springs – caves and karst – tidepole) at the 90 m spatial resolution used in this work.

This hierarchy represents a new standardized habitats scheming for Egypt. The 36 habitats mapped through this process represent 22 % of the total number of ecosystems (163) described for Africa in 2013 (Sayer *et al.* 2013). To convey a sense of the types, numbers, and distributions of habitats at the national context, Fig. 1 presents a map of the 5 main habitat systems, while Fig. 2 presents a map of the 12 habitat sub-systems and Fig. 3 presents a map of the 36 habitat classes.

As indicated in Additional file 1), the Desert habitat system represents the dominant habitat system in Egypt where it covers 868860.71 km^2 which represent 86.89 % of the total area of Egypt. The same table showed that the Fresh Water habitat system is considered the smallest habitat system in Egypt where it covers 7156.31 km^2 which represent 0.72 % of the total area of Egypt. In conclusion, the main 5 habitat systems in Egypt can be described in a decreasing order as follows: (1) Desert habitat system (868860.71 km^2 and 86.89 %); (2) Marine habitat system (269204.63 km^2); (3) Wetlands habitat system (70177.49 km^2 and 7.02 %); (4) Artificial habitat system (51938.97 km^2 and 5.19 %); and (5) Fresh Water habitat system (7156.31 km^2 and 0.72 %).

Additional file 1 showed that, the Plain Land habitat sub-system represents the dominant habitat sub-system in Egypt where it covers 480719.43 km^2 which represent 48.07 % of the total area of Egypt. The same table showed that the Islands habitat sub-system is considered the smallest habitat sub-system in Egypt where it covers 637.16 km^2. In conclusion, the main 12 habitat sub-systems in Egypt can be described in a decreasing order as follows: (1) Plain Land habitat sub-system (480719.43 km^2 and 48.07 %); (2) High Land habitat sub-system (333192.72 km^2 and 33.32 %); (3) Pelagic habitat sub-system (265154.63 km^2); (4) Marine habitat sub-system (61778.11 km^2 and 6.18 %); (5) Low Land habitat sub-system (54948.56 km^2 and 5.49 %); (6) Terrestrial habitat sub-system (41970.49 km^2 and 4.2 %); (7) Aquatic

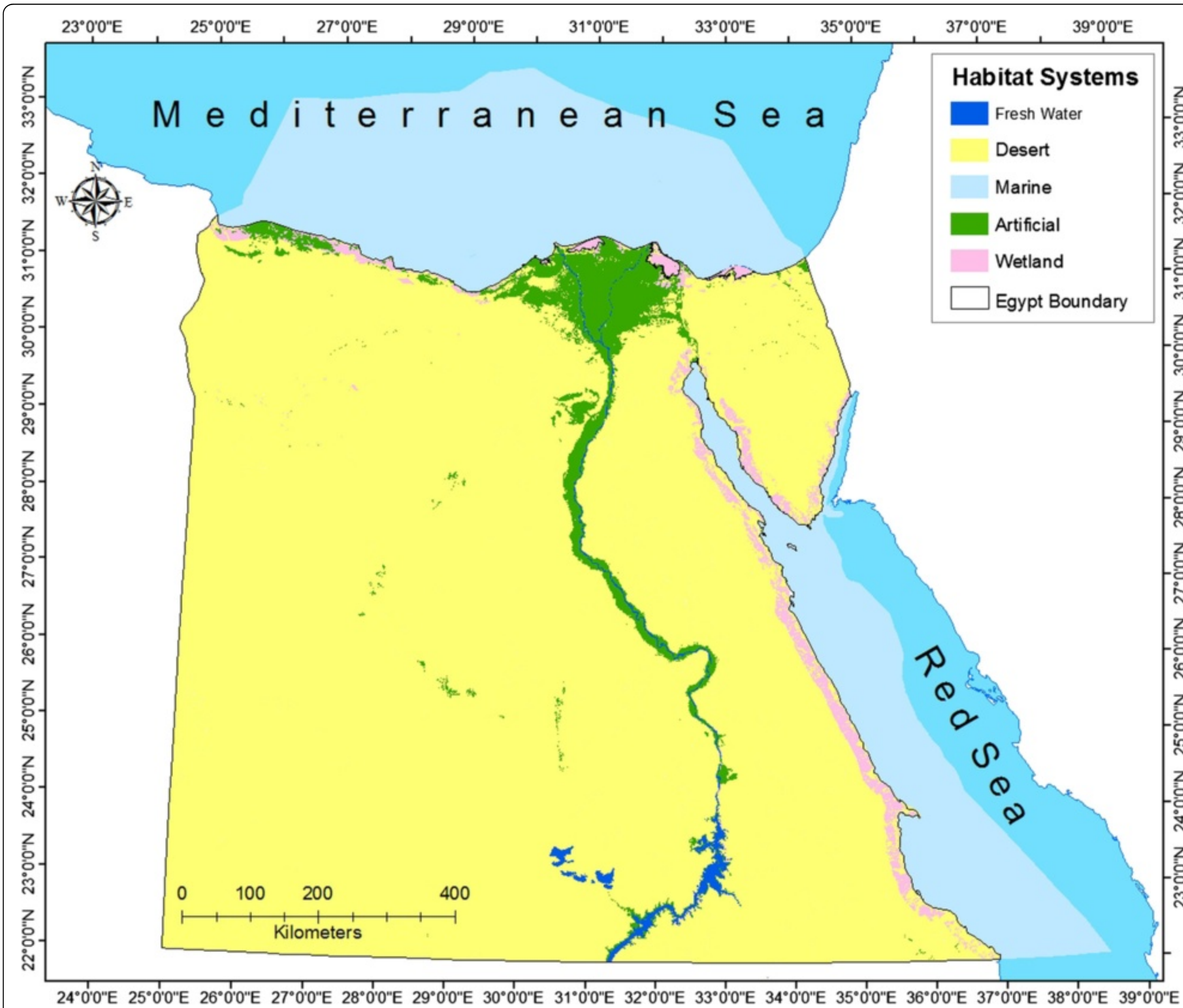

Fig. 1 Egyptian habitat Systems

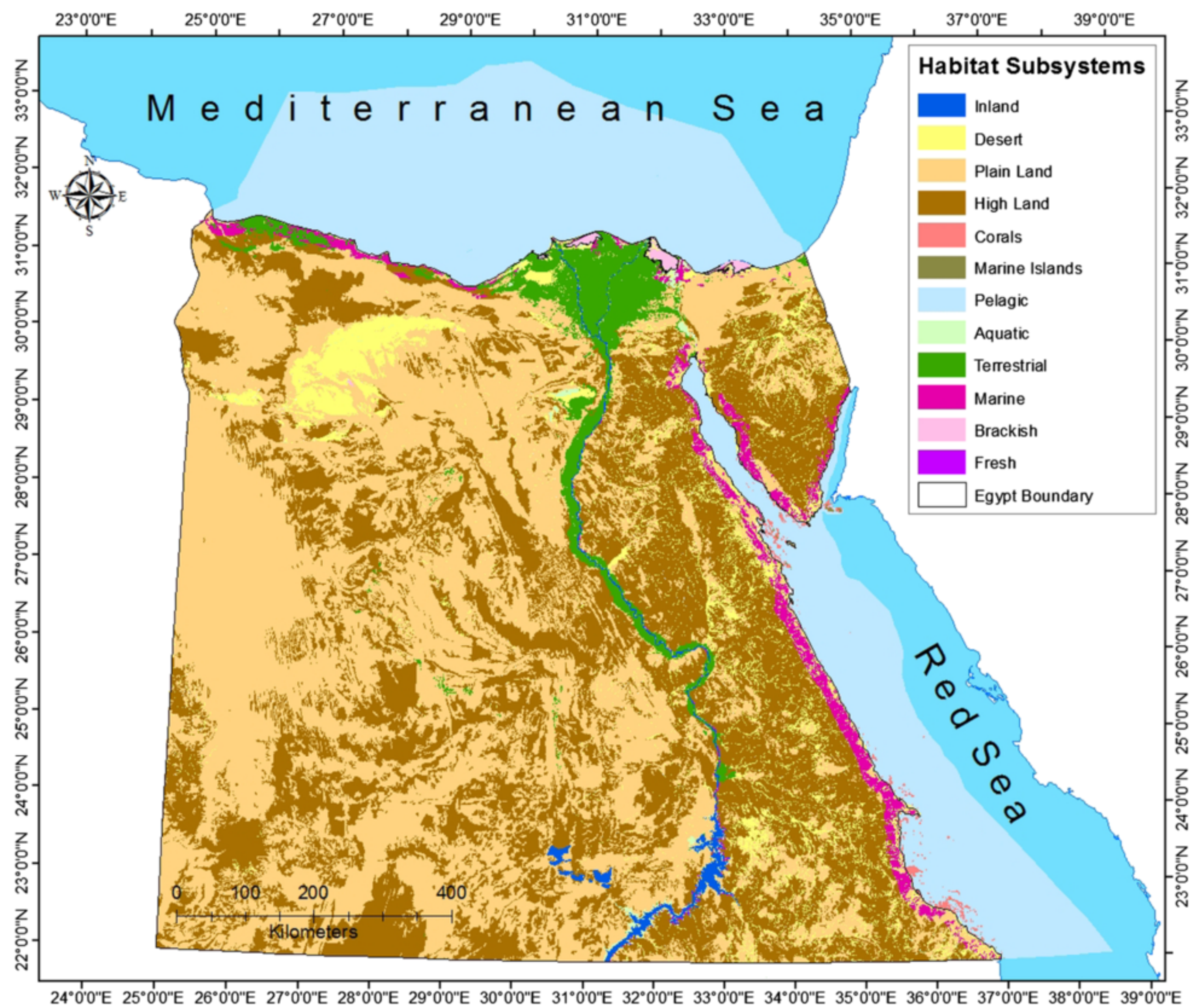

Fig. 2 Egyptian habitat Sub-systems

habitat sub-system (9968.48 km^2 and 1.0 %); (8) Inland habitat sub-system (7156.31 km^2 and 0.72 %); (9) Fresh habitat sub-system (4397.81 km^2 and 0.44 %); (10) Brackish habitat sub-system (4001.57 km^2 and 0.40 %); (11) Corals habitat sub-system (3412.84 km^2); and (12) Islands habitat sub-system (637.16 km^2).

Additional file 2 presents the 36 habitat classes where the Desert Sand Dunes, Sand Sheets and Sand Mounds habitat class represents the dominant habitat class (where it covers 254579.23 km^2 which represent 25.46 %) while the Mangrove Submerged Roots habitat class is considered the smallest habitat class (where it covers 2.44 km^2 which represent 0.001 %) of the total area of Egypt.

Conclusion

These habitats classification scheme and maps of the whole Egyptian territories represent the most interactive, most current and finest spatial characterization of the Egyptian habitats available today. It considers high level units (systems) of habitats that rarely considered in other habitats classification attempts as mentioned by Franklin (1993) and Noss (1996) and it avoids to classify habitats based only on vegetation types or/and species communities such the work done by Kirkpatrick & Brown (1994); Faith and Walker (1996a) and Kassas (1999). It was designed to support the current efforts to define the key biodiversity hotspots as well as long term planning of biodiversity (e.g., National Biodiversity Strategy & Action Plan – NBSAP) at the national level, rather than concentrate on species distribution or/and dynamics which agreed with what is concluded by Desmet et al. (1999) and Desmet *et al.* (1999). This effort will be the first step to develop approach for general habitat recording rather than as a basis for detailed study and evaluation and

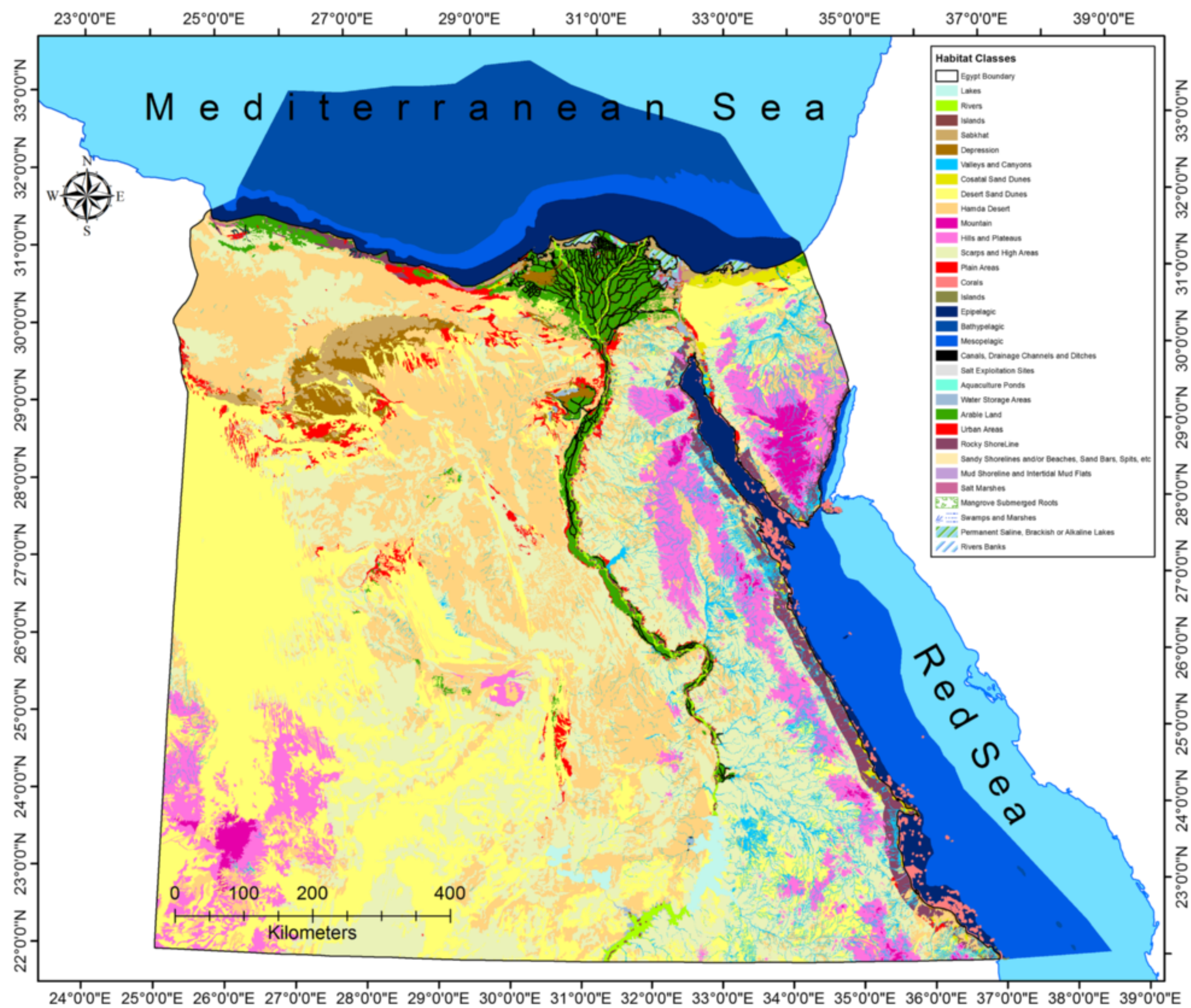

Fig. 3 Egyptian habitat Classes

it also could be the corner stone for a region-wide standardized habitat classification scheme in the Arab region and will serve as comprehensive basis to support the updating process of nature protection legislation.

During the development of this new scheme, the following considerations were taken into account: (1) Link physical processes to habitat distributions: where the scheme link historic and extent physical processes to distribution of habitats (e.g., coastal dunes to sand mounts habitat); (2) Unique and repeatable classification units at all levels: where each level of the classification scheme is unique and unambiguous to insure clear derivations of habitat type. (3) A clearly defined nomenclature: where nomenclature used in the classification scheme is exacting and clearly constrain the meaning of terms and an initial glossary of terms agreed upon and implemented by users; (4) accommodate diverse sources of data: where geospatial habitat data take many forms such as land cover and abundance data; satellite imaging; grain size and sediment type. It also robust and allow classification at many levels based on a diversity of data sources.

One of the major outputs of this present scheme is to define the boundaries of the three classes (epipelagic – mesopelagic – bathypelagic) of the pelagic sub-system. Where bathypelagic habitat class represents the dominant habitat in pelagic sub-system in both the Mediterranean Sea and Red Sea and it covers 115,066 km^2, which represent 43.05 % of the total area of the pelagic sub-system in both seas (Annex (5)). The same annex showed that the epipelagic habitat class represents the least dominant habitat in pelagic sub-system in both the Mediterranean Sea and Red Sea where it covers 32,270 km^2, which represent 20.45 % of the total area of the pelagic sub-system in both seas.

The new habitat mapping/scheming for Egypt, which developed in the present study, has considerable potential utility for conservation priority setting not only for the Ministry of Environment but also for other Egyptian authorities and institutes. This new habitat mapping/scheming could be used to design and update a set of new strategies and update the existing protected areas network in order to achieve the commitments toward international conventions. This mapping system may also be suitable to evaluate the protected areas system representativeness, climate change impacts studies which focus on the relationship between climate variability and ecosystem condition and distribution. The new habitat maps, developed in the current study, will act as a base for updating the national monitoring system and could help in logic interpretation of species assemblages for fauna and flora types in Egypt. These maps could be used in biodiversity assessment on a national scale.

Therefore, we recommend using such new habitats classification scheme for Egypt as the basis for defining habitats thresholds at the national level which will be further studied by the authors of this work at the national level. With the failure to meet 2010 targets for halting losses in biodiversity through conservation of rare and endangered habitats, the provision of biophysical maps of ecosystem services at the national level is regarded as a crucial step in setting new targets for biodiversity, which the findings from this work could assist. It is therefore important to consider how habitats scheming or classification might relate to the measurement of ecosystem services and their visualization in spatially explicit maps.

It is recommended to link habitat classification and mapping efforts in Egypt to regional and global approaches. It should be able to evaluate environmental problems at local scales (e.g., invasive species, fisheries, impacts of development) might benefit from the ability to link national to regional scale data. These "intermediate" products are useful for a variety of land planning and resource management applications apart from ecosystem delineation and conservation priority setting in Egypt and Aichi Targets.

Methods

In order to have an ideal habitat classification scheme for Egypt, specific characteristics were modified from those of Madden and Grossman (2004) Auster et al. (2009) as follow: (1) Setting geographical boundaries (the classification had geographical boundaries that are based on physical and biota community characteristics); (2) Exhibit a nested hierarchy (the classification scheme allows for geospatial data at lower/finer levels – classes - in the scheme to be easily aggregated into higher/coarser levels – systems).

Methodology is divided into two parts according to the point of view of the ecology/eco-regions and the GIS/RS: (1) regarding to the ecology/eco-regions where different aspects of the landscape (e.g., soil, geomorphology, land use, elevation, urban) is combined in order to introduce habitat classes of (Artificial, marine and wetland, fresh) systems; (2) regarding to the GIS/RS: there is a combination of input datasets produced based on a total of 53 unique gridcodes and identification codes for each grid cell. In addition vector polygons were created from contiguous raster cells with the same gridcode in a standard raster-to-polygon conversion, and these habitats were labeled to produce a total of 53 unique, mapped, multi-occurrence ecosystems for Egypt.

DEM were used by special equations in order to detect the habitat classes of the desert system (e.g., (DEM > =1000), (DEM > =500) AND (DEM < 1000) (DEM > =0) AND (DEM < 200)) to obtain Mountains, Hills and Plateaus and Plain Areas classes (Additional file 3). The labeling process, although intended to be automated, was complicated due to a strong many-to-one relationship between gridcodes and habitat types. The automated search for specific habitats based on their expected elevation, landform, geology, and land cover characteristics was confounded by habitats systems with multiple class values in the data input variables (e.g., the same habitat system could exist in elevation classes 0-500 m, and 500-1000 m). Gridcodes not assigned into a habitat class by the automated labeling procedure described above were therefore subsequently labeled in a manual, interpretive process which considered gridcode similarity (i.e., variation in class values in input variables), and in particular, similarity in land cover types.

The images used in this work have been downloaded from USGS using Earth Explorer and GLOVIS web applications. All image processing has been conducted using Intergraph ERDAS Imagine v. 2013 and ESRI ArcGIS v. 10.2 Software. All data are in shapefile or Geotiff format, in decimal degrees unit, WGS 84 Ellipsoid and WGS84 datum (Additional file 4).

Additional files

Additional file 1: Abbreviations and Areas of systems, sub-systems and classes of the habitats classification in Egypt (km^2).

Additional file 2: Unified standardized definitions for all habitat classes in the new developed classification scheme.

Additional file 3: Derived data sets of the habitat classification in Egypt.

Additional file 4: Data sets properties used in the habitat classification in Egypt.

Abbreviations

CBD: Convention on biological diversity; GIS: Geographic information system; BODC: British oceanographic data centre; DEM: Digital elevation model; EEAA: Egyptian environmental affairs Agency; EIONET: European environmental information observation network; ETC/NPB: European topic centre for nature protection and biodiversity; EUNIS: European nature information system; FAO: Food and agriculture organization; HCMs: Habitat classification models; IUCN: International union for conservation of nature; MESH: Mapping european seabed habitats; NASA: National aeronautics and space administration; NBSAP: National biodiversity strategy & action plan; NCS: Nature conservation sector; RS: Remote sensing; UK: United Kingdom; USGS: United States geological survey; WCMC: World conservation monitoring centre.

Competing interests
The author(s) declare that they have no competing interests.

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Authors' contributions
KH carried out the results and discussion, participated in the collection of data. MT carried out the paper title, abstract, literature review and initial revision. HF and MS, collect spatial data, produce the maps and process the GIS and remote sensing part. HF analyze the statistical part and develop charts. MS and KH develop the habitats classification hierarchy and carried out the final revision. All authors read and approve the final manuscripts.

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References
Auster PJ, Moore J, Heinonen K, Watling L (2005) A habitat classification scheme for seamount landscapes: assessing the functional role of deepwater corals as fish habitat. In: Freiwald A, Roberts JM (eds) Cold-water corals and ecosystems. Springer, Berlin Heidelberg, pp 761–769

Auster, P.J., K.B. Heinonen, C. Witharana and M. McKee. 2009. A habitat classification scheme for the Long Island Sound region. Long Island Sound Study Technical Report. EPA Long Island Sound Office, Stamford, Connecticut 06904. 83 p.

Barr, C.J., Bunce, R.G.H., Clarke, R.T., Fuller, R.M., Furse, M.T., Gillespie, M.K., Groom, G.B., Hallam, C.J., Hornung, M.J., Howard, D.C. & Ness, M.J. (1993). Countryside survey 1990 Main report London, Department of the Environment. (Countryside 1990 Series volume 2).

Bouma, H., de Jong, D.G., Twisk, F. & Wolfstein, K. 2005. A Dutch Ecotope System for Coastal Waters (ZES.1) To map the potential occurrence of ecological communities in Dutch coastal and transitional waters. RIZK 2005.024. English version: June 2006.

Connor, D.W., Brazier, D.P., Hill, T.O. & Northen, K.O. 1997a. Marine Nature Conservation Review: marine biotope classification for Britain and Ireland. Volume 1. Littoral biotopes. Version 97.06. JNCC Report No. 229. Joint Nature Conservation Committee, Peterborough.

Connor, D.W., Allen, J.H., Golding, N., Howell, K.L. Lieberknecht, L.M., Northen, K.O. & Reker, J.B. 2004. The Marine Habitat Classification for Britain and Ireland. Version 04.05 (internet version: www.jncc.gov.uk/MarineHabitatClassification). Joint Nature Conservation Committee, Peterborough.

Dauvin JC, Bellan G, Bellan-Santini D, Castric A, Comolet-Tirman J, Francour F, Gentil F, Girard A, Gofas S, Mahé C, Noël P, de Reviers B (1994) Typologie des Znieff-Mer, Liste des paramètres et des biocénoses de côtes françaises metropolitaines. 2ème édition. Museum National d'Histoire Naturelle, Paris, 64 p

Davies CE and Moss D. 1998. EUNIS Habitat Classification. Final Report to the European Topic Centre on Nature Conservation, European Environment Agency, with further revisions to marine habitats.

Davies, C.E. & Moss, D. 1999. EUNIS Habitat Classification. Final Report to the European Topic Centre on Nature Conservation, European Environment Agency.

Davies CE, Moss D (2002) EUNIS habitat classification, february 2002. European topic centre on nature protection and. Biodiversity, Paris

Davies, C.E. & Moss, D. 2004. EUNIS Habitat Classification. Marine Habitat Types: Proposals for Revised Criteria, July 2004. Report to the European Topic Centre on Nature Protection and Biodiversity, European Environment Agency. 22.

Desmet PG, Barret T, Cowling RM, Ellis AG, Heijnis CLE, Roux A, Lombard AT, Pressey RL (1999) A systematic plan for a protected area system in the Knersvlakte region of Namaqualand. Institute for Plant Conservation Report 9901, University of Cape Town

Dethier MN (1992) Classifying marine and estuarine natural communities: an alternative to the Cowardin system. Natural Areas Journal 12:90–100

Duigan C, Kovach W, Palmer M (2006) Vegetation communities of British lakes: a revised classification. Report Joint Nature Conservation Committee, Peterborough

EEA 2008. EUNIS habitat classification–a guide for users Dorian Moss, 2008 EUROPEAN TOPIC CENTRE ON BIOLOGICAL DIVERSITY. http://biodiversity.eionet.europa.eu

Faith DP (1994) Genetic diversity and taxonomic priorities for conservation. Biol Conserv 68:69–74

Faith DP, Walker PA (1996) Environmental diversity: on the best-possible use of surrogate data for assessing the relative biodiversity of sets of areas. Biodivers Conserv 5:399–415

Franklin JF (1993) Preserving biodiversity: species, ecosystems, or landscapes? Ecol Appl 3:202–205

Greene HG, Yoklavich MM, Starr RM, O'Connell VM, Wakefield WW, Sullivan DE, McRea JE Jr, Caillet GM (1999) A classification scheme for deep seafloor habitats. Oceanol Acta 22:663–678

Holmes NTH, Boon PJ, Rowell TA (1999) Vegetation communities of British rivers – a revised classification. Report Joint Nature Conservation Committee, Peterborough

Jacob Gibson, Gretchen Moisen, Tracey Frescino, Thomas C. Edwards. 2013. Using Publicly Available Forest Inventory Data in Climate-Based Models of Tree Species Distribution: Examining Effects of True Versus Altered Location Coordinates. Ecosystems. Online publication date: 4-Sep-2013. HABITAT CLASSIFICATION MODELING WITH INCOMPLETE DATA: PUSHING THE HABITAT ENVELOPE. Phoebe L. Zarnetske, Thomas C. Edwards Jr., and Gretchen G. Moisen. http://www.esajournals.org/doi/abs/10.1890/06-1312.1.

Kassas M (1999) Rescuing drylands: A project of the world. Futures 31:949–958

Kirkpatrick JB, Brown MJ (1994) A comparison of direct and environmental domain approaches to planning reservation of forest higher plant communities and species in Tasmania. - Conservation biology., p 8

Madden, C.J. and D.H. Grossman 2004. A Framework for a Coastal/Marine Ecological Classification Standard. NatureServe, Arlington, VA. Prepared for the National Oceanic and Atmospheric Administration, Under Contract EA-133C-03-SE-0275.

NOSS RF (1996) Ecosystems as conservation targets. Trends in Ecology and Evolution 11:351

Pérès JM, Picard J (1964) Nouveau manuel de bionomie benthique de la Méditerranée. Rec Trav Stat Mar Endoume 31(47):1–37

Rodwell, J. et al., 2013. Red List Assessment of European Habitat Types - A feasibility study John Rodwell, John Janssen, Susan Gubbay, Joop Schaminée April 2013. study was undertaken in the frame of the Service Contract No. 070307/2012/624047/SER/B3 with the European Commission, DG Environment.

Sayer J, Sunderland T, Ghazoul J, Pfund J-L, Sheil D, Meijaard E, Venter M, Boedhihartono AK, Day M, Garcia C (2013) Ten principles for a landscape approach to reconciling agriculture, conservation, and other competing land uses. Proc Natl Acad Sci 110:8349–8356

UK Biodiversity Steering Group (1995) Biodiversity: The UK Steering Group Report, Volume 1: Meeting the Rio challenge. HMSO, London

Valentine PC, Todd BJ, Kostylev V (2005) Classification of marine sublittoral habitats, with application to the northeastern North America region. Am Fish Soc Symp 41:183–200

Vanderstraete T, R Goossens & T K Ghabour, 2004. Coral Reef Habitat Mapping in The Red Sea (Hurghada, Egypt) Based On Remote Sensing. EARSeL eProceedings 3, pp. 191-207.

Vane-wright RI, Humphreys CJ, Williams CJ (1991) What to protect? Systematics and the agony of choice. Biol Conserv 55:235–254