Web-based biodiversity geodatabases for environmental assessment in mid-income Namibia

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Abstract

Geodatabases on the web containing biodiversity geodata of Namibia were identified and examined for applicability in Environmental Assessment (EA). A number of such databases of terrestrial organisms were identified. These were hosted and populated by civic organisations, quangos or academia, never by government authorities. The format of this geodata was found to be unsuitable for direct use in EA. Additional biodiversity geodata that are known to exist, e.g. protected area boundaries and inventories of marine organisms, were not accessible through the web. Models are proposed for the upgrade of existing geodatabases to technical and financial fitness for EA purposes as well as for funding and populating of additional relevant biodiversity geodatabases.

Introduction

Biodiversity data requirements for Environmental Assessment (EA) depend on the national statutory context. Legislation may protect *inter alia*, listed species in situ (protected; red-listed), listed habitats as in the European Union Habitat Directive (e.g. Overijssel 2015) and protected areas (National Parks; Reserves; Ramsar sites; corridors/networks). These categories of protection may overlap to various extents. In Namibia, maintenance of biodiversity is stipulated in the constitution. However, only the protected and huntable game species are explicitly protected by current national law, directly and through protected areas, since the latter mostly originate in Game Reserves. Fortunately, the constitution provides for international agreements to be the law of the land in the absence of adequate national legislation. Therefore, the Convention on Biological Diversity (CBD), the African Convention on the Conservation of Nature and Natural Resources and the Ramsar Convention are *de jure* national law. Article 14 of the CBD requires Environmental Impact Assessment (EIA) for projects that are likely to have a significant adverse effect on biological diversity. Further, the African Convention prescribes signatories to "…undertake inventories of species of fauna and flora and prepare maps of their distribution and abundance".

Digital spatial data, also known as geodata, are generated in two fundamentally different formats, i.e. raster or vector. Vector format is the standard in land parcel registries (aka cadastres) as well as in construction drawings and land use zoning. Therefore, compatibility and efficiency requires the biodiversity geodata to match the spatial format of parcel registries, project plans and land use zoning. Additional compatibility issues may arise when physical and anthropogenic geodata layers are overlaid with biodiversity data. Spatially-specific data of plant and animal species are often systematically recorded over long periods. The recording institutions include Multi-lateral Agencies (e.g. IUCN 2015), national government (e.g. Botswana wildlife census), subnational government (e.g. Overijssel 2015), quangos (government funded research institutes; e.g. Loots 2005) and/or civic organisations. Among the latter are associations of birders, botanists, and herpetologist. However, access to such data for EA appears problematic across high to middle income countries (Bidstrup & Hansen 2014; Briggs & Hudson 2013; Gonzales et al. 2011; Smith et al. 2014).

Namibia is a mid-income country with a significant and expanding mining industry (diamond; uranium; base minerals). More than half of the diamonds mined in Namibia are dredged off-shore. Further, Namibia's Exclusive Economic Zone (EEZ) in the Atlantic Ocean contains proven reserves of phosphate and natural gas. Exploration for further hydrocarbons is in progress. In addition, Walvis Bay port is an international logistic hub, with road and rail spokes to the neighbouring land-locked countries. The port is also the industrial heart of the country. Second in economic importance are industrial marine fisheries including aquaculture. The third largest economic sector in Namibia, tourism, has its resort hotspot in the coastal town of Swakopmund. Tourism is largely nature-based. Consequently, the maintenance of biodiversity is an economic imperative. Due to aridity, crop and livestock farming is relatively insignificant in terms of Gross National Product. Consequently, findings from Namibia may apply to other mid-income economies, especially natural resource-based ones.

We identify the suitability of the current geodatabases for timely provision of biodiversity data for EA in the mid-income country Namibia. Timeliness is essential as EA process steps have to be completed by law within short periods that is weeks rather than months. The mid-income income level implies a reasonable IT infrastructure and a critical mass of substantive investment projects requiring EA to make geodatabases of biodiversity relevant. Based on our findings on suitability, we recommended the way forward for better customized geodatabases on all relevant biodiversity categories.

Methods

An inventory was made during January/February 2015 of web-based geodatabases containing biodiversity data. The following database features were gathered: biodiversity category, spatial format (vector versus raster), output format (digital versus analogue), spatial resolution (grid size), coordinate system (geographical versus projected), completeness of data, website host and type of hosting institution. The geodatabases features are matched with input data requirements of EAs, both EIA and Strategic Environmental Assessment (SEA). Mismatches may be identified and discussed, and a way forward recommended.

Results and discussion

We identified six online geodatabases containing terrestrial biodiversity data that are potentially instrumental in EA (Table 1). Five of these geodatabases contain primary occurrence data of larger organisms (tree, bird, carnivore/mammal, grass, red-listed plant). The University of Cologne geodatabase (2015) provides secondary biodiversity information derived from unpublished species presence data: plant diversity; gemsbok density; 'important' plant species. Comprehensive geodatabases of marine organisms, protected areas or habitats could not be traced on the web. None of the online geodatabases contains all the features required for fast tracking of biodiversity data in EA (Table 1). The Tree (Curtis & Mannheimer 2005) and Bird (SABAP2 2015) Atlases appear to be the most suitable as their species inventory is comprehensive and their digital output format suitable. However, their geographic coordinate system (latitude/longitude in degrees) is unsuitable, especially for EIA. Data with geographical coordinates cannot be directly overlaid in a Geographic Information System (GIS) over topographic or other projected maps; neither can distances nor surface areas be calculated without transformation of coordinates. The carnivore, herbivores, grass and red-list plant geodatabases are all incomplete, in unsuitable output formats, and with unsuitable coordinate systems for EA and/or coarse resolutions (Table 1). The spatially incomplete species inventories would need to be modelled before becoming useful in EIA (Angelieri & de Souza 2012; Gils et al. 2014).The remaining geodatabase (University of Cologne) represent selected, aggregated information of unknown provenance that are therefore currently unsuitable for EA on account of

several features (Table 1). None of the identified geodatabases matches the vector format, spatial resolution, output format and/or comprehensiveness requirements of EA. Probably as a consequence of these technical and/or content hurdles, none of the biodiversity geodatabases was referenced in the reviewed EA reports during 2014 (Gils 2015). All EAs either inventoried biodiversity *de novo* at considerable costs in time and money, or reverted to spatially undefined generalisations of doubtful applicability. The latter compromises the commitments of the CBD.

Table 1. Online terrestrial biodiversity geodatabases for Namibia

Biodiversity category	Spatial format	Output format	Species all	Host*	Institution
Tree	15' grid**	shp/csv	yes	NBRI	quango
Bird	05/15' grid	csv	yes	ADU/SANBI/Birdlife	university/quango/civic
Carnivore	15' grid	analogue	yes	EIS/NNF	civic
Mammal	15' grid	analogue	yes	EISNNF	civic
Grass	30' grid/16 point	analogue	yes	Natural person***	civic (quango)
Red-list plant	30' grid/16 point	analogue	no	NBRI	quango
Plant diversity	polygon	shp	no	Uni. of Cologne	university
Important plant	polygon or point	shp	demo	Uni. of Cologne	university
Gemsbok km^{-2}	polygon	shp	demo	Uni. of Cologne	university

* See Table 2 for acronyms;** '= geographical minute; Klaassen & Craven 2003

Table 2. Institutions hosting terrestrial biodiversity geodatabases on Namibia

Institution	Website of the geodatabase
NBRI = National Botanical Research Institute	www.nbri.org.na/projects/tree-atlas
ADU = Animal Demography Unit, University of Cape Town; South Africa	sabap2.adu.org.za
EIS/NNF = Environmental Information Service/Namibian Nature Foundation	www.the-eis.com/atlas_outputs
Natural person	www.researchgate.net
University of Cologne; Germany	www.uni-koeln.de/sfb389

Namibia is a marine country from an economic, biodiversity (e.g. seals, penguins, whales, dolphins) as well as from an ecosystem (Benguela) perspective. Inventories are known to exist (e.g. seals; commercial fish species; seabed fauna), however online geodatabases of these marine organisms could not be traced. This paradox needs explanation. The Namibian coastline is a harsh contact between the Atlantic and the Namib Desert, hostile to human habitation by the absence of permanent rivers, fresh water springs and natural harbours over large stretches. Ominously, "Skeleton" coast refers to human remains. Not even artisanal coastal fisheries could be practised, contrary to Angola in the north and South Africa. Consequently, an indigenous seaborne nation could not develop in Namibia prior to industrial borehole and water reticulation technology. Marine mining, fisheries and shipping were therefore foreign forays with little indigenous knowledge of marine biodiversity.

The freshwater biodiversity browser, in short Bio Browser (IUCN 2015), provides online analogue polygon maps of fishes, molluscs, dragonflies, crabs and aquatic plants. The spatial unit of measure is the river basin and the map scale equivalent to 1:1m. Species occurrences are point observations or, if unavailable, inferred per river basin by expert consultation.

The terrestrial species-presence geodatabases (Table 1: tree, bird, carnivore and herbivore) are built by conversion of point observation records (off-line) into a raster, published on the web. The underlying primary records and attribute table containing point coordinates and other source data (e.g. calendar date) would be instrumental in EA, but are not included in the online geodatabase. The secondary raster geodata are suitable for SEA, but for EIA a finer resolution and

vector data are required. In one test case (EIS 2015), the off-line attribute table and point data were supplied on request within a reasonable period for research purposes, but not fast enough for the legal deadlines applicable to EA. In other test cases, the underlying geodata were not provided on request, but instead reference was made to lengthy administrative procedures in effect prohibiting using the geodata in EA. The underlying point data of the compound biodiversity categories in the University of Cologne geodatabase are undocumented. Moreover, the projection file is lacking from the shapefiles (Table 1), requiring time and cost for re-projection. Often EA-Practitioners in Namibia lack the GIS expertise and software for re-projection.

The species occurrence data were collected in half of the cases (tree, bird, carnivore/mammal in Table 1) by citizen scientists, representing crowd sourcing *avant la lettre*. These three Namibian geodatabases were designed, built and populated by experts sponsored by foreign donors. The Tree Atlas is maintained by a quango, whereas the carnivore plus mammal geodatabases are a project within the Environmental Information System (EIS 2015), hosted by a not-for-profit foundation (civic institution). The Bird Atlas of Southern Africa, including Namibia (SABAP2 2015) is hosted by the University of Cape Town (UCT), supported by SANBI (quango) whereas the geodata are provided and quality controlled by BirdLife South Africa (civic organisation). The set of compound geodata at the website of the University of Cologne is a selection and edited version of geodata-layers also available at the EIS website and originating in a foreign sponsored Atlas of Namibia project (Mendelsohn et al. 2002). Originally, these Atlas geodata were also downloadable from a national government website. None of the biodiversity geodatabases is held by national line ministries or agencies such as environmental, coastal, wildlife or park authorities, although these capture and store significant amounts of pertinent biodiversity data. We could not locate any biodiversity database at regional or local government level in Namibia, although these are standard in high income countries (e.g. Overijssel 2015).

Recommendations

The organised private sector companies (e.g. chamber of mines) could take the lead by voluntarily submitting biodiversity data obtained in their EAs to independent geodatabases. The larger firms in mining and parastatals (NamPower; NamWater; NamPort) could do the same. Further, a contract clause for research projects and EAs to submit the captured biodiversity data in a prescribed digital format (vector; projection) to an independent geodatabase at project completion is suggested. The flip side of the coin could be a standard budget-line in EA contracts to purchase the relevant biodiversity information generated by the independent geodatabase institutions.

The online Tree and Bird geodatabases could be optimized for EA purposes by online provision of their underlying species occurrence point data in suitable projections and with the attribute table, probably at a price. Further, incomplete point data sets could be extrapolated and/or spatially modelled in a vector format suitable for EA. The carnivore/mammal and red-list geodatabases may be technically and institutionally remodelled on the bird and tree example. The biodiversity component of University of Cologne geodatabase may be seen as a demo of the type derived, secondary biodiversity information that may be generated from the primary data in the geodatabases.

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