ECOCYCLES
ISSN 2416-2140

OPEN ACCESS
Scientific journal of the
European Ecocycles Society

Ecocycles, Vol. 6, No. 2, pp. 19-24 (2020)
DOI: 10.19040/ecocycles.v6i2.173

OPINION

Human geography of drylands. I. Planning the database: Physical, built-up, chemical, biological (ecological), and social indicators

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Abstract – We propose a method based on multilayered mapping for investigating the current problems of people who live in drylands and we urge decision-makers to support such studies to establish the foundations for future decisive and preventive actions. This paper contains an expandable compilation of the environmental indicators (mostly mappable) that may influence the human geography of a certain region. We believe that this geospatial approach may help to resolve convoluted physical, chemical, and social relationships and, at the same time, generate a valuable database for further research. The application of the concept, if successful, will give directions to tackle certain contemporary problems in drylands and predict future ones caused by global climate change.

Keywords – drylands, human geography, database, GIS, geoinformation, geodata, multilayered mapping, social sciences

Received: July 24, 2020 Accepted: October 5, 2020

...the least initial deviation from the truth is multiplied later a thousandfold.

Aristotle, 350 BC

INTRODUCTION

The rapid development of the geographic information system (GIS) during the last quarter of a century has led to a diversity of uses in data visualization and analysis and paved the method's way for a wide range of scientific disciplines, including agriculture (Gaborjanyi et al., 2003), geology, environmental science (Healy and Walshe, 2019), and most recently in social sciences (Ballas et al., 2017; Carter 2019; Lechner et al., 2019). Thus, human geography (also called anthropogeography) studies investigate political-economic, cultural-social, and human-environment relations by using the multilayered mapping feature of GIS to resolve convoluted social relationships and, at the same time, generate valuable databases for further research (Li et al., 2019). The most important benefit of the method is that it can visualize a vast variety of data. From the maps, valuable information can be extracted and used in feasibility studies or to achieve better-informed decisions (Ballas et al., 2017).

In this paper, we outline a concept of a) using multilayered mapping for studying current, day-to-day existential problems of people who live in drylands and b) present an expandable compilation of the environmental indicators (mostly mappable) that may influence the human geography of a dryland region. The application of the concept, if successful, will give directions to tackle certain contemporary problems and predict future ones caused by global climate change in drylands.

DRYLANDS

Approximately one-fifth of the total surface area of the Earth is defined as habitable by humans (Cervigni and Morris, 2016). Human habitats are conditions in which people live. Besides, to be accessible, a human habitat needs to be able to provide shelter, uncontaminated water, clean energy, unpolluted environment, and an adequate amount of nutritious food. Furthermore, the habitat should not be vulnerable to climate or other natural or human hazards (Filho et al., 2018).

Dryland type human habitats are specific areas defined by a scarcity of water. The United Nations Environment Program defines drylands as tropical and temperate areas characterized with an aridity index (AI, the ratio of the annual precipitation and potential evapotranspiration totals) less than 0.65 (Plaza et al., 2018).

All dryland countries, although widely different in many respect (resources, opportunities, etc.), need to address continuously problems related to the variability (and possible further changes) in the climate that influence the countries' viability and may lead to social turbulence. COST Action CA16233 of the European Union has been initiated to improve the coordination of drylands research between scientific disciplines and different geographical areas. (Anon., 2019).

To carry out a human geography project the following tasks need to be executed:
a) database design: selection of indicators for multilayered mapping
b) data collection
c) data processing, analysis, and interpretation
d) proposals for tackling the current key problems of the study area and forecasting future ones
e) action, followed by monitoring and reflection.

DESIGN OF THE DATABASE

Selection of indicators

We propose, for consideration, the indicators listed in Tables 1-12 as possible attributes (preferably in time-course format) for building a geoinformation database on drylands.

Naturally, except for the general indicators in Table 1, during the construction of the database, all Tables 2 to 12 would be united into a single table of attributes. Our list of indicators in the Tables, although it covers a wide range of environmental factors (physical, chemical, biological, and social) is not intended to be complete: criticism, additions, and corrections are welcome.

Indicator redundancy and identifiability

The number of indicators included in this paper may be considered unnecessarily extensive. Besides, several of the indicators listed in the Tables do not have yet established, widely-accepted scientific definitions, and quantifiable measures and units. Pilot investigations need to address the complex problems of indicator redundancy and identifiability using well-established complex mathematical models (Little et al., 2010).

For practical reasons, a pilot study may use a very narrow set of dryland-specific indicators and a composite indicator that characterizes the human carrying capacity of the region studied.

Table 1. General information on the country studied

	Indicator	**D / U ***
1	Area	km^2
2	Drylands area	km^2
3	Water area	km^2
4	Gross domestic product per capita	USD
5	Gross national product per capita	USD
6	National debt	percent GDP
7	Inflation rate	percent
8	Population size	number
9	Human development index	normalized
10	5-year average growth of GDP	percent
11	Level of urbanization	3 categories
12	Proportion of science expenditure	percent
13	Proportion of education expenditure	percent
14	Proportion of welfare expenditure	percent

* Dimension / unit

Table 2. Physical and natural environment: resources and hazards [mappable data]

	Indicator	**D / U ***
1	Average yearly temperature	°C
2	Average monthly temperature	°C
3	Sunshine duration	h/year
4	Relative humidity	percent
5	Precipitation (yearly)	mm
6	Precipitation (monthly)	mm
7	Volume of collected precipitation	km^3
8	Aridity Index	composite
9	Number of reservoirs	number
10	Reservoir capacity	km^3
11	Irrigated area	km^2
12	Total water consumption	km^3
13	Residential water consumption	km^3
14	Disasters: crop area affected	km^2
15	Disasters: size of affected population	percent
16	Disasters: economic losses	per centGDP
17	Flooding hazard	composite
18	Land area of the admin. district	km^2
19	Arable land	km^2
20	Soil texture	composite
21	Soil coarse fragments	composite
22	Soil depth	m
23	Soil drainage	5 classes
24	Soil available water capacity	liter/m^3
25	Soil sodicity	composite
26	Soil salinity	dS/m
27	Soil pH	number
28	Soil organic matter content	percent
29	Soil cation exchange capacity	composite

30	Soil calcium carbonate content	percent
31	Slope	percent
32	Erosion	tons/hectare
33	Terrain (elevation, slope, shelter)	composite
34	Seismic (earthquake) hazard	composite
35	Volcanic activity hazard	composite
36	Sandstorm hazard	composite
37	Green areas in cities	km^2
38	Crops: total area	km^2
39	Forest area	km^2
40	Edible wild plants	Y/N
41	Edible wild animals	Y/N
42	Predator hazard	composite
43	Poisonous plant and animal hazard	composite
44	Vectors of diseases	composite
45	Emerging invasive species	composite

* Dimension / unit

Table 3. Built environment [mappable data]

	Indicator	D / U *
1	Built-up area	km^2
2	Sewage system	percent
3	Internet	Y/N
4	Public lighting	Y/N
5	Transport: rural access index	composite
6	Transport: internatl. roughness index	composite
7	Public transportation	Y/N
8	Museums	number
9	Theatres	number
10	Film theatres	number
11	Concert halls	number
12	Schools	number
13	Hospitals	number

* Dimension / unit

Table 4. Environment: extent of pollution [mappable data]

	Indicator	D / U *
1	Pollution management projects	USD
2	Environmental infrastructure projects	USD
3	Utilized waste products	percent
4	Waste water managed	percent
5	Industrial sulfur dioxide emission managed	percent
6	Industrial soot emission managed	percent
7	Air pollution managed	percent
8	Water pollution managed	percent

* Dimension / unit

Table 5. Social environment: population [mappable data]

	Indicator	D / U *
1	Population tree	image
2	Average age	number
3	Aged below 35 y	percent
4	Aged below 15 y	percent
5	Density	people km^{-2}
6	Sociodynamics	composite
7	Fertility rate	number

* Dimension / unit

Table 6. Social environment: community problems [mappable data]

	Indicator	D / U *
1	Illegal drug use	composite
2	Alcohol use	composite
3	Crime	composite
4	Youth violence	composite
5	Child abuse	composite
6	Discrimination (minority issues)	composite
7	Availability of recreational activities	composite
8	Racism	composite
9	Homelessness	composite
10	Poverty	composite
11	Smoking status	composite
12	Obesity	composite
13	Malnutrition	composite
14	Housing: renters	percent
15	Housing: single-family dwellings	percent

* Dimension / unit

Table 7. Social environment: economy [mappable data]

	Indicator	D / U *
1	Average income	USD
2	Availability of food	composite
3	Extractable geological materials	composite
4	Tourism: guest nights	number
5	Tourism: proportion of local GDP	percent
6	Annual electricity consumption	GW
7	Residential electricity consumption	GW
8	Liquefied petroleum gas consumption	m^3

* Dimension / unit

Table 8. Social environment: healthcare [mappable data]

	Indicator	D / U *
1	Health care in GDP	percent
2	Life expectancy index	composite
3	Mental health	composite
4	Availability of hospitals	composite
5	Availability of local doctors	composite
6	Infectious disease hazard	composite

* Dimension / unit

Table 9. Social environment: education [mappable data]

	Indicator	D / U *
1	Mean years of schooling index	number
2	Expected years of schooling index	composite
3	Education index	composite

4	Illiteracy	percent
5	Availability of adult education	composite

* Dimension / unit

Table 10. Social environment: culture [mappable data]

	Indicator	**D / U ***
1	Arts (performing, visual)	composite
2	Education (primary, secondary, tertiary)	composite
3	Literature	composite
4	Gastronomy	composite
5	Architecture	composite
6	Politics	composite
7	Clothing	composite
8	Entertainment	composite
9	Sports	composite
10	Traditions	composite
11	Mass media	composite
12	Religion	composite

* Dimension / unit

Table 11. Social environment: creativity [mappable data]

	Indicator	**D / U ***
1	Human capital index	composite
2	Creative class index	composite
3	Scientific talent index	composite
4	Innovation index	composite
5	R&D index	composite
6	Global social tolerance index	composite

* Dimension / unit

Table 12. Social environment: security [mappable data]

	Indicator	**D / U ***
1	Unemployment	percent
2	Language skills	composite
3	Inequality (Gini coefficient)	composite
4	Work ethics	composite
5	Opportunities for youth	composite
6	Social structure	composite
7	Social net	composite
8	Social care	composite
9	Democracy level	composite
10	Mobility	composite
11	Migration	composite
12	Wealth distribution	composite
13	Family structure	composite
14	Leisure	composite
15	Crime and public safety	composite

* Dimension / unit

DATA COLLECTION

Building a database of this scale is a tremendous task, that can be achieved only through a very large amount of human effort: collecting and sifting through existing quantitative and qualitative data, evaluating existing written and digital records from libraries and satellite images.

On a positive note, artificial intelligence can be used to monitor and analyze social media with automation, improved accuracy, and reduced input of human labor (Perakakis et al., 2019). Furthermore, in addition to professionals (e.g., teachers and researchers), volunteers, activists, and the general public may provide unprecedented contributions *via* social media and citizen science (Roy et al., 2018).

DATA PROCESSING, ANALYSIS, AND INTERPRETATION

Several goals may be considered when evaluating the data. For example,
a) evaluation of resource and environmental carrying capacity (Li, 2019) (Bao et al., 2020)
b) multi-criteria analysis of land suitability (Niles et al., 2015)
c) factors limiting adaptation (Nguyen et al., 2015)
d) community health, population and environment, neighborhood effects, land use, fertility, migration (Logan et al., 2010)
e) population dynamics (Organ, 2019)
f) ecological risk assessment using fuzzy analytical hierarchy process (Radionovs and Užga-Rebrovs, 2016)
g) multi-criteria decision analysis (Vaissi and Sharifi, 2019)
h) local and regional vulnerability assessment (Polese et al., 2020).

CONCLUDING REMARKS

This paper contains an expandable compilation of environmental indicators (mostly mappable) that may influence the human geography of a certain region. We believe that a geospatial approach may help to resolve convoluted physical, chemical, and social relationships and, at the same time, generate a valuable database for further research. The application of the concept, if successful, will give directions to tackle certain contemporary problems and predict future ones caused by global climate change.

ACKNOWLEDGMENTS

The authors gratefully acknowledge the contribution of COST Action CA 16233 and helpful discussions with Dr. Peter Pal Toth (Demography Institute, Hungarian Central Statistical Office) and Dr. Tamas Hermann (Pannon University, Keszthely).

PUBLIC INTEREST STATEMENT

The purpose of the paper was to outline a concept based on the application of multilayered mapping for investigating contemporary problems of inhabitants of drylands. It presents an expandable compilation of a large number of environmental indicators (mostly mappable) that may influence the human geography of a dryland territory. We conclude that the technique of multilayered mapping may help scientists and decision-makers in resolving convoluted physical, chemical, and social relationships and, at the same time, generate a valuable database for further research. Besides, the concept may provide guidance to tackle current dryland-related problems and forecast ones caused by global climate change.

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