



Global Geo-informatics Options by Context (GeOC) Tool for Supporting Better Targeting and Scaling-out of Sustainable Land Management: Designing the System and Use Cases

By
Quang Bao Le
Richard Thomas
Enrico Bonaiuti

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AUTHORS:

Quang Bao Le¹, Thomas Richard¹, Enrico Bonaiuti¹

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¹ CGIAR Research Program on Dryland Systems (CRP-DS) and International Center for Agricultural Research in Dry Areas (ICARDA)

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Abstract

Sustainable Land Management (SLM) are required to achieve Land Degradation Neutrality (LDN). SLM options are fitted to the social, economic and ecological contexts. The high contextual diversity of drylands in particular prevents the design and application of “uniform blanket” policies to promote SLM over large scales where significant impact is expected. To address this challenge the CGIAR Research Program on Dryland Systems (CRP-DS) has initiated a web-based geoinformatic tool for overviewing, comparative assessing and co-learning SLM options fitted to the social-ecological context at global, regional and national scales. This Global Geo-informatic Options by Context (GeOC) tool aims to support the implementation of SLM practices by the local and international communities and to help countries report on their commitments to achieving LDN via the UNCCD and Sustainable Development Goal 15. This working paper presents the concepts and technical frameworks designing the GeOC and its typical use cases.

The GeOC tool is designed to provide land users, projects/programmes and policy decision-makers with plausible, robust extrapolation domains for guiding decisions on the selection and use of SLM options, and an open platform for docking different disciplinary projects into integrative/holistic and converging actions for promoting SLM at scale. It integrates standardized SLM databases such as WOCAT with spatially explicit data on socio-ecological drivers and impacts of land use/management practices to derive plausible soil and water conservation options across different contexts. The tool is based on a systems framework, is scientifically sound and able to cope with the high level of contextual diversity. It can improve linkages among different scales and kinds of data that are essential for SLM implementation, evaluation and out-scaling. By offering common use functions, it is easy-to-use with multiple languages and is an interoperable online tool. It is flexible to allow for continuous improvements and customizations.

Its utility is increased by our *use-case approach* that provides multiple entry points for diverse needs and preferences of users. A typical use-case is a sequence of limited steps that describes the interactions between a typical user and the information system to accomplish a typical goal. We designed three typical use cases of the tool: (1) searching for implemented SLM options within a user-defined context, (2) searching similar contexts for a given SLM option, and (3) evaluation of land degradation/improvement by context that would be important for assessing gaps in achieving LDN.

1. Background and Research Questions

It is widely recognized that sustainable land management practices (SLM) are urgently needed for improving land-based livelihoods of 2.5 billion people living in the dry areas across the globe. Adoption and effectiveness of SLM practices depend on specific contexts. The high contextual diversity of global drylands limits the use of uniform blanket policies promoting SLM and restricts the synthesis and upscaling of site-based successful interventions. The CGIAR Dryland Systems CRP with the funding support of GIZ-BEAF, ICARDA and its partners is developing and implementing a web-based GIS tool for defining sustainable land management (SLM) options by social-ecological context at global scale. This Global Geo-informatics Context and Options (GeoC) tool aims to support the implementation of SLM practices by the international community. The GeoCOs is designed to provide stakeholders/projects and programmes with plausible, robust extrapolation domains for guiding decisions on SLM options, and an open platform for docking different disciplinary projects into integrative/holistic, converging actions for SLM. The tool can contribute to a country's nationally determined contribution to Sustainable Development Goal (SDG) 15 and other land-related SDGs. The tool will be used to continuously assess impacts of SLM options based on local assessments linked to remote sensing data. It will also support stakeholders answer common questions in land use and management at different scales. These questions include:

- 1) How to target relevant geographies at different scales better as well as prioritize investments/intervention given limited resources?
- 2) How to identify plausibly geographical extrapolation domains that capture key biophysical, economic and social drivers of land management practices and outcomes?
- 3) How to anticipate future impacts of SLM in terms of land ecosystem services and affected/benefited populations.

2. Design concepts

2.1. Design criteria

The criteria for the development of GeoCOs includes:

- based on a *systems framework* that is science-sound and coping sufficiently with the diversity of social-ecological contexts
- *improved linkages* among *different scales* (from global to regional and local landscape) and between *pixelized* codes (raster GIS layers of social and ecological data) and *descriptive/profile data* (standardized profiles of SLM data),
- *multiple entry points* for diverse needs and preferences of users, and
- *common use functions*, yet *easy-to-use*, and open for improvements and customizations (*version-by-version*)

2.2. Systems-based rationales

Our review of contemporary systems frameworks has pointed out three main gaps. Firstly, some frameworks commonly used in SLM analysis and assessment (e.g. Driver – Pressure – State – Impact – Response (DPSIR)) generally overlook the contextual diversity that would shape SLM outcomes. Secondly, many current studies use typologies as strata to aggregate/design management options without testing whether the types do actually shape SLM outcomes. There is a lack of spatially explicit tools capable of generalizing regional/global patterns from place-based findings.

The thrust of conceptual framework for GeOC is a systems-based clarification of the relationship between context (including drivers) and management options as the basis for data integration, selection of objective-oriented indicators and analysis/assessment of the diversity of land use systems and related contexts over space (Figure 1). The framework draws on insights of current frameworks for social-ecological systems in transitions (Ashley and Carney, 1999; Pahl-Wostl et al., 2010; Reynolds et al., 2007; Scholz et al., 2011), but is kept simpler for operational implementation.

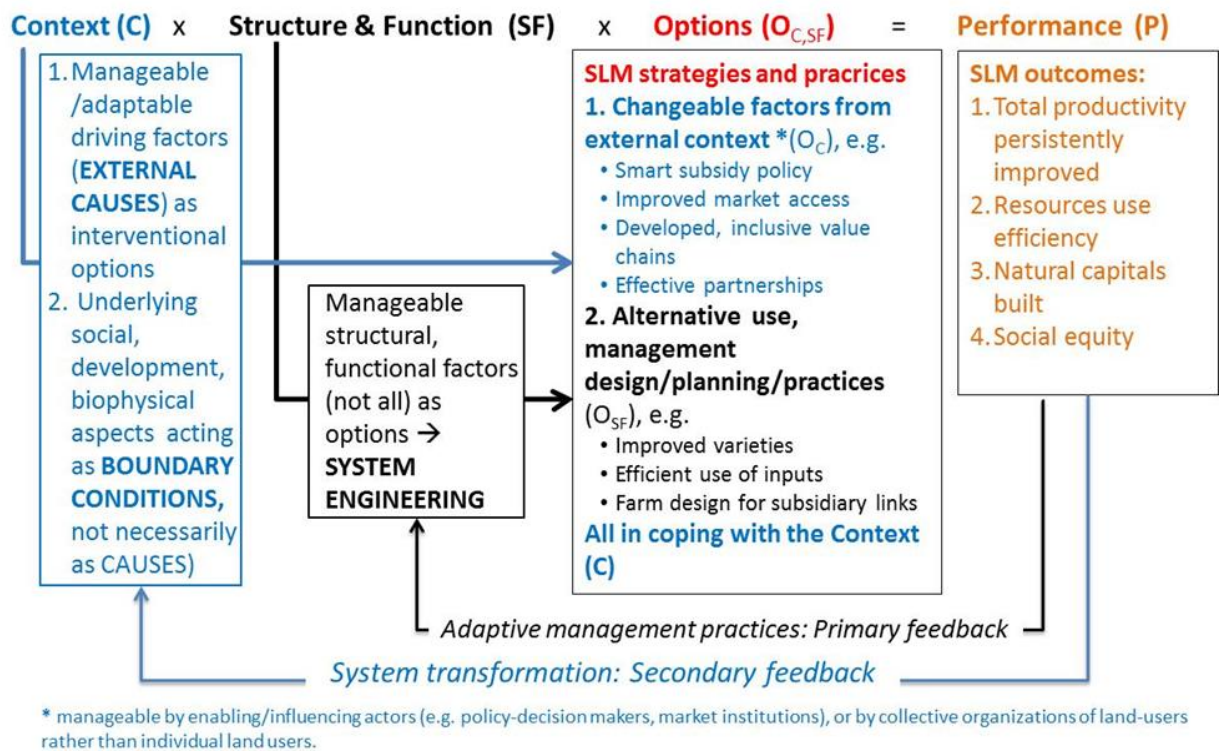


Figure 1: Relationship between SLM management options, structure and function of land use systems and context with a system-in-transition thinking. Sources: (Le et al., 2016b; Le et al., in prep-c)

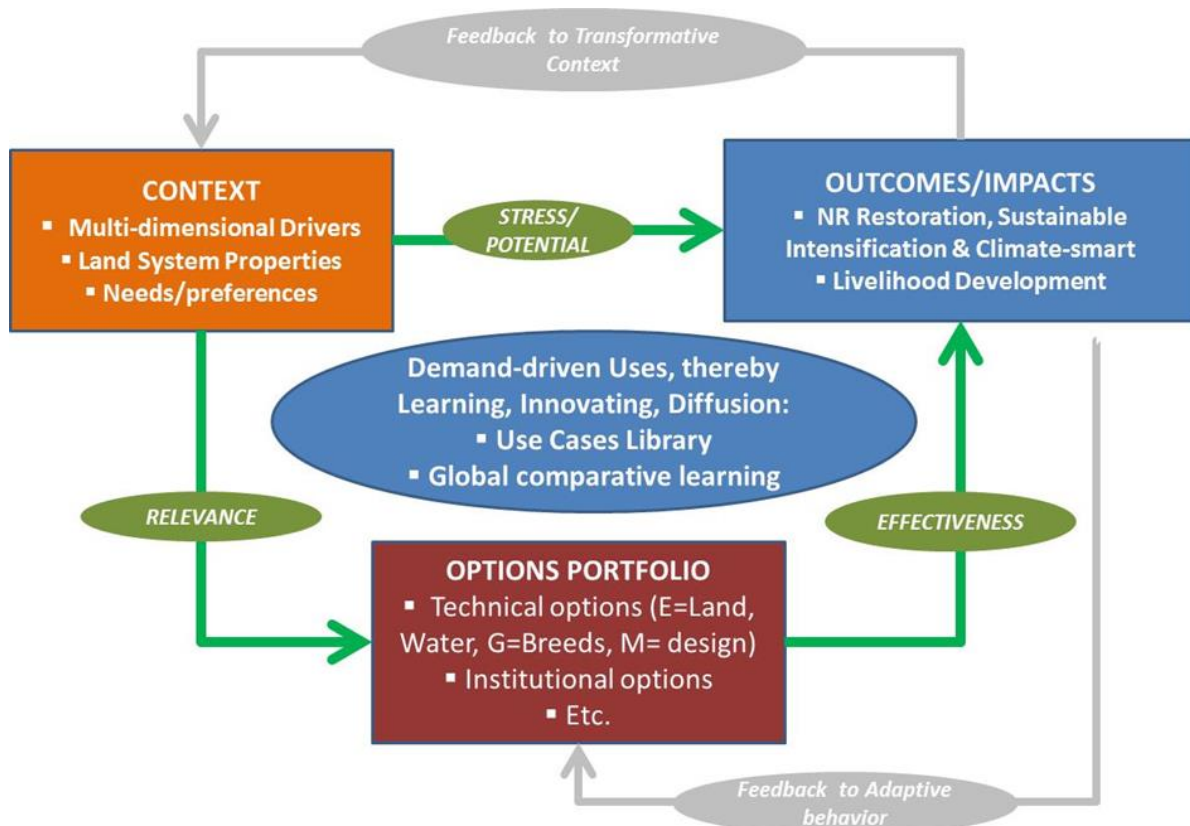


Figure 2: Data domains and influencing linkages in GeOC. Source: (Le et al., 2016a)

In light of the systems framework in Figure 1, the structure of GeOC database includes three domains and influencing linkages as showed in Figure 2. The contextual data include not only the social, economic and biophysical drivers of land management, but also the identities of the land use system itself and land users' needs/preferences. The SLM data is a portfolio of technical and institution options that is kept open for continuous addition by stakeholders in the course of learning and development.

3. Data domains

3.1. "Context/Drivers" database (GIS, global)

Contextual variables in the current version of GeoCOs are briefly described in Table 1. The selection of these variables was based on literature reviews of drivers of land degradation and its reversal (Geist and Lambin, 2002; Mirzabaev et al., 2016; Nkonya et al., 2011; Vlek et al., 2010), as well as the availability of global GIS data. The global data are collected and resampled (up- or down-scaled to 1 km resolution) from different sources (such as USGS, FAO-IIASA, UNEP, IUCN, CIESIN-CIAT, CGIAR-CSI). Important data such as inter-annual trends of rainfall, social-ecological contextual types are driven from the analyses of CRP-DS' Overarching Cluster, e.g. (Le et al., 2016c) and Le et al. (in prep), agricultural resource poverty, proximities to roads, towns and water bodies were calculated by ICARDA Geoinformatics Unit (<http://geoagro.icarda.org/en/>)

Table 1. Key contextual variables in the ‘Context/Drivers’ database. Note: Source of original data is in another document (ref?). Each variable when displayed and exported (see queries) should report the source and the year both visually and in the form of embedded metadata.

Variable	Definition (measuring unit) (sources)	Spatial coverage	GIS type, resolution
<i>Biophysical driver</i>			
ARIDITY	Aridity index (Trabucco and Zomer, 2009)	Global	Raster, 1-km pixel size
PRECIP-TREND	Long-term trend of annual precipitation (floating trend coefficient) (Le et al., 2016c)	Global	Raster, 1-km pixel size
WATER- PROXIMITY	Proximity to water body (m) (Bidarar/ICARDA, 2015)	Global	Raster, 1-km pixel size
BROAD-COVER	Broad class of land cover (10 classes ² aggregated from 22 classes of Globcover data (Bicheron et al., 2008)	Global	Raster, 1-km pixel size
TREE-DEN	Tree density (trees/km ²) (Glick et al., 2016)	Global	Raster, 1-km pixel size
DEM-GTOPO30	Altitude above sea level (m) (USGS, 1998)	Global	Raster, 1-km pixel size
SLOPE-DEG	Surface slope (degree) (calculated from GTOPO30 data (Le, 2016)	Global	Raster, 1-km pixel size
SQC1-NUTAVA	Soil quality constraint regarding nutrient availability (4 ordinary classes from HWSD supplementary data ³) (Fischer et al., 2008)	Global	Raster, 1-km pixel size
SQC2-NUTRCAP	Soil quality constraint regarding nutrient retention capacity (4 ordinary classes from HWSD supplementary data ²) (Fischer et al., 2008)	Global	Raster, 1-km pixel size
SQC3-ROOTCOD	Soil quality constraint regarding rooting condition (4 ordinary classes from HWSD supplementary data ²) (Fischer et al., 2008)	Global	Raster, 1-km pixel size
SQC4-OXYGEN	Soil quality constraint regarding soil oxygen (4 ordinary classes from HWSD supplementary data ²) (Fischer et al., 2008)	Global	Raster, 1-km pixel size
SQC5-SALT	Soil quality constraint regarding salinity (4 ordinary classes ²) (Fischer et al., 2008)	Global	Raster, 1-km pixel size
SQC6-TOXICITY	Soil quality constraint regarding toxicity (4 ordinary classes ²) (Fischer et al., 2008)	Global	Raster, 1-km pixel size
SQC7-WORKCAP	Soil quality constraint regarding work capacity (4 ordinary classes) (Fischer et al., 2008)	Global	Raster, 1-km pixel size
<i>Physical and institutional accessibility to land resources</i>			
DIST-ROAD	Distance to main road (km) (Biradar/ICARDA, 2015)	Global	Raster, 1-km pixel size
DIST-TOWN	Distance to district capital (km) (Biradar/ICARDA, 2015)	Global	Raster, 1-km pixel size
PROTECT-AREA	Protected area (1= protected, 0= otherwise) (IUCN world database of protected areas – WDPA) (UNEP-WCMC, 2016; https://protectedplanet.net/)	Global	Raster, 1-km pixel size

² Ten aggregated land cover classes: 1- irrigated crop areas, 2- rain-fed crop areas, 3- mosaic crop-vegetation, 4- forested areas, 5- mosaic forest-shrub-grassland, 6- shrubland, 7- grassland, 8- sparse vegetation areas, 9- wetland, 10- bare soil areas

³ Four ordinary classes of soil quality constraint: 1- no/slight constraint, 2- moderate constraint, severe constraint, 4- very severe constraint

TENURE-SEC	USAID's tenure security level (Mirzabaev et al., 2016)	Global	Raster, 1-km pixel size
Demographic dynamics and pressure			
POP-DEN2015	Average population density 2015 (persons/km ²) from GPW data (CIESIN-CIAT, 2005 and 2016)	Global	Raster, 1-km pixel size
POP-DEN-RURAL	Rural population density 2000 (person/km ²) (downscaled from FGGD database (FAO, 2007))	Global	Raster, 1-km pixel size
POP-CHANGE	Change in population density over the period 1990-2015 (persons/km ²) (calculated from GPW data) (Le, 2016)	Global	Raster, 1-km pixel size
National economic development			
GDPCAP	Average GDP per capita per 15 x 15 minutes in 2008 (\$US/person/yr) (Global 15 x 15 Minute Grids of the Downscaled GDP Based on the SRES B2 Scenario, averaged for 1990-2025 (Gaffin et al., 2004))	Global	Raster, 1-km pixel size
GDPCAP-GRW	Mean growth rate of annual GDP during 1990-2025 (% of baseline value in 1990) (Calculated using gridded downscaled GDP (SRES B2 Scenario) (Gaffin et al., 2004))	Global	Raster, 1-km pixel size
AGRI-POVERTY	ICARDA's index of agricultural resource poverty	Global	Raster, 1-km pixel size
Socio-ecological contextual similarity			
SES-TYPE	CRP-DS's socio-ecological context type (numeric codes of different contextual types) (Le et al., in prep.)	Global	Raster, 1-km pixel size

The innovation introduced by the tool is the initiation of the **functional context socio-ecological type (fCSET)** approach to overcome these challenges of socio-ecological context diversity. The fCSET approach groups common biophysical, economic and social drivers of land use adoption and change into distinct context types that shape SLM adoption and resulting primary productivity and efficiencies of the use of critical resources for terrestrial biological production (e.g. rain water and mineral nutrients). The drivers selected for analyses were based on a literature review. We identified and mapped context types using spatial cluster analysis with global data retrieved from different sources (such as USGS, FAO-IIASA, UNEP, IUCN and CIESIN-CIAT) and calculated by the scientists involved in this project. The functionality of the derived context types was evaluated by unbalanced ANOVA that measured and tested the differences in primary productivity and rain use efficiency among the context types. The testing of the types' function regarding SLM adoption will be the subject of follow-up studies at regional or national scale, where adoption data are available such as those will be produced by ICRAF EC/IFAD project on "Restoration of Degraded Lands for Food Security and poverty Reduction in East Africa and the Sahel: Taking Successes in Land Restoration to Scale". Our initial result demonstrates the potential of the fCSET approach to further our understanding of the role of socio-ecological contexts in SLM, and management of the contextual diversity. The results can be used by SLM-oriented projects/programs and citizen scientists to improve targeting of SLM options. For example given limited resource and aims, we can know approximately *where* efforts should be focused by managing, or coping with *what* drivers. The result can also be used as an extrapolation domain: given SLM outcomes in a number of project sites, we can identify where similar intervention options have a potential of success based on contextual similarity. Demonstrative example for Uzbekistan's agricultural land is shown in Figure 3, resulting from integrated systems research cluster of the CRP Dryland Systems in 2016 (Le

et al., in prep-a). Similar work was done in Vietnam (Vu et al. 2014). The identification and testing fCSET at a regional setting will be done for Maghreb area in 2017.

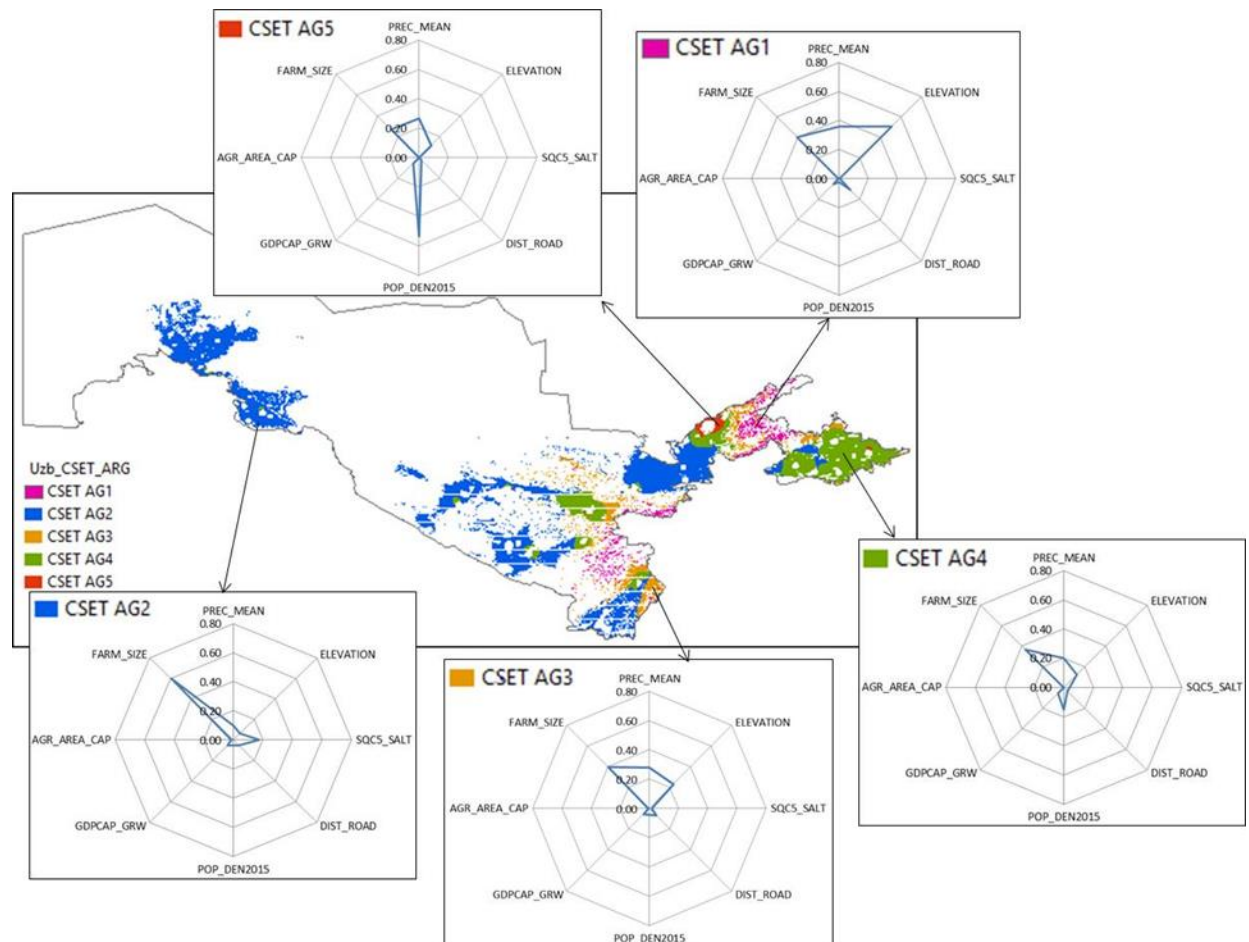


Figure 3. Five major functional Contextual Social-ecological Types (fCSET) of agricultural land in Uzbekistan. These CSETs are functional units regarding degradation in total biomass productivity, total crop yield and crop diversification as these impact/outcome variables are significantly different among CSETs (data not shown). Source: Le, Akramkhanov et al. (2016; in prep.). Note: Abbreviations of variables (normalized to scale 0-1 for possible comparisons) in the fCSETs' spider diagrams can be found in Table 1.

Connections between fCSET and land use/cover (LUC) units and contemporary Land Use Systems (LUS) unit

Broad land use/cover (LUC) categories were used as a starting stratification frame to continue to define fCSET. As a land use category can be defined as the sequence of operations carried out with a purpose to obtain land-based goods and services, land use is recommended to be used as the entry level for identifying contextual indicator set of land management (Sommer et al., 2011). The fCSET approach follows the same direction. As a results, we classified different contextual types for each board LUC class. Pilot analyses done for Vietnam specified 15 fCSETs for three main LUC, namely forestland, cropping land

and mixed shrub-grassland (Vu et al., 2014). In Uzbekistan we also objectively isolated 15 fCSETs for three main land use classes: agricultural land, pastoral/grassland and range/bare land (Le et al., in prep-b) (also partly shown in Fig. 5). The fCSET analysis at global level for major global LUC categories is still underway (expected to be finalized in March/April 2017) due to high intensity in spatial multivariate calculation over very large datasets.

fCSET is in the same line with the so-called land use system (LUS) unit such as what proposed/developed by FAO-LADA and Global Land Project (GLP), but developed with a tested functionality. FAO-LADA (Nachtergaele and Petri, 2008) nested 10 global biophysical and societal datasets with major global land use classes to yield 28 major LUS globally. With the same approach, the Global Land Project (GLP) developed a global map of 30 LUS units (van Asselen and Verburg, 2012), and 16 LUS classes at national level such as in Laos (Ornetsmüller et al., 2016). The major limitation of these studies is that the functionality of the derived LUS units in shaping the SLM adoption and outcomes (e.g. land degradation/improvement and poverty reduction) is rather assumptions based on knowledge priorities, than tested. With the fCSET approach, testing if the derived CSET response differently from each others regarding SLM outcomes are crucial to concludes the units are functional. The land unit (or land system unit) in the UNCCD Land Degradation Neutrality framework (Orr et al., in prep) should be truly functional, such as the fCSET developed by this project.

3.2. “Outcome/Impact” database (GIS, global)

Impacts/outcomes variables are briefly described in Table 2. Only the global gridded HANPP and NPP gap data are collected and resampled (up- or down-scaled to 1 km resolution) from the Institute of Ecology at University of Klagenfurt/Austria. The remaining data were calculated by scientists in the Program Management Unit (PMU) of CRP Dryland Systems.

Table 2. Key outcome and/or impact variables in the ‘Impact-Outcome’ database.

Variable	Definition (measuring unit) (sources)	Spatial coverage	GIS type, resolution
<i>Biomass Productivity and Water Use Efficiency</i>			
PROD-DEG	Biomass productivity-based land degradation, approximated by inter-annual trend of NDVI with statistical test, correction of confounding effects of rainfall variation, atmospheric and artificial fertilization (Le et al., 2016c)	Global	Raster, 1-km pixel size
PROD-IMP	Biomass productivity-based land improvement, approximated by inter-annual trend of NDVI with statistical test, correction of confounding effects of rainfall variation, atmospheric and artificial fertilization (Le et al. 2016)	Global	Raster, 1-km pixel size
RUE	Rain use efficiency = mean of annual sum NDVI / annual rainfall (Le, 2016)	Global	Raster, 1-km pixel size
<i>Pressure on land carrying capacity in term of biomass potential</i>			
HANPP-PCT	Human appropriation of natural NPP (% of natural NPP) in 2000 (Haberl et al., 2004; Krausmann et al., 2008)	Global	Raster, 1-km pixel size

NPP-GAPPC	Gap between actual and potential Net Primary Production (NPP) in 2000 (% of potential NPP) (Haberl et al., 2004; Krausmann et al., 2008)	Global	Raster, 1-km pixel size
Affected population			
AFFECTED-POP	Approximately population affected by land degradation (affected persons/km ²) (Le, 2016)	Global	Raster, 1-km pixel size
AFFECTED-RPOP	Approximately rural population benefited by land improvement (affected person/km ²) (Le, 2016)	Global	Raster, 1-km pixel size

3.3. SLM database

We developed both Excel-based (Figure 4) and online (Figure 5) templates of SLM option by context database that are standardized following the WOCAT approach, but embedded in the contextual and impact GIS database. The innovation is that the contextual and impact variables include not only those provided by SLM researcher and implementers (like the WOCAT approach that is site-specific), but also data automatically retrieved from independent GIS databases. The latter allows users to compare assessment/collation of site-specific SLM and context to similar contexts elsewhere for wider contextualization, and anticipation of potential impacts once out-scaled.

Template for Standardized Description of Sustainable Land Management (SLM) Technologies with a Focus on Field-Landscape Level			
Created by Quang Bao Le, Program Management Unit (PMU), CGIAR Research Program on Dryland System; Claudio Zucca, ICARDA			
Note: This CRP-DS template of SLM technology description is partly adapted from those of WOCAT, however with major modifications and additions. Though CRP-DS is still development this template until August 2016, it can be used for cataloguing SLM technologies considered by current CRP-DS projects.			
Field of information	Your input	Note: please fill the lined boxes, with the use of the provided formats or information lists if you are asked in the Note column.	Note
PART 1: GENERAL INFORMATION			
1.1. Name of the SLM Technology			
1.1 Name:	Jessours rainwater harvesting in southern Tunisia	Max 70 letters including spaces	
1.2 Locally used name:	"Jessours"	Max 70 letters including spaces	
1.3 Country:	Tunisia	Select from the provided list	
1.2 Documentors and Resources Persons/Information			
Main Documentor			
Name (first name + last name):			
Sex (M/F):			
2.3.1 Illustrative photo 1:			
		Insert a photo	
Caption of photo 1	Technical scheme for Jessour (ref: Taamallah et al., 2010, "Gestion durable de terres en Tunisie, Bonnes pratiques agricoles", p:7)		
2.3.2 Illustrative photo 2:			
		Insert a photo	
Caption of photo 2	An overall view of an area arranged in Jessour in Tunisia		
3.1 Purposes of the SLM Technology (max. 3 most important purposes):			
3.1.1 The 1st most important purpose	Reduce land degradation (soil, water, vegetation)	Select from the provided list	
If the main purpose was selected as "Other ...", please specify:		Max 70 letters including spaces	
3.1.2 The 2nd most important purpose	Restore/rehabilitate land degradation (soil, water, vegetation)	Select from the provided list	
If the main purpose was selected as "Other ...", please specify:		Max 70 letters including spaces	
3.1.3 The 3rd most important purpose	Reduce risk of disasters (e.g. droughts, floods, landslides)	Select from the provided list	
If the main purpose was selected as "Other ...", please specify:		Max 70 letters including spaces	
3.2 Type of the SLM Technology (max. 3 most relevant SLM types):			
3.2.1 The 1st most relevant SLM type:	Water harvesting	Select from the provided list	
If the SLM type was selected as "Other ...", please specify:		Max 70 letters including spaces	
3.2.2 The 2nd most relevant SLM type:	Irrigation management (incl. water supply, drainage)	Select from the provided list	
If the SLM type was selected as "Other ...", please specify:		Max 70 letters including spaces	
3.2.3 The 3rd most relevant SLM type:	Minimal soil disturbance	Select from the provided list	
If the SLM type was selected as "Other ...", please specify:		Max 70 letters including spaces	
3.2.4 Relevant SLM types (formula is used, please do not delete it):	Most relevant type: Water harvesting; Relevant types: Irrigation management (incl. water supply, drainage)/ Minimal soil disturbance	Auto-generated intergal text	
3.3 SLM measures comprising the SLM Technology:			
3.3.1a Type of Agronomic measures (1st):	A1: Vegetation/ soil cover	Select from the provided list	
3.3.1b Concrete Agronomic measures (1st):		Examples for typing	
3.3.1c Type of Agronomic measures (2nd):		Select from the provided list	
3.3.1d Concrete Agronomic measures (2nd):		Examples for typing	

Figure 4: Screenshots of the standardized Excel template filled by a SLM option locally called as 'Jessours', an technology for harvesting rainwater in the context of southern Tunisia.

The screenshot displays the 'SLM Form' interface, which is part of the CGIAR Monitoring, Evaluation and Learning (MEL) platform. The form is structured into six steps, with the current step being 'Step 3 of 6: SLM Purpose and Classification'. The steps are: 1. Name of the SLM Technology, 2. Description of SLM Technology, 3. SLM Purpose and Classification, 4. Geographic Locations, Extents and Socio-Ecological context/Environment, 5. Technical Specification, Inputs and Costs, and 6. Impacts, Influencing Factors. The current step is highlighted with a green bar. Below the step indicator, the form is divided into two main sections: '3.1. Purposes of the SLM Technology' and '3.2. Type of the SLM Technology'. Under '3.1. Purposes of the SLM Technology', there are two sub-sections: '3.1.1 Most Important Purpose' and 'Other Important Purpose'. Under '3.2. Type of the SLM Technology', there is a sub-section '3.2.1 Most Relevant SLM Type'. A dropdown menu is open for '3.2.1 Most Relevant SLM Type', showing a list of options: 'Improve production (crop, fodder, wood, fibre, water, energy)', 'Prevent land degradation (soil, water, vegetation)', 'Reduce land degradation (soil, water, vegetation)', 'Restore/rehabilitate land degradation (soil, water, vegetation)', 'Protect a watershed/ downstream area - in combination with other Technologies', 'Preserve/improve biodiversity', and 'Reduce risk of disasters (e.g. droughts, floods, landslides)'. The form is user-friendly with clear labels and a search bar for the dropdown menu.

Figure 5. An on-fly screenshot of the web-based template for data importing by SLM researchers and implementers. The template is as part of the CGIAR Monitoring, Evaluation and Learning (MEL) platform and linked to the web-based GIS systems of GeOC.

4. Use functions and “Use Cases”

4.1. Use functions

GeOC has web-based GIS Graphic User Interface (GUI) and integrated databases that allow users to start from the entry points they prefer. The tool will allow querying the different SLM measures from around the world to search ‘similar’ environments based on their geographical, biophysical and socioeconomic context and to search ‘similar’ SLM measures or SLM types or SLM techniques with the same goals. By showing all the options for a certain context, the platform facilitates the dissemination of SLM techniques to researchers, policy decision-makers, and land manager (including farmers). The main functions of the GeOC are expressed in Figure 6.

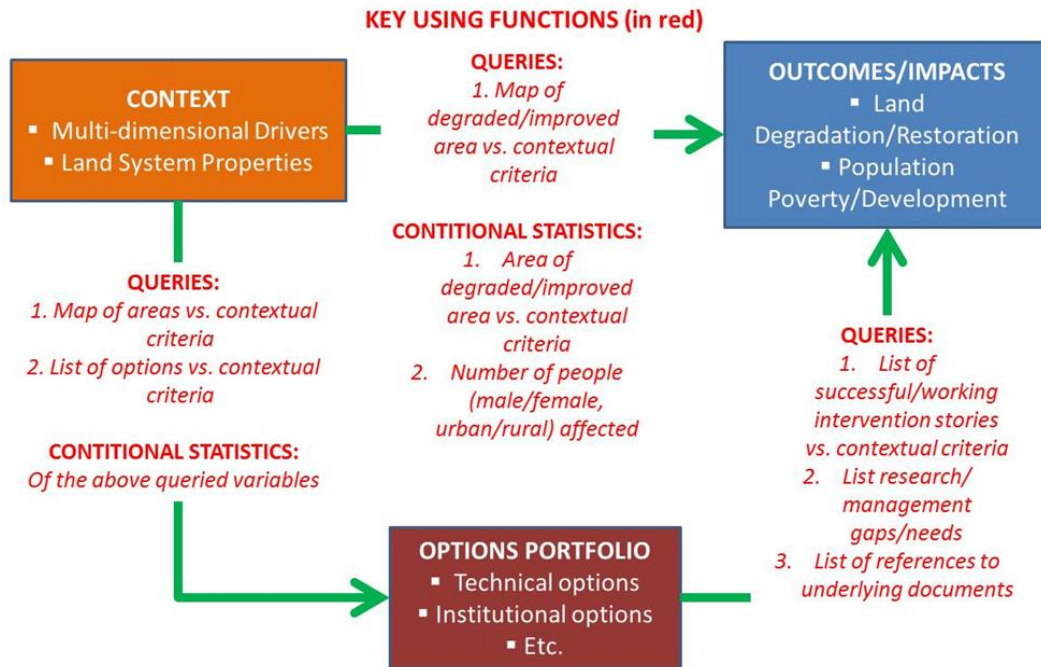


Figure 6: Key functions (expressed by the red texts in linking with three data domains) of the GeOC (Le 2016, Le et al. 2016b)

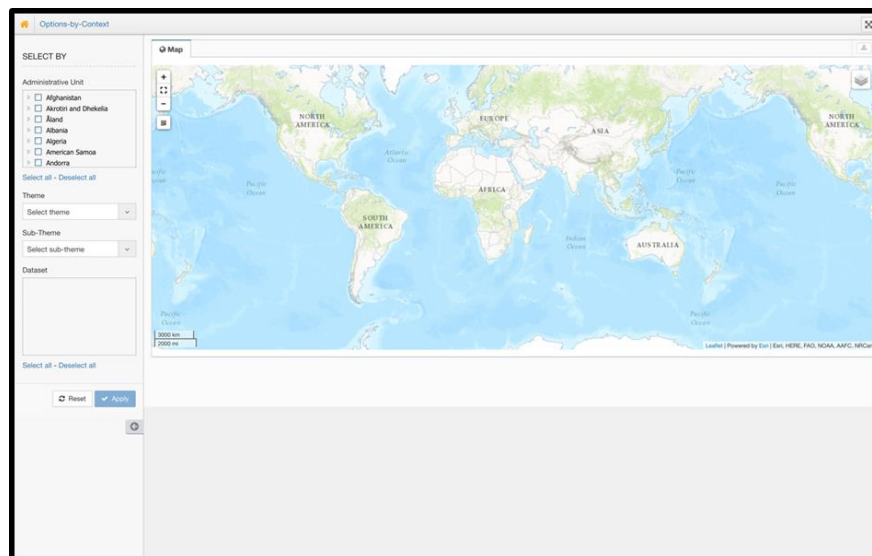


Figure 7. Snapshot of the current web-based GIS sub-system of GeOC that is being developed and tested.

4.2. “Use Cases” approach


A common challenge in this type of work deals with the absence of sufficient guidance to utilize complex data resources for **diverse users' contexts**, including user-specific purpose,

objective, application scales, institute's or group's capacity and many other factors. Today, system informatics deals with this complex challenge by following use case approach. A typical use-case is a sequence of limited steps that describes the interactions between a typical user (or users group) and the information system to accomplish a typical goal. To cope with diverse uses needed, the approach aims at establishing a use cases library that consists of as many as possible typical use cases. Given a use case library, a specific user can find a typical use case that is similar to his/her need for rapid application with low cost. Recognized strengths of the approach are: (1) strong analytical perspective and complete analysis assurance, (2) simple and easy to understand and adopt, (3) widely recognised market standard, (4) encourage join work between users and system designers to develop typical use case library.

We are developing the three typical use cases in line with common entry points:

- Context-based analysis: searching implemented SLM options with a defined context
- Option-based analysis: searching similar contexts given a considered SLM option
- Outcome-by-context evaluation: Evaluation of outcomes (via a limited set of performance indicators) given a defined context

4.2.1 Common Use Case 1: Context-based analysis of SLM options

The user has selected the context-based analysis. The user has two options as a radio-button () to select “Pre-defined context-types” or “User-defined Criteria”. The following is currently under development by the project.

Entry point option 1: Pre-defined contextual types

Users select the radio buttons then a window will slide down with a series of pre-defined context-type (fCSET) that are retrieved by the fCSET GIS map loaded by the GeOC Administrator. The types are listed with check boxes and the user can select multiple types. Once selected the global map will highlight the different types selected. A first button will appear under the map “Download Image”. This will allow the user to download the visualized map in the format JPEG. A second button will appear on the left to request the user to “Retrieve Options”. Once the button is pressed the Option polygons will appear on the map and a table (ensure good quality) will be displayed under the map with:

OID (#) / Option (name) / Category (SLM group) / Details (view) / Data (download) / Map (download) / Outcome Stories (view)

Info in () should not be used in the table head row (see below example). This table will have five interactive columns:

- Option: this function will color the polygon(s) on the map as reference. Vice versa mouse over on the polygon(s) on the map will highlight the name
- Details: this function will open a sliding popup window displaying the Option details previously entered in MEL (ref. to the SLM Excel file). This function can be also

performed as a new tab that present a webpage for each Option. See below for Outcome Stories. (ref. blog page / project open page)

- Data: this function will initiate the download of the Excel/pdf file with the Option details previously selected.
- Map: this function will initiate the download of JPEG image where only the boundaries of the Polygon(s) are included and laying on the map.
- Outcome Stories: This function will open a new tab, which is the webpage, presenting the outcome story.

The table is produced based on the three possibilities the user has in MEL to register an option. The option can be one among: 1) Upload a Shape file; 2) Entering the 4 GPS points (or multiple) for each polygon; 3) Designing the Polygon(s) using WebGIS interface.



Figure 8: Sample graphical representation and flows of the 'context-based analysis' use case (entry point option 1)

Entry point option 2: User-defined contextual criteria

Once the user selects this radio button a window will slide down with a series of criteria that the user can selected. When a criterion is selected a slide box appears on the left with min-max range for the user to enter the information. Units of range are provided. At the bottom of the page, a button is visible immediately after at least one criterion is selected to visualize map. Once the map is visualized a second button appears to "Retrieve Options". The process is then equal to the one presented above.

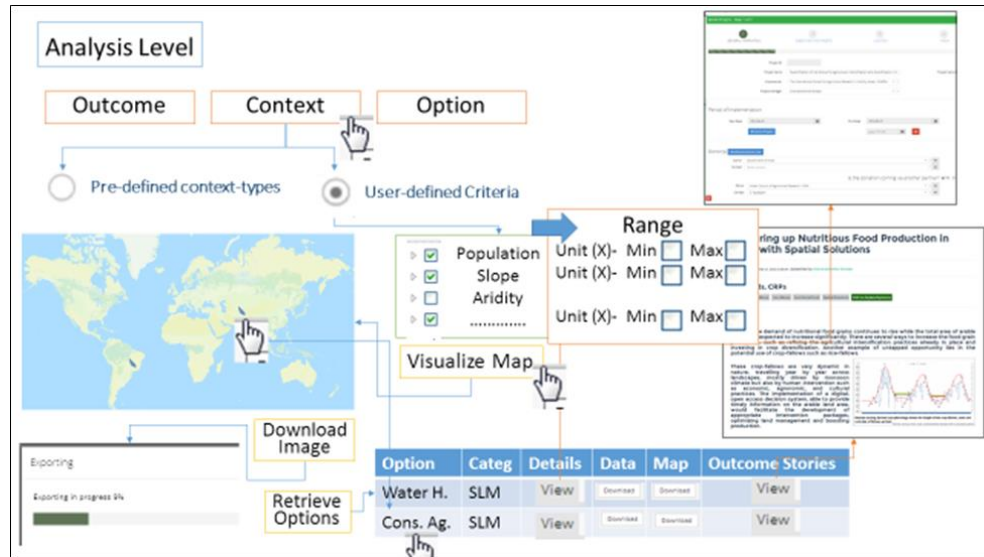


Figure 9: Sample graphical representation and flows of the ‘context-based analysis’ use case (entry point option 2)

4.2.2 Common Use Case 2: Option-based analysis

Users have selected the option-based analysis. Users have two entry point options as radio-button to select “Pre-defined option-types” or “Users’ free text Search”.

Entry point option 1: Pre-defined a SLM option

Once the user selects this radio button a window will slide down with a series of pre-defined option types: 1) TREE/VEGETATION-BASED; 2) SOIL-BASED; 3) WATER-BASED; 4) AGRONOMY/FARM SYSTEM-BASED; 5) NATURAL RESOURCES CONSERVATION-BASED; 6) OTHERS. These are the types in an off-line form (Excel file) (see section 3.2) used for SLM data entry. The types are listed with check boxes and the user can select multiple types. Once selected a button appears to “Visualize” both the map and the list of options. Once the button is pressed the Option polygons will appear on the map (map layer only under the polygons), with Legend for types and a table (ensure good quality) will be displayed under the map with:

OID (#) / Option (name) / Category (SLM) / Context (name) / Details (view) / Data (download) / Map (download) / Outcome Stories (view)

Info in () should not be used in the table head row (see below example). This table will have six interactive columns:

- Option: this function will color the polygon(s) on the map as reference. Vice versa mouse over on the polygon(s) on the map will highlight the name
- Context: this function should be the name of the context legend. Clicking on the context name the map will highlight the other options in the list for the same context.

- Details: this function will open a sliding popup window displaying the Option details previously entered in MEL (ref. to off-line SLM input form - Excel file). This function can be also performed as a new tab that present a webpage for each Option. See below for Outcome Stories. (ref. blog page / project open page)
- Data: this function will initiate the download of the Excel/pdf file with the Option details previously selected.
- Map: this function will initiate the download of JPEG image where only the boundaries of the Polygon(s) are included and laying on the map.
- Outcome Stories: This function will open a new tab, which is the webpage, presenting the outcome story.

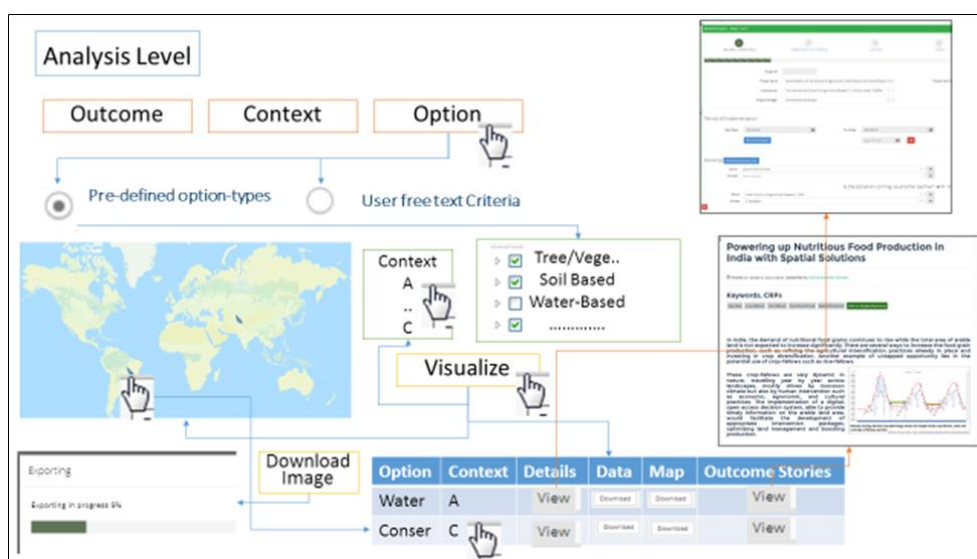


Figure 10: Sample graphical representation and flows of the 'option-based analysis' use case (entry point option 1)

Entry point option 2: Users' free-text search

Once the user selects this radio button, a search text box is showed and full search is performed using Options information. Option information retrieved is not only those in Excel but also associated metadata in case the option has been entered into a project (e.g. donors name, implementer name and so on). Once the search button is pressed the Option polygons will appear on the map (map layer only under the polygons), with Legend for types and a table (ensure good quality) will be displayed under the map with:

*MEL OID (#) / Option (name) / Category (SLM) / Context (name) / Details (view) /
Data (download) / Map (download) / Outcome Stories (view)*

Info in () should not be used in the table head row (see below example). The map can visualize one or more options based on the specificity of the search.

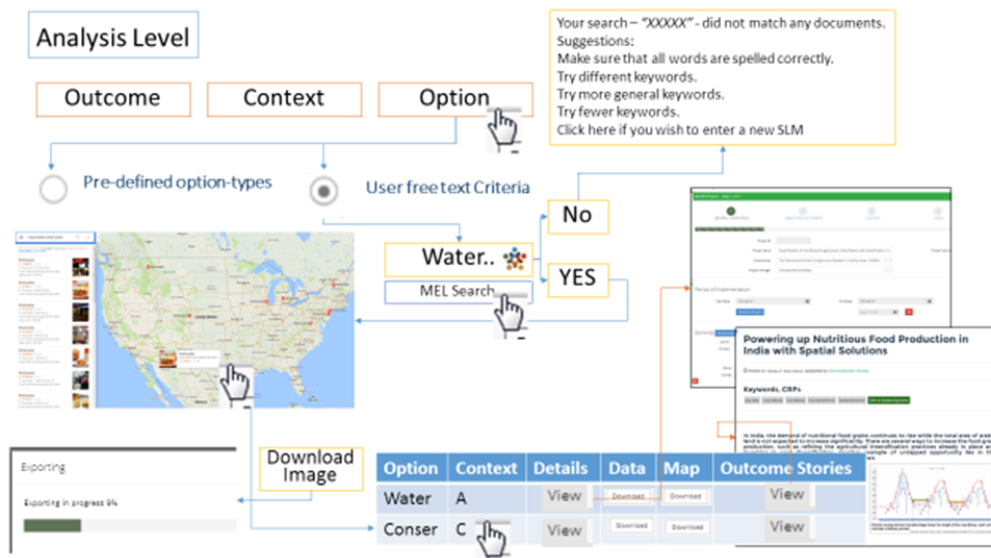


Figure 11: Sample graphical representation and flows of the 'option-based analysis' use case (entry point option 2)

Given fCSET map, users will select one or more fCSET they want to evaluate the impact/outcome variables and these selected fCSET will be visualized in the table. Another option can be that the user specifies the 4 GIS points or with a sample shape file. Points or shape can be placed on different classes to simulate the context. This will be in the table.

4.2.3. Outcome-by-context evaluation

The user has selected the outcome-based analysis. The user have two options as radio-button to select "Pre-defined context-types" or "User-defined Criteria". This analysis is not linked to options but only to Global GIS information retrieved by the uploaded layers.

Entry point option 1: Pre-defined context-types

Once the user selects this radio button a window will slide down with a series of pre-defined context-type that are retrieved by a GIS Layer loaded by the Administrator (note. This is not a programmer). The types are listed with check boxes and the user can select multiple types. Once selected and pressed the button "Generate map" the global map will highlight the different types selected. A first button will appear under the map "Download Image". This will allow the user to download the visualized map in the format JPEG. A second button will appear on the left to request the user to "Retrieve Outcome Variables". Once the button is pressed a table (ensure good quality) will be displayed under the map with:

Context (name) (COVER-BROAD) / Areas in Km2 (number) / Area of biomass productivity degradation in km2 (integer number) (PROD-DEGRAD) / Area of biomass productivity improvement in km2 (integer number) (PROD-IMPROV) / Human appropriation of net primary productivity (NPP) in % (floating number between 0 and 100) (HANPP-PCP2000) / Gap between actual NPP and potential NPP (floating number between 0 and 100) (NPP-

GAPPC2000) / Proxy of rain use efficiency (floating number) (RUE)/ Trend of rain use efficiency (floating number) (RUE-TREND) Affected rural population in (1000 persons) (floating number) (AFFECTED-POP) / Benefited rural population in 1000 person (floating number) (BENEFITED-POP)/

Info in () should not be used in the table head row (see below example). This table will have only one interactive functionality in case more than one type selected. When mouse over or click is performed on the type the map will highlight the type selected.

Given the fCSET map, users can select one or more classes and this will be visualized. Once the Administrator will replace this map with the real one the functionality to retrieve the Outcome variables (“classes”) will still exist. Once the user has selected the classes the button download image (JPEG) should work. This will return the table. Now the table functions presented above can be tested replacing land cover classes information such as area.

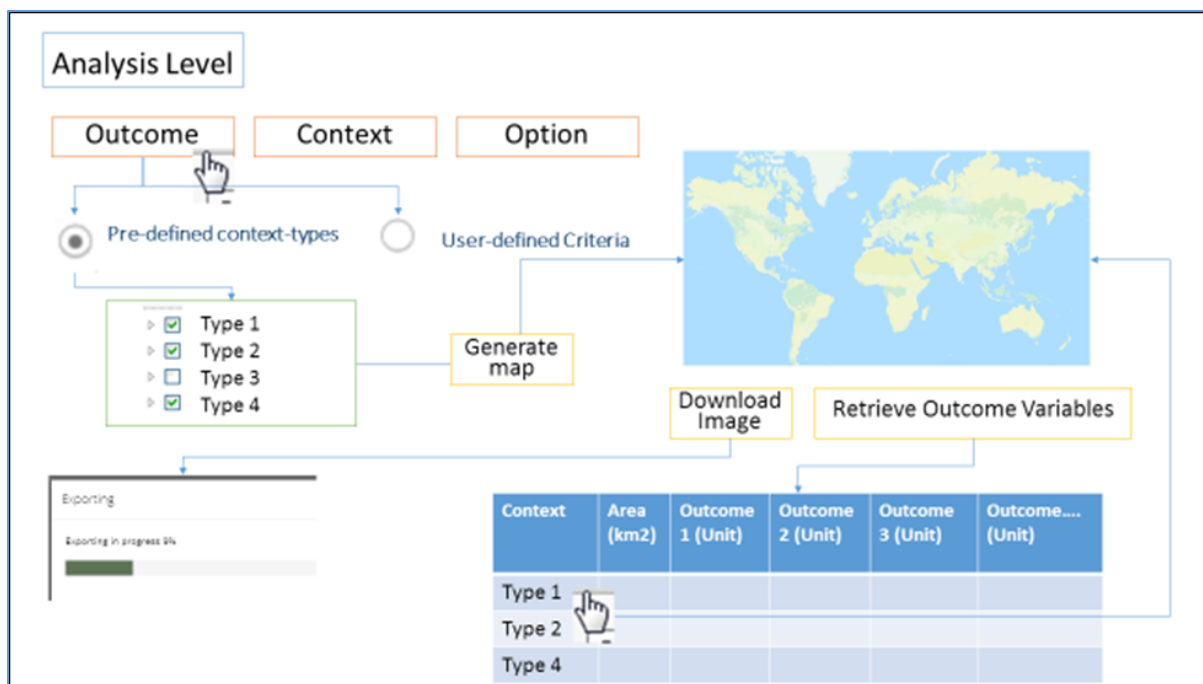


Figure 12: Sample graphical representation and flows of the ‘outcome-by-context evaluation’ use case

User-defined criteria for outcome-by-context evaluation

Once the user selects this radio button a window will slide down with a series of criteria that the user can selected. When a criterion is selected a slide box appears on the left with Min and Max Range for the user to enter the information. Units of range are provided. A button “Generate map” is visible immediately after at least one criterion is selected and once pressed the button “Generate map” the global map will highlight the different types selected. A first button will appear under the map “Download Image”. This will allow the user

to download the visualized map in the format JPEG. A button is visible to “Retrieve Outcome Variables”. The process is then equal to the one presented above despite the table will present only one type that is the customized from the user and thus the map represent only one scenario and its name will be *Name_Surname_data_time* considering the user and the time.

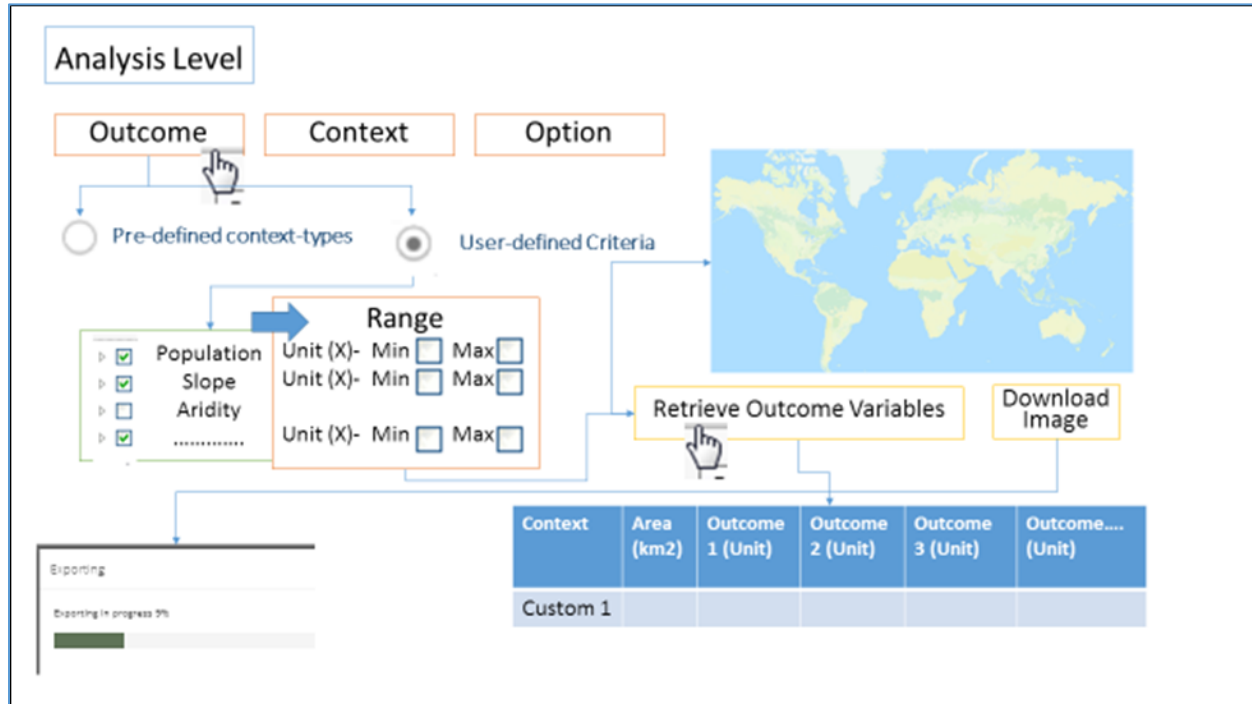


Figure 13: Sample graphical representation and flows of the ‘outcome-by-context evaluation’ use case with user-defined criteria

5. The way forwards

As the tool was designed and typical use cases were planned, an IT installation guide is being also written. Since the context data is already set, the GIS consultant will develop now the outcome-Impact data according the Impact variables as described in Table 2. In addition, the web-based template is being tested now and the first version will be finalized in the middle of 2017. The software developers of the GeOC team are working for realization of the three typical use cases mentioned above. Already the context-based analysis is almost done, the work now will be focused on the two others use cases: option-based analysis and outcome-by-context evaluation. A first version of the tool will be released officially by June/July 2017.

A training workshop to introduce the Web-GIS tool and gather feedback from potential national users is planned for March where we test its first version with national organizations on SLM research and development. Upon our findings, we plan to release a journal article where we will work on analysing the pre and post impact of SLM practices in Tunisia. Furthermore, we will release a policy brief to the policy makers in Tunisia pointing out the potential of our tool to support decision making in SLM national policies. Videos are

planned also with the stakeholders, the potential users of the tool to caption the different activities of the project.

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