Federal Ministry
for Economic Cooperation
and Development

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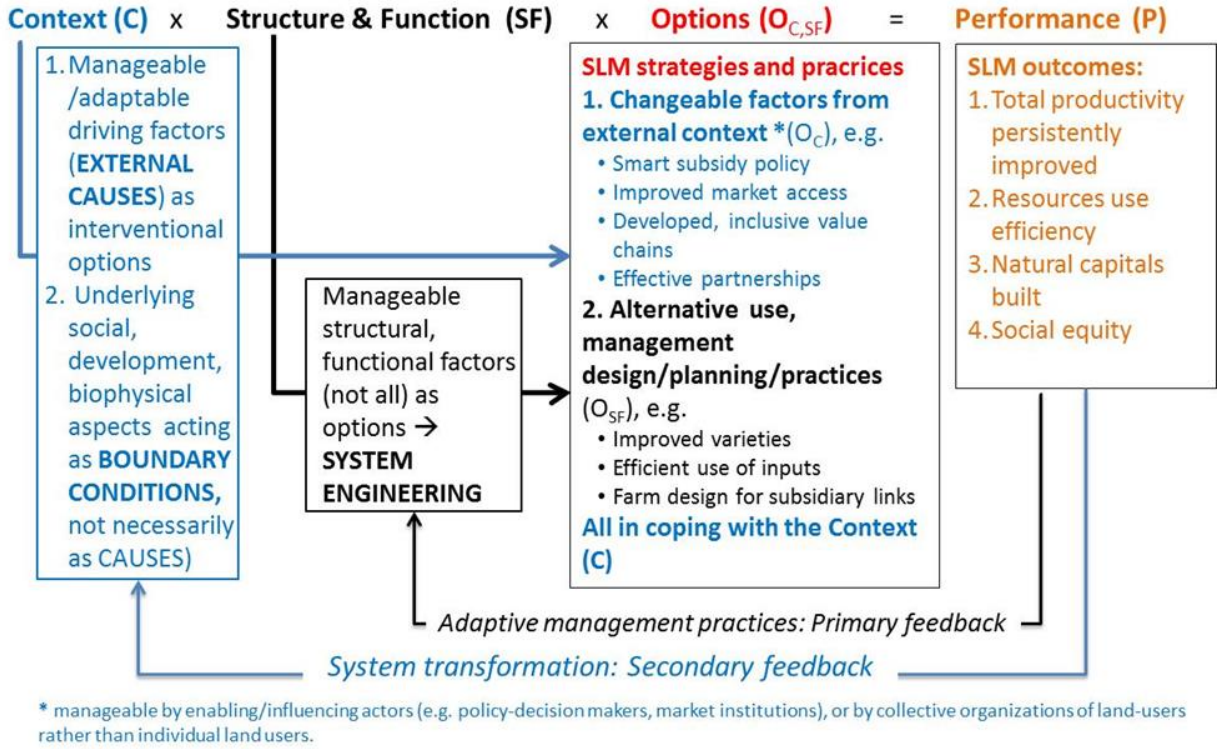
Zusammenarbeit (GIZ) GmbH

Annexes of Final Report **BMZ Small Grants**

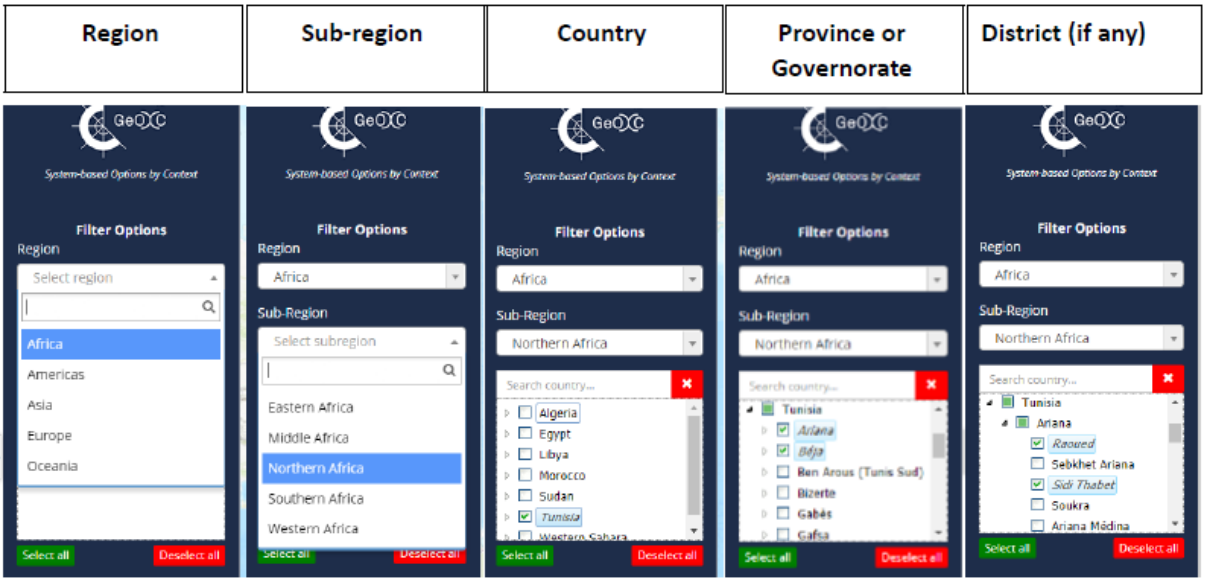
The IARC applicant	ICARDA
Project title	Impact evaluation of SLM options to achieve land degradation neutrality
Funding type, GIZ Project Number and Contract Number	Small Grant GIZ Project number: 14.1432.5-001.00 Contract number: 81204252
Reporting Period	From 01/08/2016 to 28/02/2018

Annex 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)

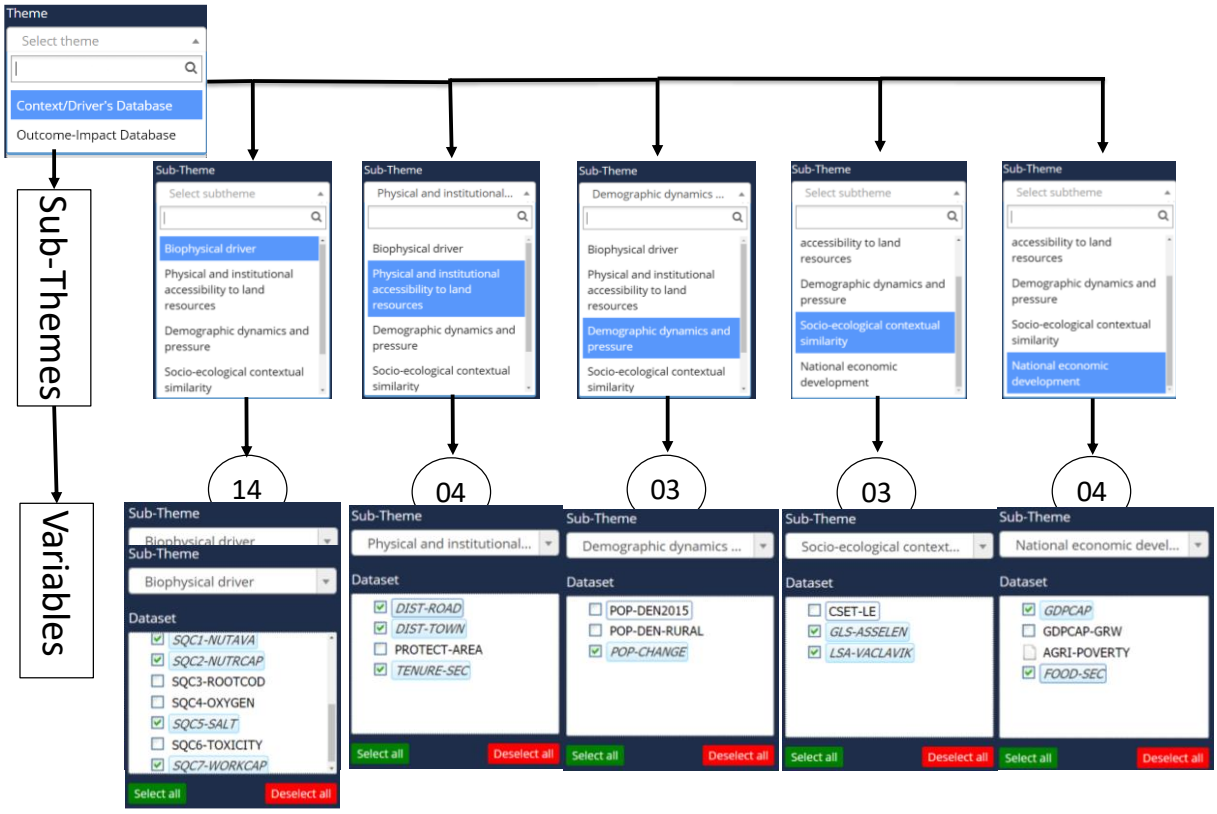


* manageable by enabling/influencing actors (e.g. policy-decision makers, market institutions), or by collective organizations of land-users rather than individual land users.

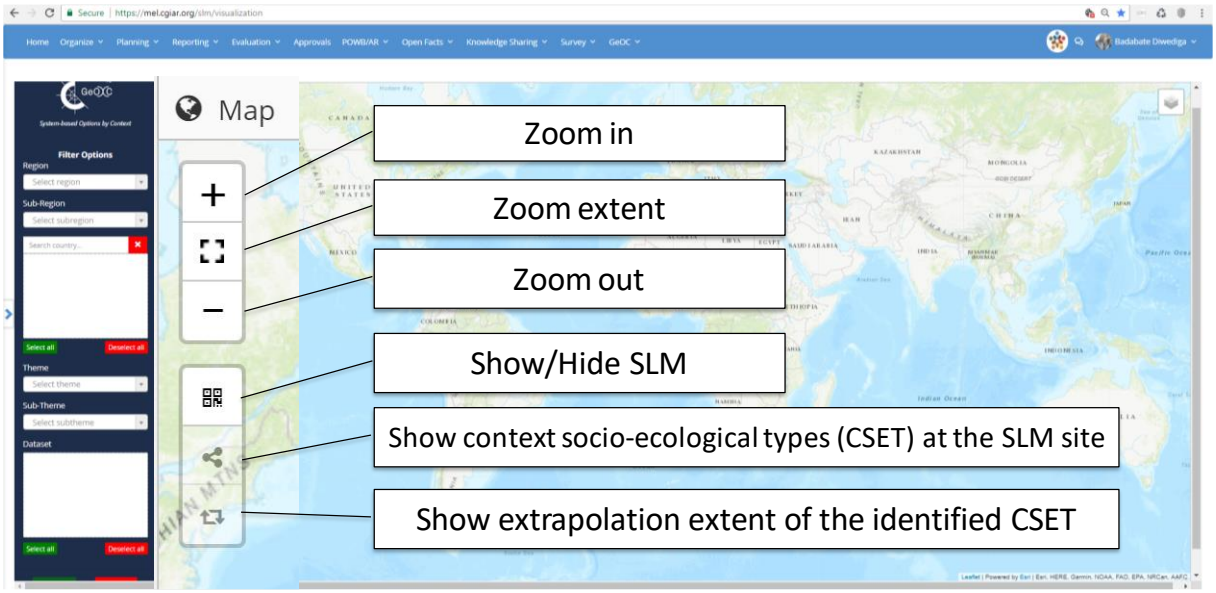
Annex 2. Fillter Options of WebGIS: Drop-down menus allow users to select the administrative units of interest.

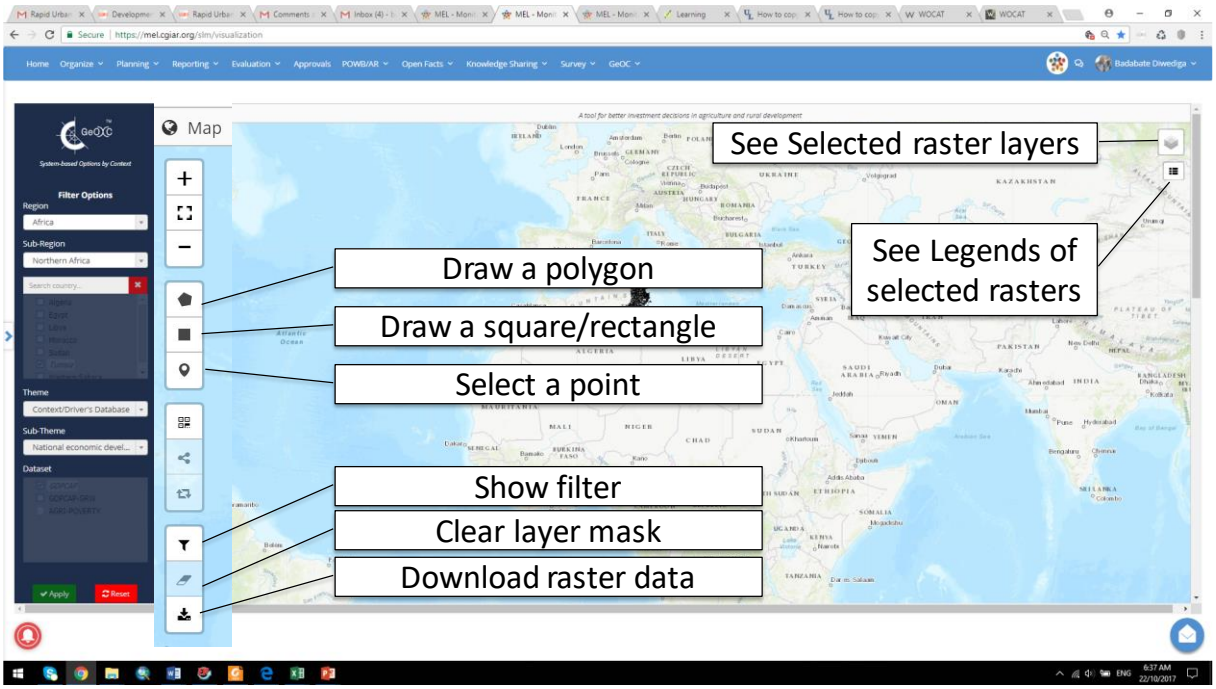


Annex 3. Fillter Options of WebGIS: Drop-down menus allow users to select contextual criteria and/or performance/impact indicators (all in GIS format), therefrom define the geographic area meeting these criteria. Note: numeric code indicates the number of GIS variables under each sub-theme.



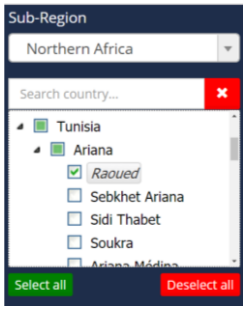
Annex 4. Mapping Tool part of the WebGIS and its key functions



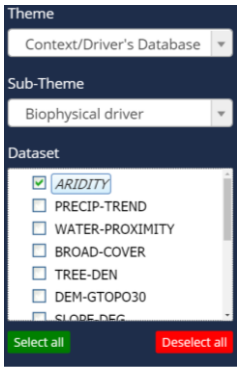


Annex 5. Steps for defining an area of interest with a specific context using WebGIS

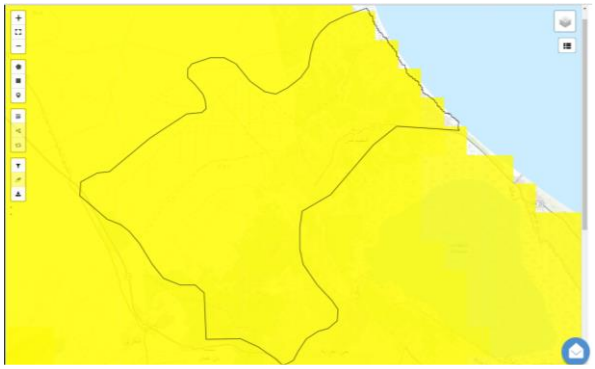
Step 1: Select area of interest



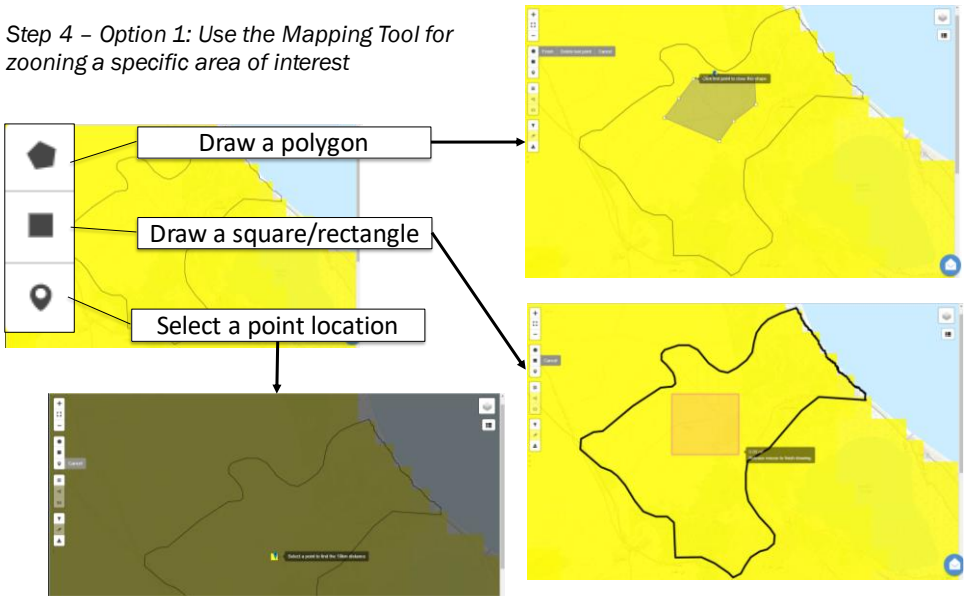
Step 2: Select raster variable of interest



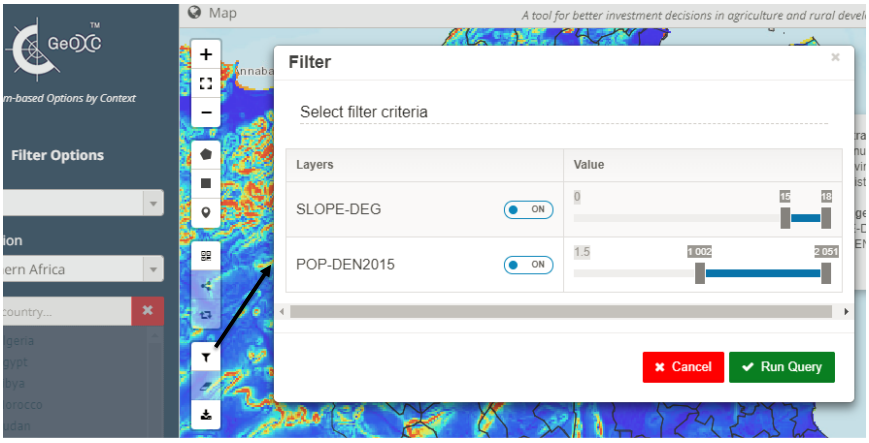
Step 3: Apply filter and zoom in to the area of interest



Step 4 – Option 1: Use the Mapping Tool for zooning a specific area of interest

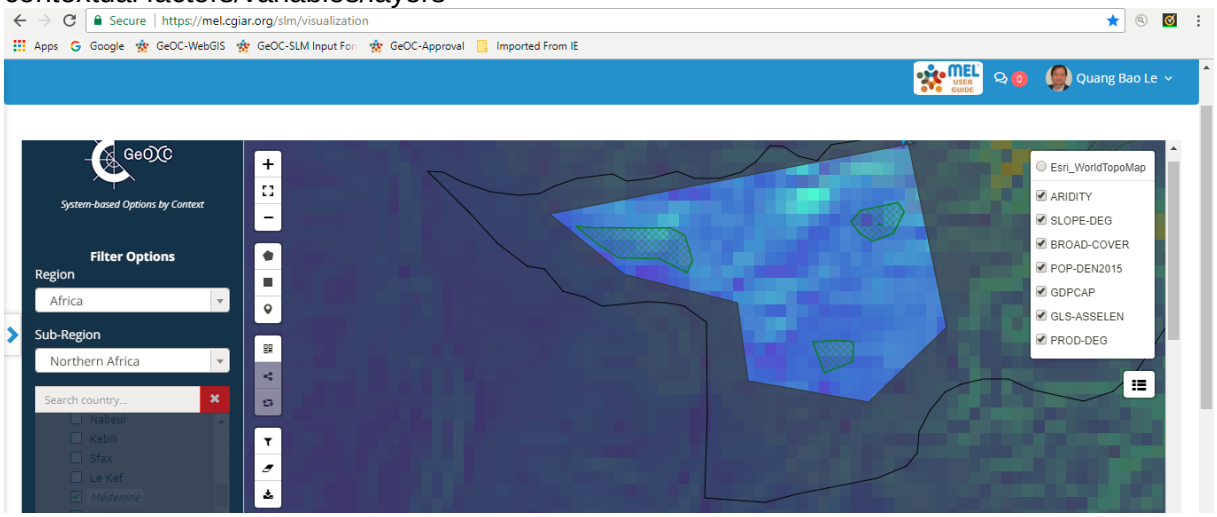


Step 4 – Option 2: Use filter to select specific ranges of certain contextual criteria, then define the area of interest based on these ranges. E.g. defining the area of interest with: slope > 15 degree AND population density > 1000 persons/km2.



Annex 6. Screenshots of statistic summaries of contextual condition and SLM performance/impacts given an area of interest.

6a/ An example of area of interest, cover 4 SLM implementation sites, with 7 selected contextual factors/variables/layers



6b/ Descriptive statistics of 7 contextual factors/variables/layers

Descriptive statistics of selected continuous/ordinary layers/rasters (within

Layer	Min	Max	Mean	Stdv	Range	Display Unit
ARIDITY	0.1	0.2	0.1	0.0	0.1	Index
SLOPE-DEG	0.0	9.5	1.1	1.1	9.5	Degree
POP-DEN2015	4.4	60.2	40.8	18.4	55.8	Persons/km2
GDPCAP	0.0	567.1	148.0	60.9	567.1	$US/person/yr

Continuous GIS layers/variables:
ARIDITY: an index measure humidity
SLOPE-DEG: Slope of land surface in degree
POP-DEN2015: Population density in 2015
GDPCAP: GDP per capita

Categorical GIS layers/variables:
BROAD-COVER: Broad class of land cover
GLS-ASSELEN: Global land system in according to Asselen et al. (2011)
PROD-DEG: Long-term declining of biomass productivity (Le et al. 2016)

Descriptive statistics of categorical layers/rasters (within the area of interest) (% of total area for each catergory)

Layer	Rainfed crop areas	Mosaic crop-vegetation	Mosaic forest-shrub-grassland	Sparse vegetative areas	Bare soil areas	Artificial areas	Permernant snow/Ice/Domestic water surfaces
BROAD-COVER	0.0%	0.1%	0.1%	7.5%	88.7%	0.9%	2.8%
Layer	**Bare**	**Bare with few livestock**					
GLS-ASSELEN	8.4%	91.6%					
Layer	**Significant long-term NDVI decline (RF- and AF-corrected, LAI > 4 masked)**	**prod_degrad.255**					
PROD-DEG	5.5%	94.5%					

Annex 6 (continued). Screenshots of statistic summaries of contextual condition and SLM performance/impacts given an area of interest.

6d/ Synthesis tables of on-site and off-site impacts of 4 queried SLM technologies given the context defined in 6a and 6b.
Notes: i) Impact data (in likert scale) was taken from relevant fields in the corresponding SLM database. ii) in the real WebGIS interface, the short name of SLM technologies (the blue texts in the first column) are hyperlinked, by clicking any of them users will see the whole record of SLM data.

On-site impacts of the SLM options

Show 10 entries Search:

SLMs in the area of interest	Socio-economic impacts- Production	Socio-economic impacts- Water availability and quality	Socio-economic impacts- Income & costs	Socio-cultural impacts	Ecological impacts- Water cycle/runoff	Ecological impacts- Soil & biodiversity	Ecological impacts- Climate & disaster risk reduction
Cisterns	Slightly positive	Slightly positive	not available	Positive	Slightly positive	Slightly positive	Slightly positive
Plantation for landscape restoration	Slightly positive	not available	not available	Very positive	not available	Positive	Positive
Well in the desert	not available	not available	not available	not available	not available	not available	not available
Well in the desert	Slightly positive	Very positive	not available	Positive	not available	Positive	not available

Showing 1 to 4 of 4 entries Previous 1 Next

Off-site impacts of the SLM options

Show 10 entries Search:

SLMs in the area of interest	Water availability, quality and stable stream flow	Reduced downstream flooding	Reduced downstream siltation	Buffering/ filtering capacity (by soil, vegetation, wetlands)	Reduced wind transported sediments	Reduced damages on neighbour field and infrastructures	Reduced greenhouse gasses emissionsn
Cisterns	Slightly negative	Slightly positive	Slightly positive	not available	not available	not available	not available
Plantation for landscape restoration	not available	not available	not available	not available	not available	not available	not available
Well in the desert	not available	not available	not available	not available	not available	not available	not available
Well in the desert	Very positive	not available	not available	not available	not available	not available	not available

Showing 1 to 4 of 4 entries Previous 1 Next

Annex 7: A screenshot of synthesis, comparative tables of performance/impacts (7a) and cost (7b) of SLM options queried by a specific context in the WebGIS user interface

7a – Synthesis, comparative table of performance/impacts of SLM options queried by a specific context in the WebGIS user interface

SLMs in the area of interest	Biomass productivity decline (PROD-DEG) (Unit: % degraded area per the total area)	Biomass productivity improvement (PROD-IMP) (Unit: % improved area per the total area)	Rain use efficiency (RUE) (Unit: floating index)	Human appropriation of NPP (HANPP-PCT) (Unit: % of natural NPP used by human activities)	Gap between actual and potential NPP (Unit: NPP-GAPPC) (% of potential NPP)	Affected population (AFFECTED – POP) (Unit: 1000 people)	Affected rural population (AFFECTED-RPOP) (Unit: 1000 people)
Hill Dam	0.00	0.00	0.00	85.75	275.12	0.00	0.00
Manual benches	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Manual benches	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mechanical bench terraces	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mechanical bench terraces	0.00	0.00	0.00	85.31	282.40	0.00	0.00
Semi-circular bunds	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Semi-circular bunds	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Showing 1 to 7 of 7 entries

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7b – Synthesis, comparative table of cost of SLM options queried by a specific context in the WebGIS user interface

SLMs in the area of interest	Establishment cost					Maintenance cost				
	Labor	Equipment	Materials	Other inputs for establishment	Total	Labor	Equipment	Materials	Other inputs for maintenance	Total
Hill Dam	0	0	0	0	0	0	0	0	0	0
Manual benches	585	0	0	0	585	135	0	0	0	135
Manual benches	585	0	0	0	585	135	0	0	0	135
Mechanical bench terraces	0	500	0	0	500	0	300	0	0	300
Mechanical bench terraces	0	500	0	0	500	0	300	0	0	300
Semi-circular bunds	585	0	0	0	585	180	0	0	0	180
Semi-circular bunds	585	0	0	0	585	180	0	0	0	180

Showing 1 to 7 of 7 entries

Previous 1 Next

Annex 8. Key contextual variables in the GIS database embeded in WebGIS. 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*
Biophysical driver			
ARIDITY	Index of humidity, based on the balance between rainfall and evaporating transpiration (ET) (no unit) (Trabucco and Zomer, 2009)	Global	Raster, 1-km pixel size
PRECIP-TREND	Long-term trend of annual precipitation (floating trend coefficient) (Le et al., 2016)	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[1] aggregated from 22 classes of Globcover data (Bicheron et al., 2008)	Global	Raster, 1-km pixel size
TREE-DEN	Tree density (trees/km2) (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[2]) (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
Physical and institutional accessibility to land resources			
DIST-ROAD*	Distance to main road (km) (ICARDA, 2016)	Global	Raster, 1-km pixel size
DIST-TOWN*	Distance to district capital (km) (ICARDA, 2016)	Global	Raster, 1-km pixel size

[1] 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

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

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
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/km2) (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 (ICARDA, 2016)	Global	Raster, 1-km pixel size
Socio-ecological contextual similarity			
CSET-LE	CRP-DS's socio-ecological context type (numeric codes of different contextual types) (Le et al., in prep-a)	Global	Raster, 1-km pixel size
GLS-ASSELEN	Global land system (GLS) type (resampled from Asselen et al., 2012)	Global	Raster, 1-km pixel size
LSA-VACLAVIK	Land system archetypes (resampled from Vaclavik et al., 2016)	Global	Raster, 1-km pixel size

* indicates that the variable was computed by a member of the project team.

Annex 9. The concept of functional context socio-ecological type approach (fCSET)

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 retried 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 'the restoration of degraded land 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 4, resulting from integrated systems research cluster of the CRP Dryland Systems in 2016 (Le et al., in prep-a). Similar work will be done for Tunisia in 2017.

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 isolate 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) due to high intensity in spatial multivariate calculation over very large datasets.

fCSET is in the same line with what so-call land use system (LUS) unit such as what proposed/developed by FAO-LADA and Global Land Project (GLP), but developed with a tested functionality. The Global Land Use Systems propsed by FAO-LADA (Nachtergaele and Petri, 2008) to nest 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) developped 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/improvment and poverty reduction) is rather assumptions based on knowledge priories, 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 Deggradation Neutrality framework (Orr et al., in prep) should be truely functional, such as the fCSET developed by this project.

Annex 10. Classifications of Socio-Agro-Ecological Zones (SAEZ) and Agregated Land Use Systems (ALUS) in Tunisia

10a - Classifications of Socio-Agro-Ecological Zones (SAEZ)

Name of SAEZ	**CODE (given by the project)**
Mogods and Kroumerie	SAEZ1
Nord Est Cap Bon	SAEZ2
Dorsale et Tell	SAEZ3
Basse steppe	SAEZ4
Haute steppe	SAEZ5
Chainons atlassiques	SAEZ6
Chotts	SAEZ7
Dahar et Matmata	SAEZ8
Jeffara- El Ouara	SAEZ9
Grand Erg	SAEZ10

Source: CNEA/Elaboration d'une étude sur l'état de désertification pour une gestion durable des RN / Avril 2007.

10b - Classifications of Agregated Land Use Systems

Name of ALUS	**CODE (given by the project)**
Irrigated crops	ALUS1
Rainfed crops	ALUS2
Non-irrigated agro-pastoralism	ALUS3
Irrigated agro-pastoralism	ALUS4
Pastoralism on bare soils	ALUS5
Pastoralism on shrub lands	ALUS6
Natural zones	ALUS7
Urban areas	ALUS8
Parks and natural reserves	ALUS9
Ramsar sites	ALUS10

Source: DGACTA (2008). Rapport de préparation d'une carte LUS nationale : Version préliminaire. Réalisation d'une carte d'utilisation des terres à l'échelle 1/500 000 en se basant sur des données nationales disponibles et en suivant les directives LADA pour la starification et la cartographie LUS. MINISTERE DE L'AGRICULTURE ET DES RESSOURCES HYDAULIQUES. Tunisia, DIRECTION GENERALE DE L'AMENAGEMENT DES TERRES AGRICOLES**:** 76 pp.

Annex 11. SLM option by context (SLM OxC) data generated in the two study regions (Medenine and Zaghuoan governorates). Note : SLM OxC = SLM type x SAEZ x ASUS, where SAEZ and ASUS are shown in Annex 10, and SLM type are characterized using standardized SLM form.

11a- SLM OxC data generated in Medenine

Order ID	SLM Type	SAEZ	ALUS
1. Techniques targeting water and soil conservation			
1	Jessour	SAEZ8, SAEZ9	ALUS2
2	Tabia	SAEZ9	ALUS2, ALUS5
		SAEZ8	ALUS2, ALUS5
3	Runoff water collection (Flood spreading)	SAEZ9	ALUS1
4	Contour ridges	SAEZ9	ALUS7
5	Check dam for recharge	SAEZ8, SAEZ9	ALUS1
2. Techniques for controlling sand dune mobility			
6	Linear palm leaves fences	SAEZ9	ALUS1, ALUS2
		SAEZ8	ALUS2, ALUS3
7	Checkboard fences	SAEZ9	ALUS2
8	Biological fixation of sand dunes	SAEZ9	ALUS6
3. Techniques for rangelands management and improvement			
9	Rangeland fallow cropping	SAEZ9	ALUS5
4. Agronomic techniques and practices			
10	Deficit irrigation with salted water	SAEZ9	ALUS1
11	Buried diffusor	SAEZ9	ALUS1
5. Techniques targeting specifically water harvesting			
12	Cisterns	SAEZ9	ALUS4
		SAEZ8	ALUS4
13	Recharge well	SAEZ9	ALUS1
14	Artesian well	SAEZ8	ALUS4
15	Wells in the desert	SAEZ8	ALUS5
16	Oasis	SAEZ8, SAEZ9	ALUS3
6. Tree-based techniques			
17	Reforestation	SAEZ9	ALUS7

18	Tree plantation	SAEZ8	ALUS7
19	Area enclosure	SAEZ9	ALUS7

11a- SLM OxC data generated in Zaghouan

Order ID	SLM type	SAEZ	ALUS
1. Techniques targeting water and soil conservation			
1	Mechanical bench terraces	SAEZ2	ALUS1, ALUS2, ALUS3
		SAEZ3	ALUS1, ALUS2
2	Manual bench terraces	SAEZ2	ALUS2
3	Semi-circular bunds	SAEZ2	ALUS2
4	Stone bund terraces	SAEZ2	ALUS2, ALUS3
5	Gully restoration	SAEZ2	ALUS7
6	Gabion threshold	SAEZ2	ALUS2, ALUS7
		SAEZ3	ALUS2
Order ID	Techniques	SAEZ	ALUS
2. Techniques for rangelands management and improvement			
7	Planting of forage trees	SAEZ2	ALUS3
8	Replanting of local forage species	SAEZ2	ALUS3
3. Techniques targeting water harvesting			
9	Hill lakes	SAEZ2	ALUS1
		SAEZ3	ALUS1
		SAEZ5	ALUS1

10	Hill dams	SAEZ2	ALUS1
		SAEZ3	ALUS1
4. Tree-based techniques			
11	Reforestation/tree plantation	SAEZ2	ALUS7
		SAEZ3	ALUS7