Design soil-water-ecosystem processes experiments and monitoring campaign

Training of trainers / workshop

Mira Haddad and Stefan Strohmeier
s.strohmeier@cgiar.org

Nov 17, 2021 (online)

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“An ecosystem is a geographic area where plants, animals, and other organisms, as well as weather and landscape, work together to form a bubble of life. Ecosystems contain biotic or living, parts, as well as abiotic factors, or nonliving parts”

National Geographic Society I https://www.nationalgeographic.org/encyclopedia/ecosystem/print/

-> An ecosystem consists of biotic and abiotic components and thrives their interaction
-> Ecosystem services are the benefits from functioning ecosystems to humans

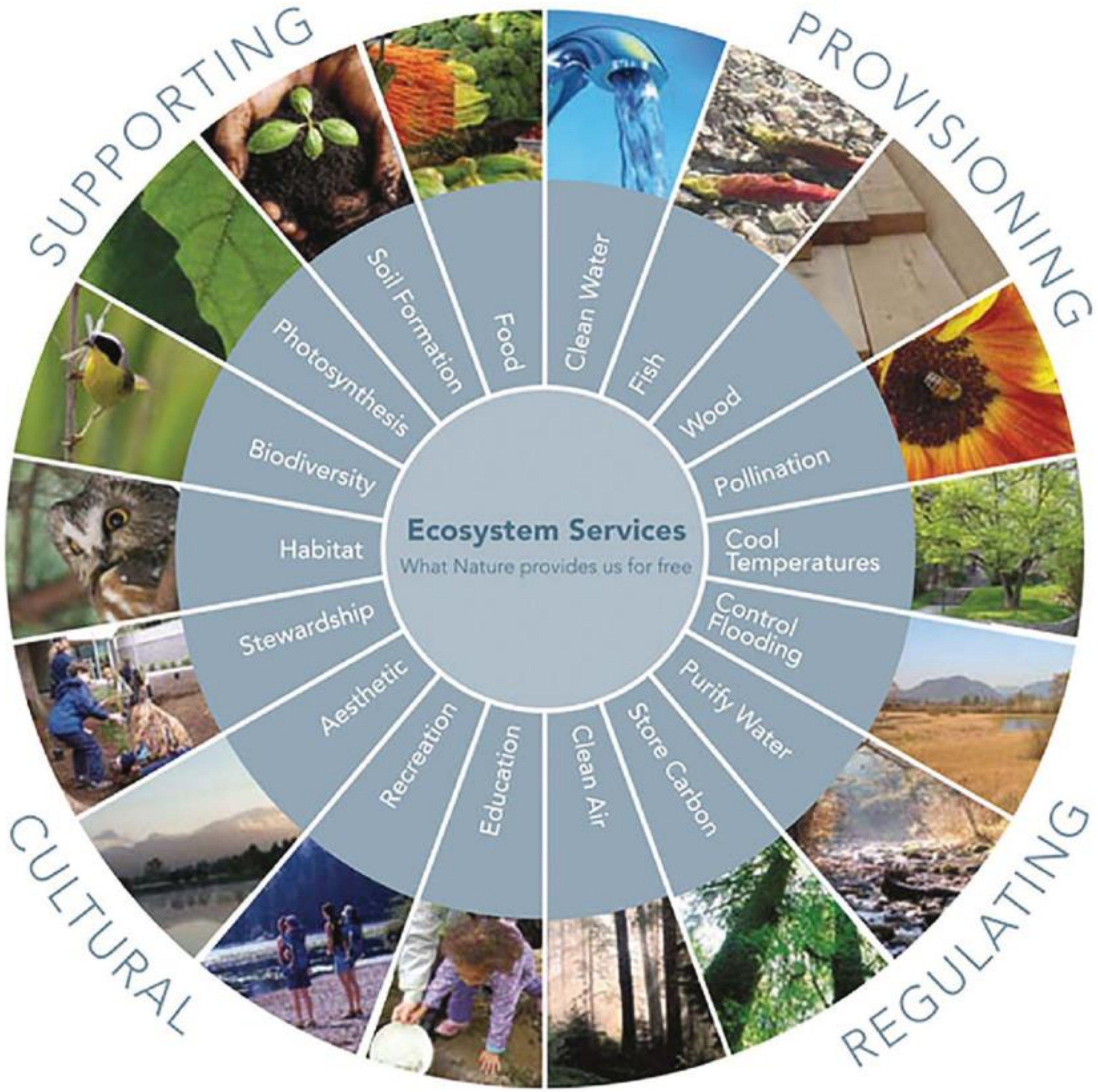
Development and history

- Scientific discussion on ecosystem (services) exists since decades
- 1990s: Various UN agencies identified the need for a harmonized procedure for ecosystem (services) assessment
- 2000s: Launching of the Millennium Ecosystem Assessment (MA)

MA confined 4 categories of ecosystem services

- Supporting
- Provisioning
- Regulating
- Cultural

Millennium Ecosystem Assessment (MA)

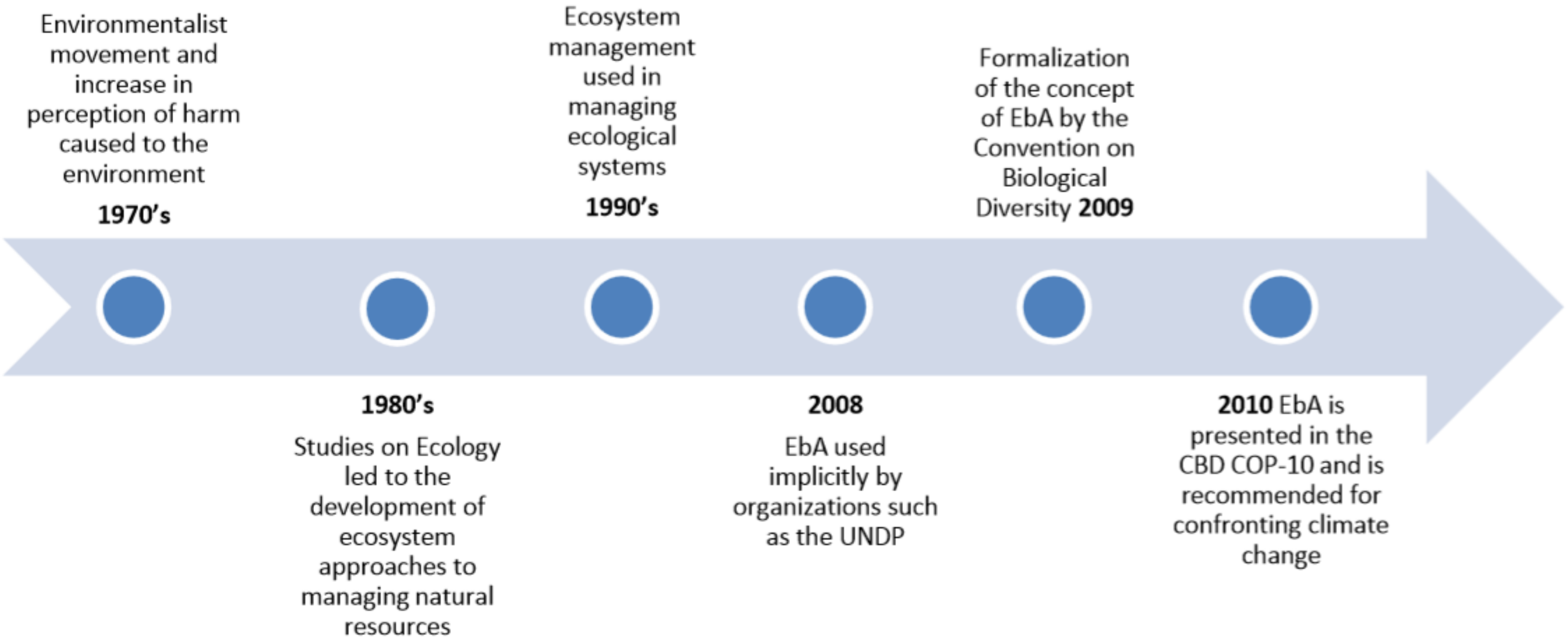


Millennium Ecosystem Assessment 2005

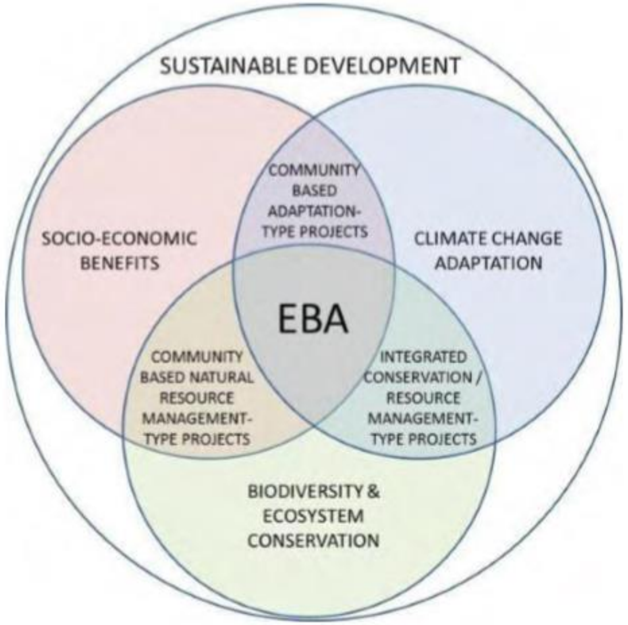
Climate Change is one of the greatest challenges of our time…

“Ecosystem-based adaptation is the use of biodiversity and ecosystem services as part of an overall adaptation strategy to help people to adapt to the adverse effects of climate change.”

CBD, 2009



EbA initiatives draw on a wide range of existing **practices** employed by the conservation and development sectors, such as **sustainable natural resource management**, **community-based natural resource management** and **community-based adaptation.**



FEBA, 2017

Livelihood sustenance and food security
help to ensure continued availability and access to essential natural resources so that communities can better cope with current climate variability and future climate change

Sustainable water management
Managing, restoring and protecting ecosystems can also contribute to sustainable water management by improving water quality, increasing groundwater recharge and reducing surface water run-off during storms.

Carbon sequestration
Sustainable management of forests can store and sequester carbon by improving overall forest health, and at the same time sustain functioning ecosystems that provide food, fibre and water resources that people depend on.

Hassan et al, 2005

… can help to assess the dynamics and value of and within the 'existing' system…
… can generate scenarios of potential futures for pre-evaluation…

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Brief recap from yesterday's RHEM exercise….

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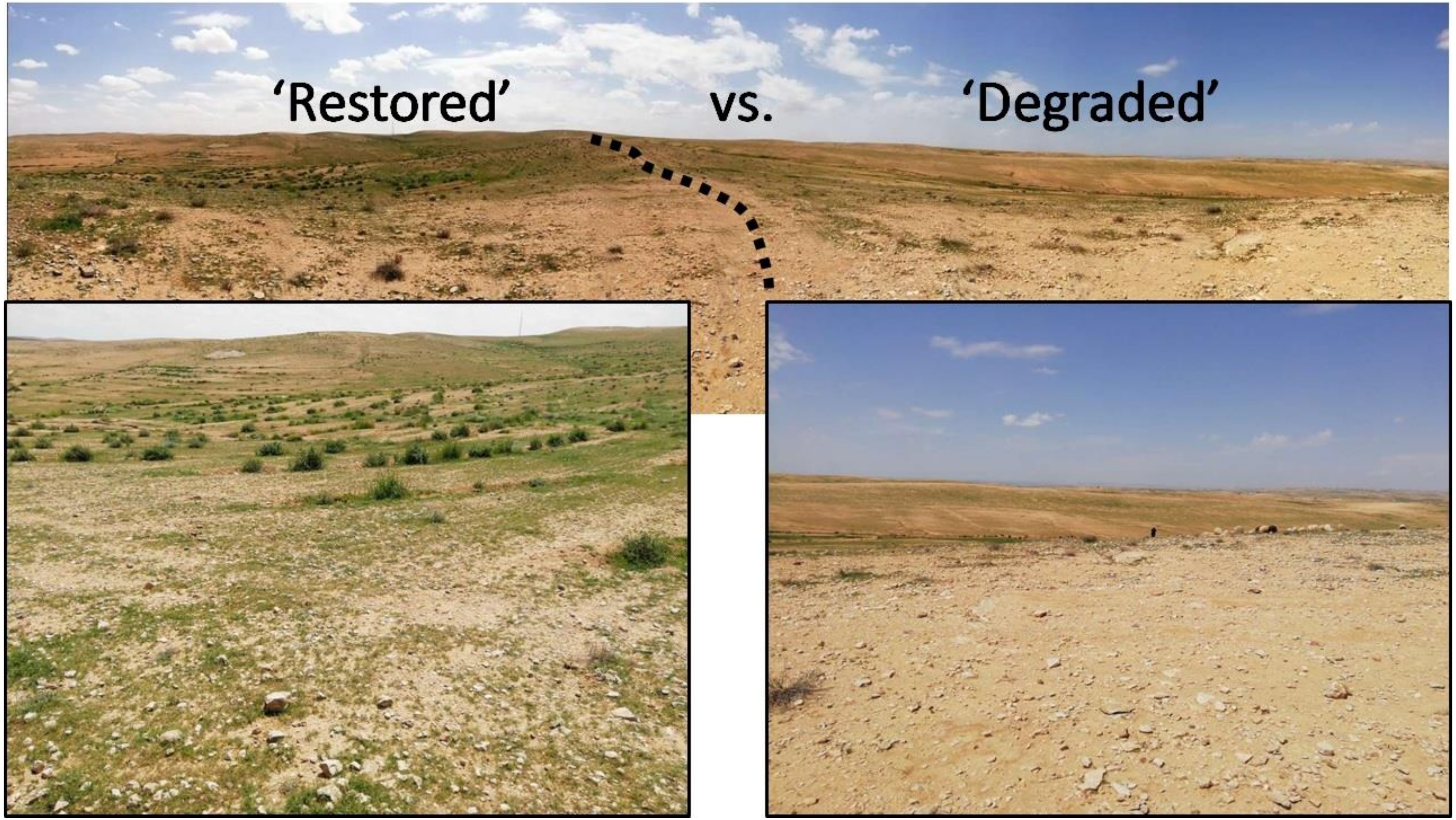
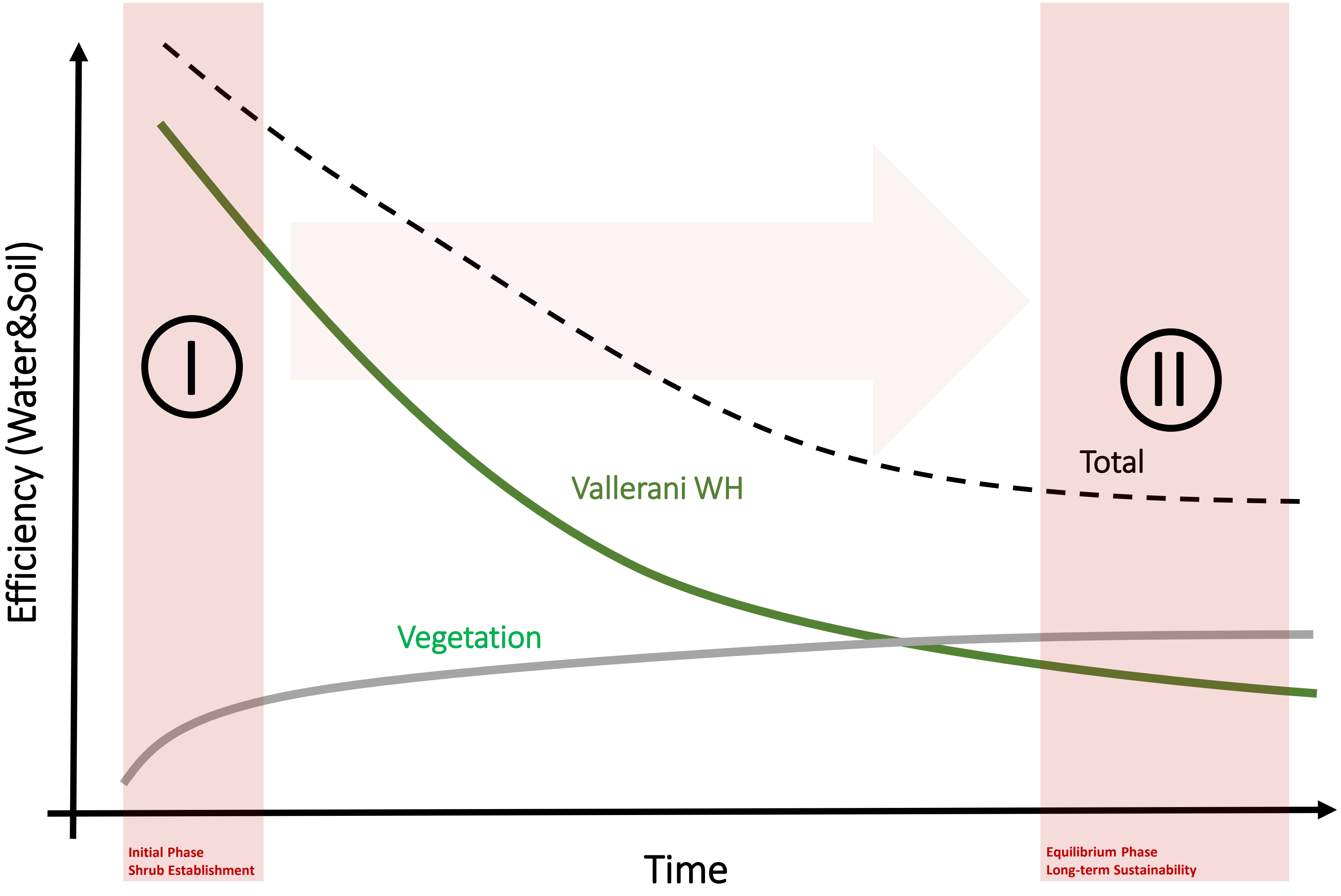
Transition status of degraded rangelands

Ecosystem transition proof

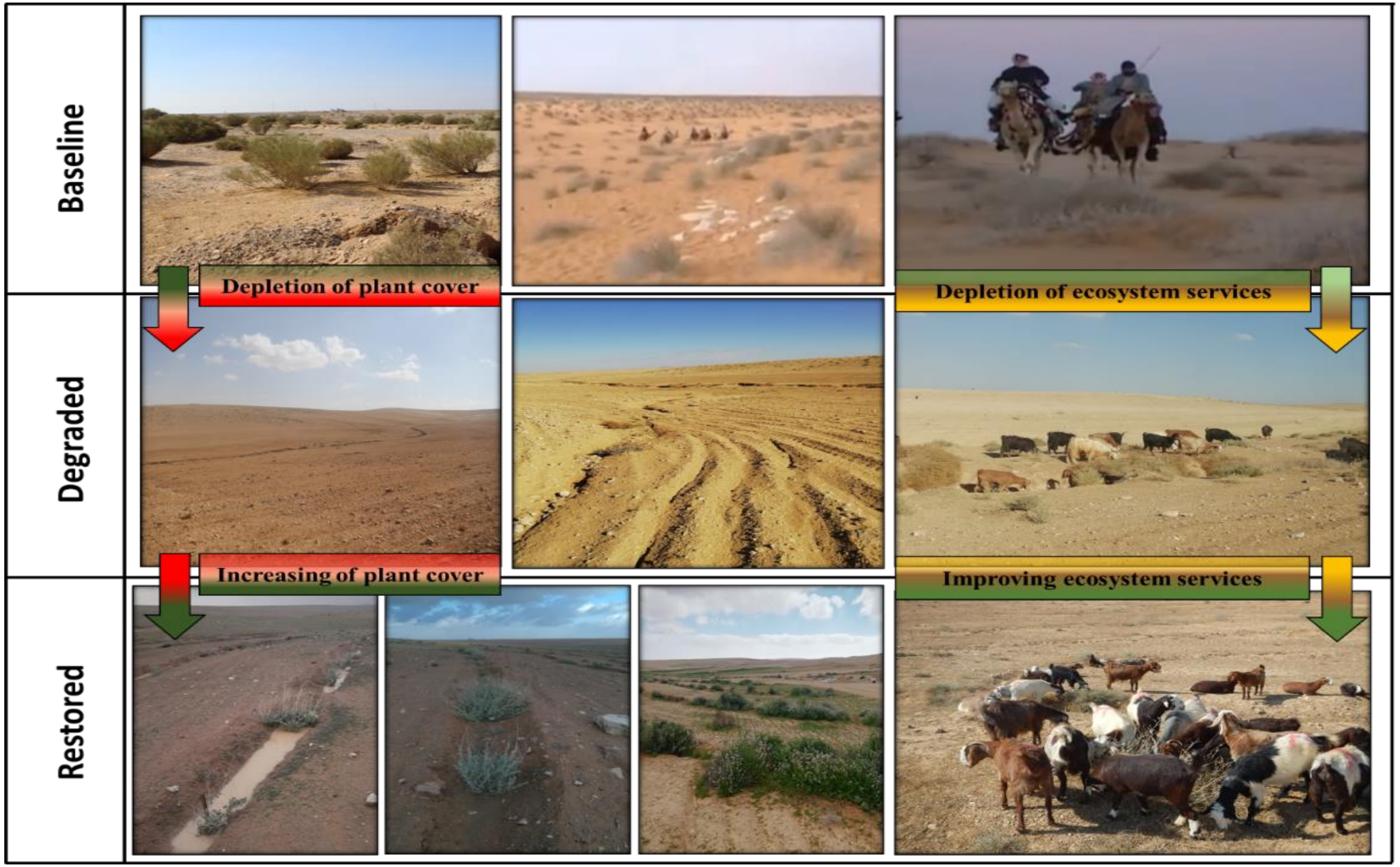


Can we assess and quantify change..?

Theoretical model



Modeling: rangeland status transition scenarios



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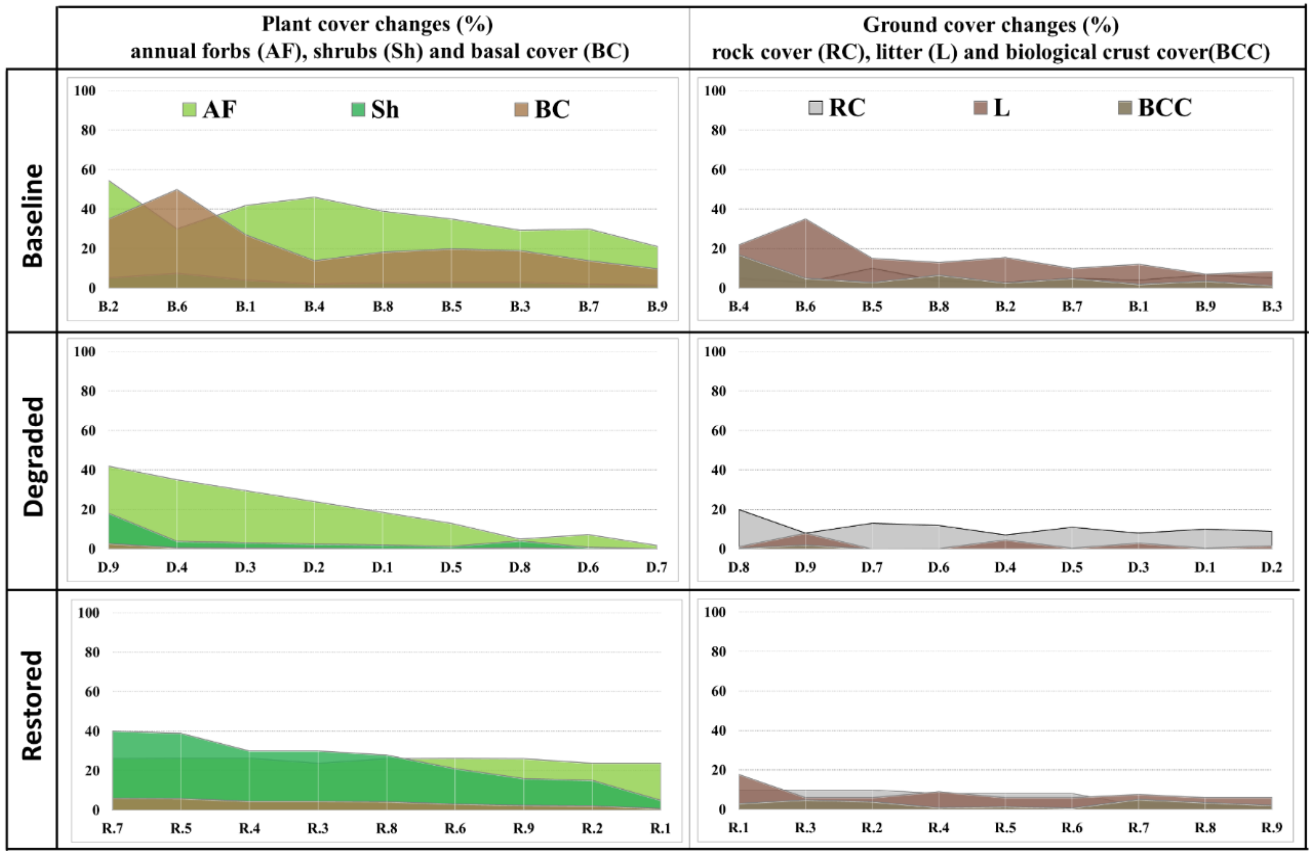
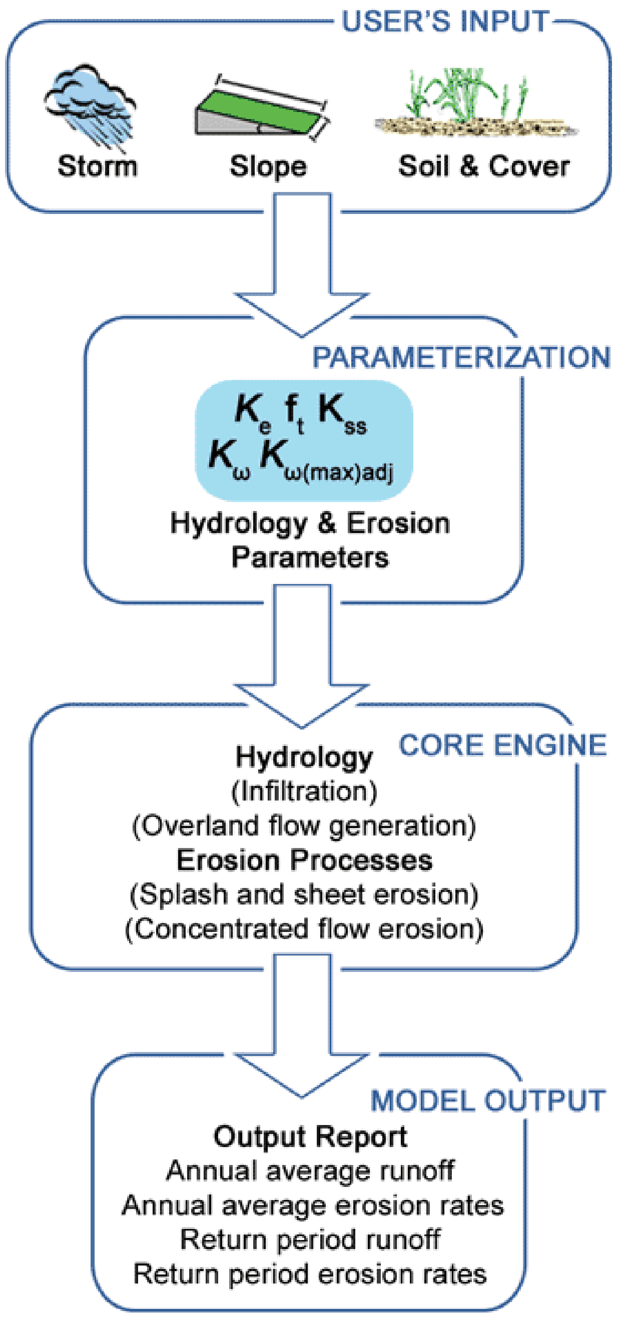
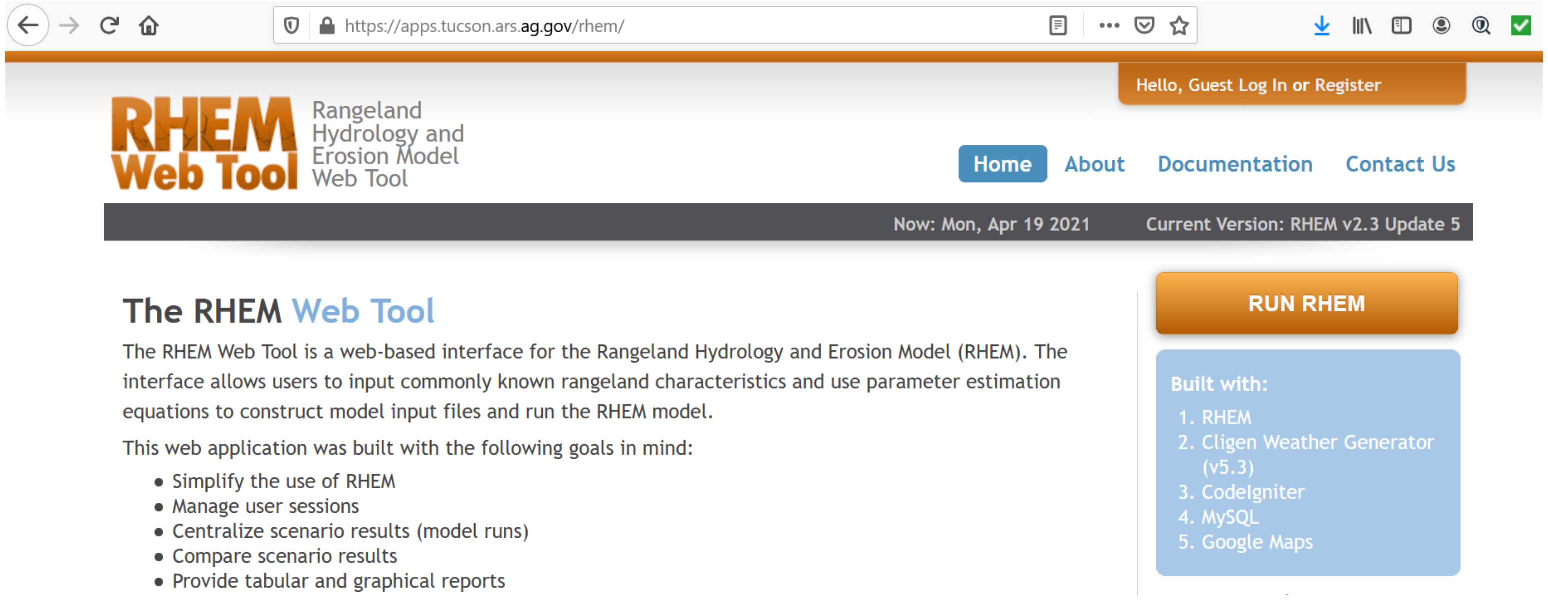
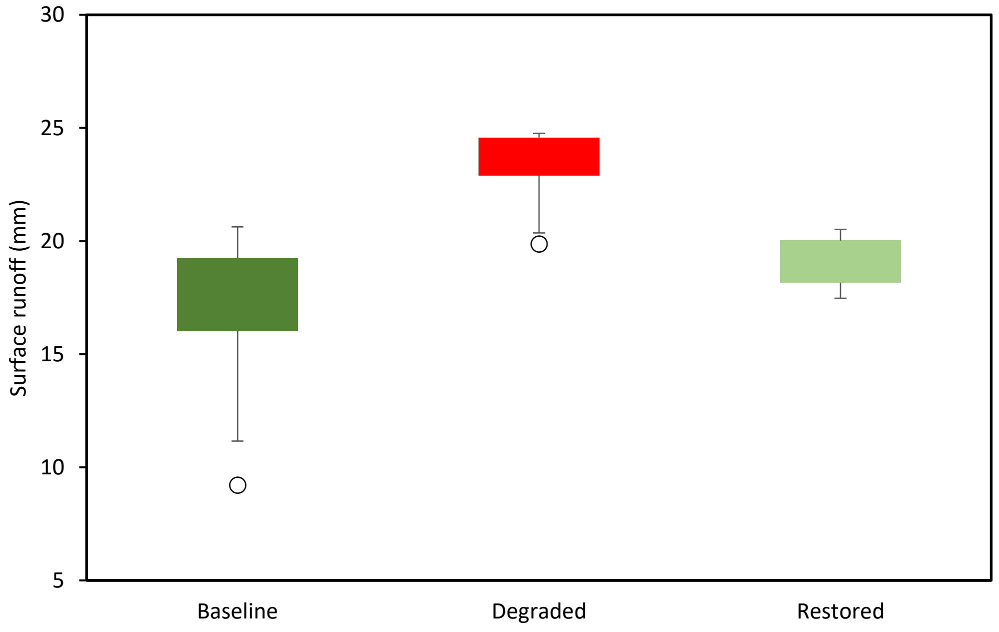


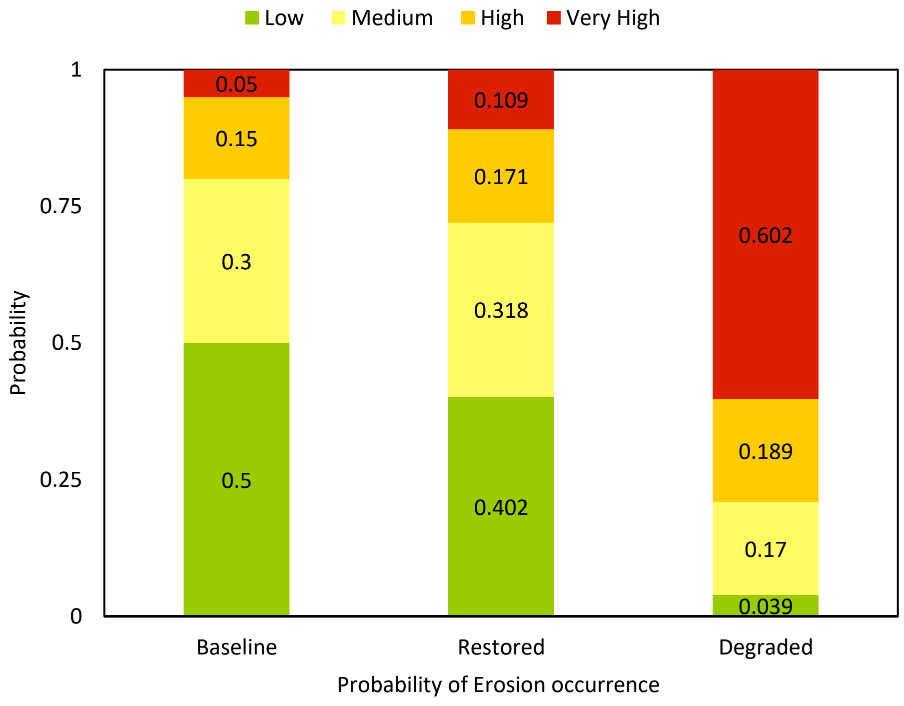
Modeling: rangeland status transition scenarios





Scenarios: surface runoff and erosion





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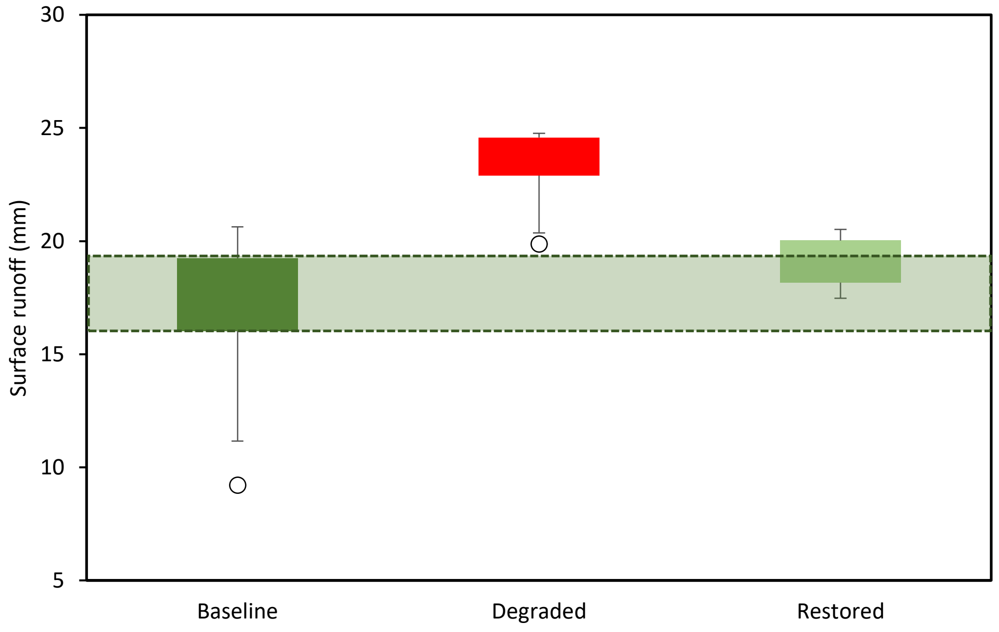
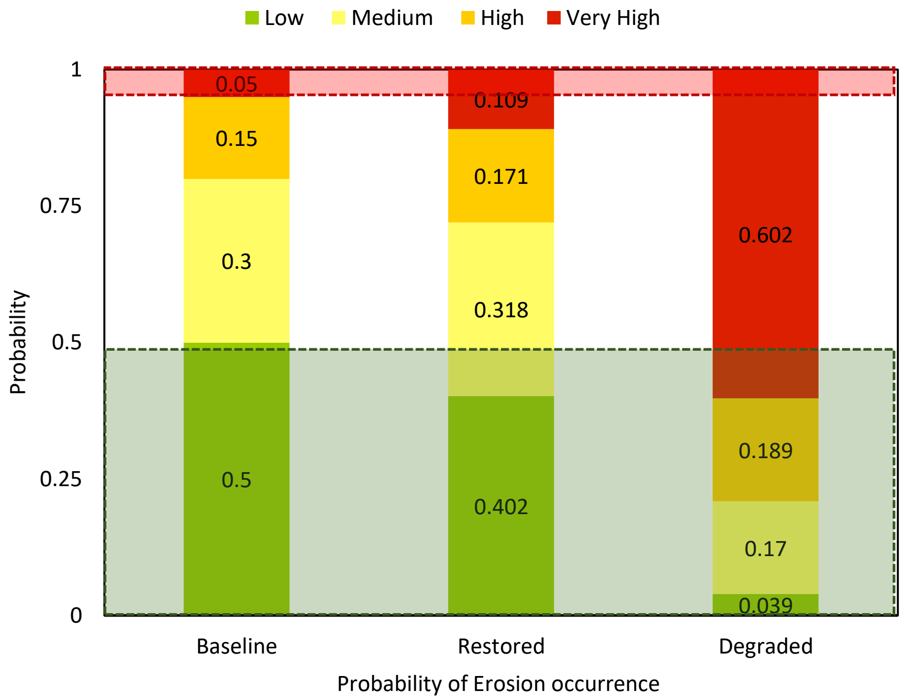
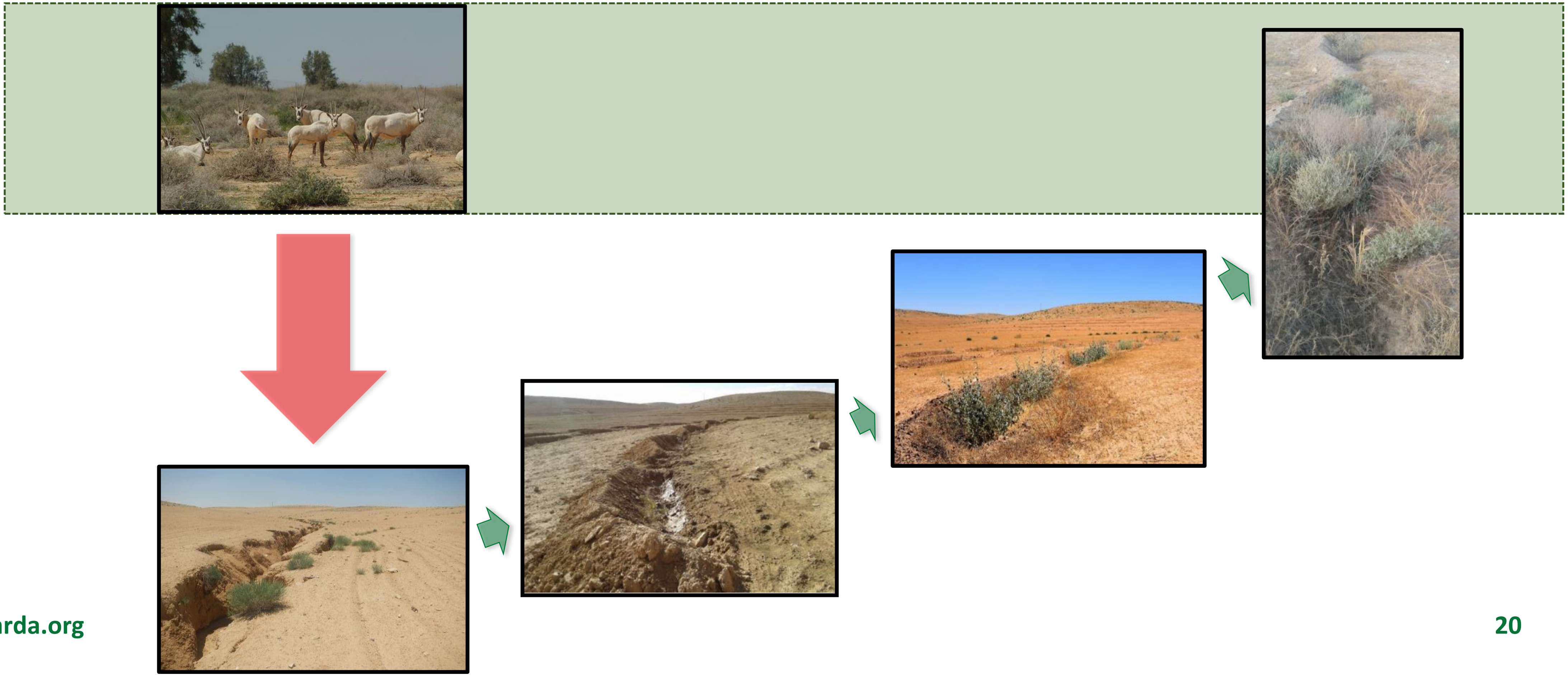
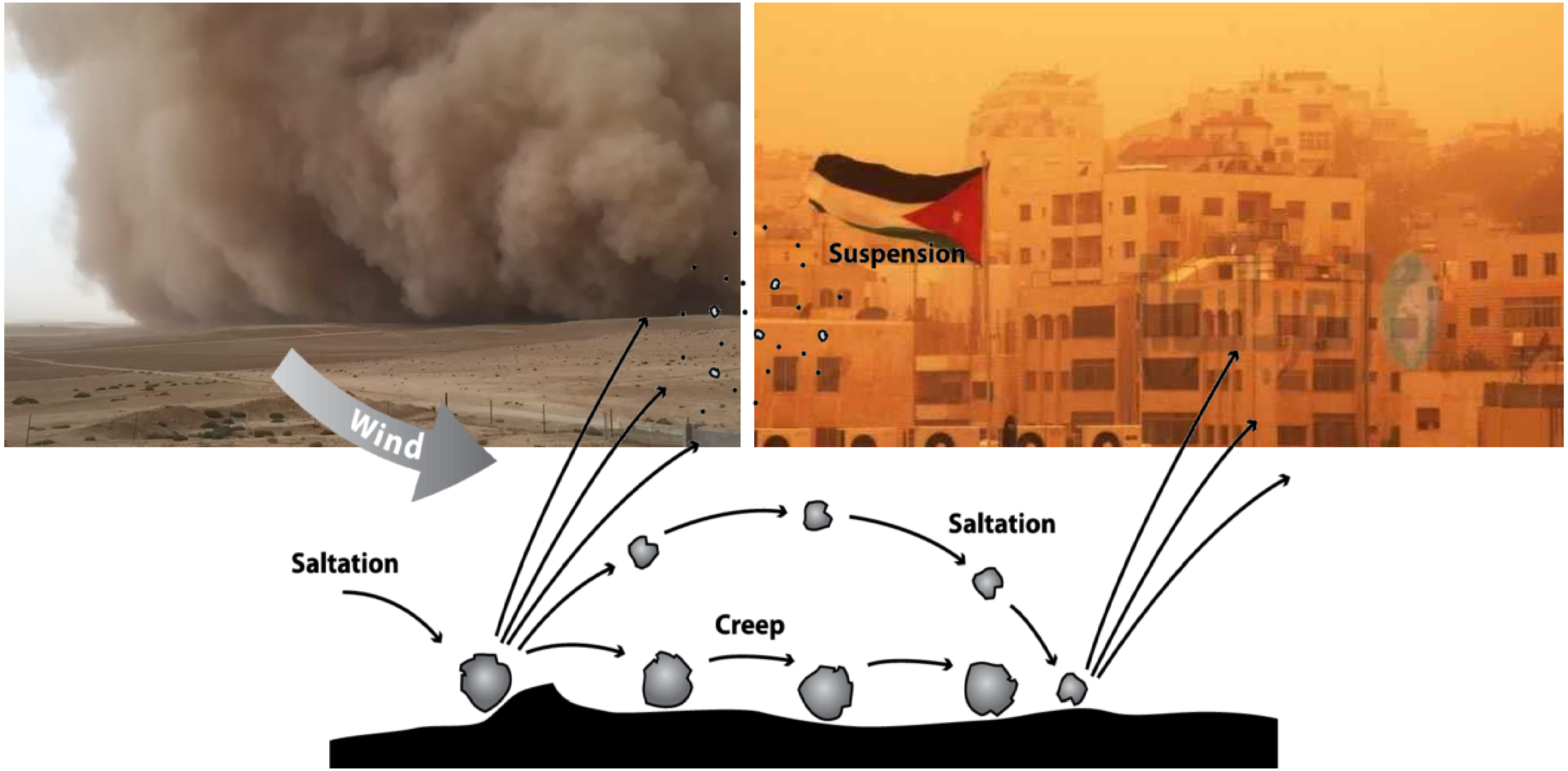




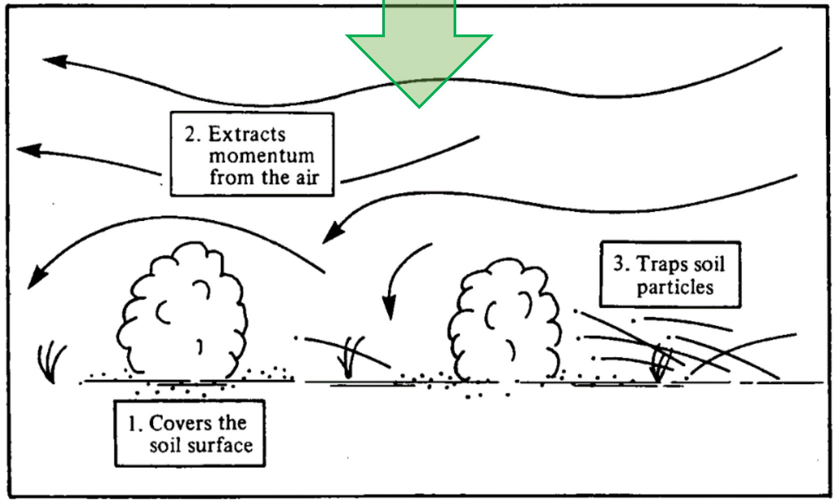
Ecosystem transition states



Ecosystem services: combatting Sand and Dust Storms



Agro-pastoral rehabilitation using in-situ Water Harvesting

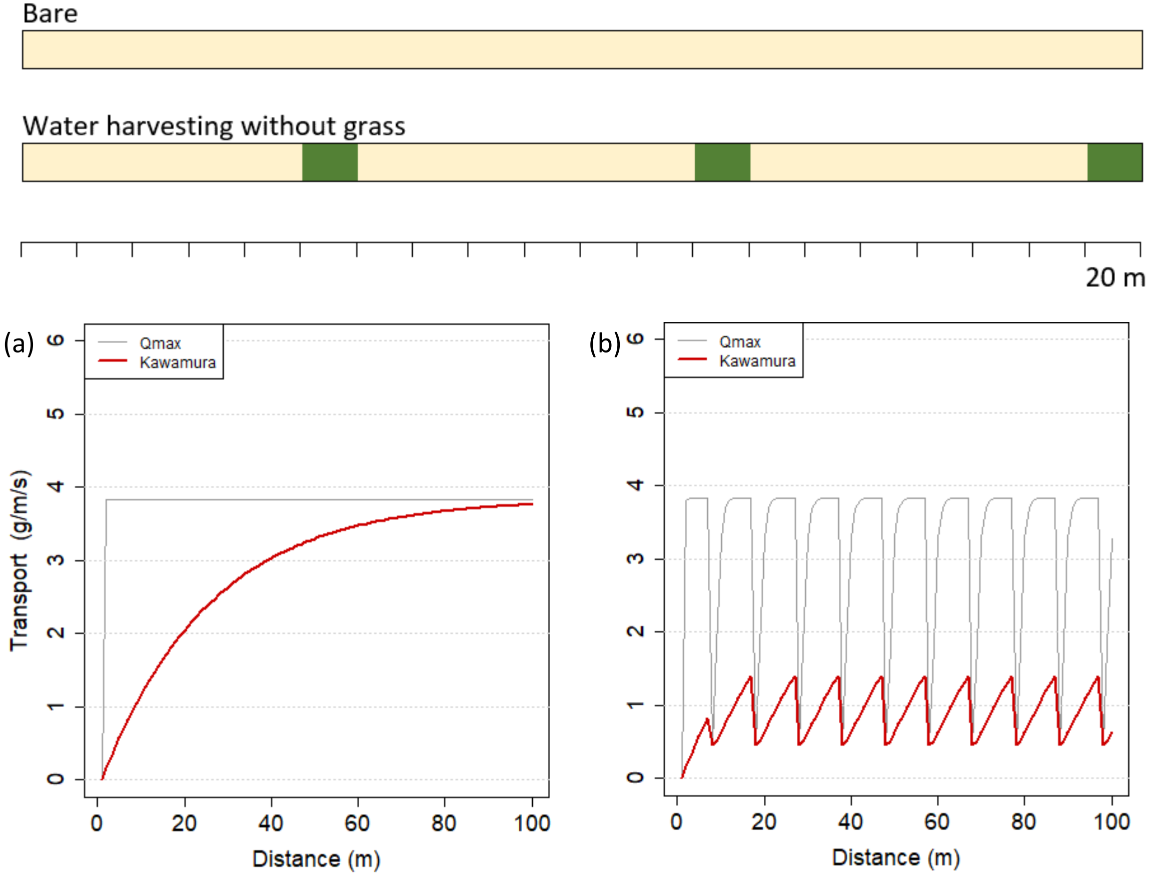


Source:
Kersten (2015)

Modeling rehabilitation scenarios

Setting up a wind erosion model

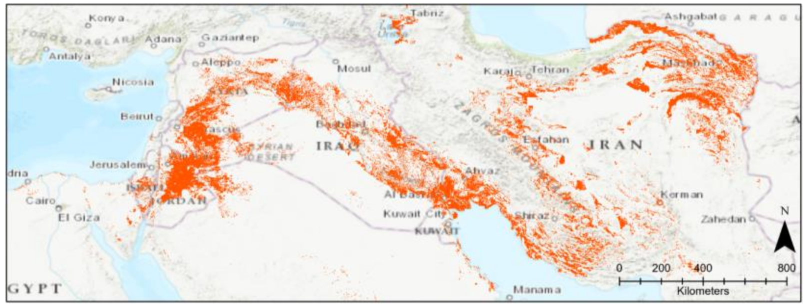
- 1D Cellular model (CCAS)
- Horizontal transport -> vertical flux
- WH and vegetation as obstacles (roughness)



Acknowledgement: Joint MSc of Utrecht University, National and Kapodistrian University of Athens, and ICARDA.

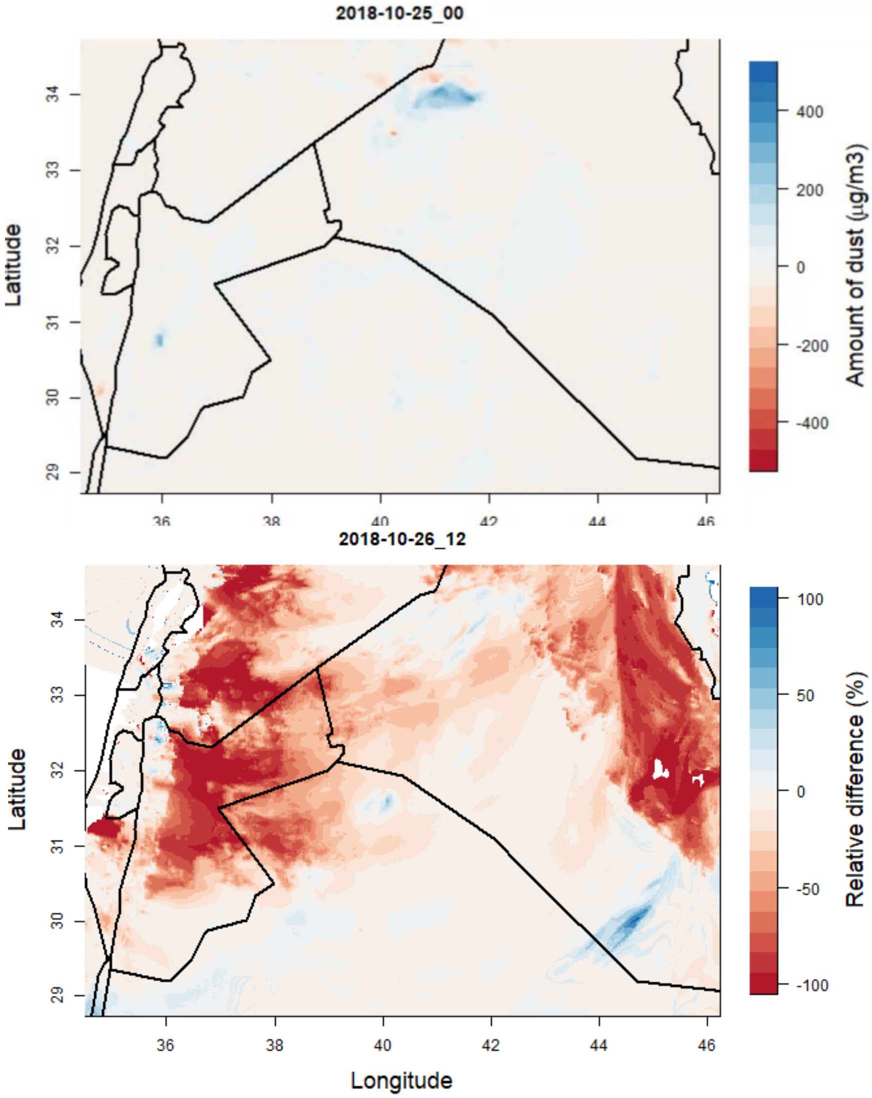
Large scale ecosystem benefits: combating sand and dust storms

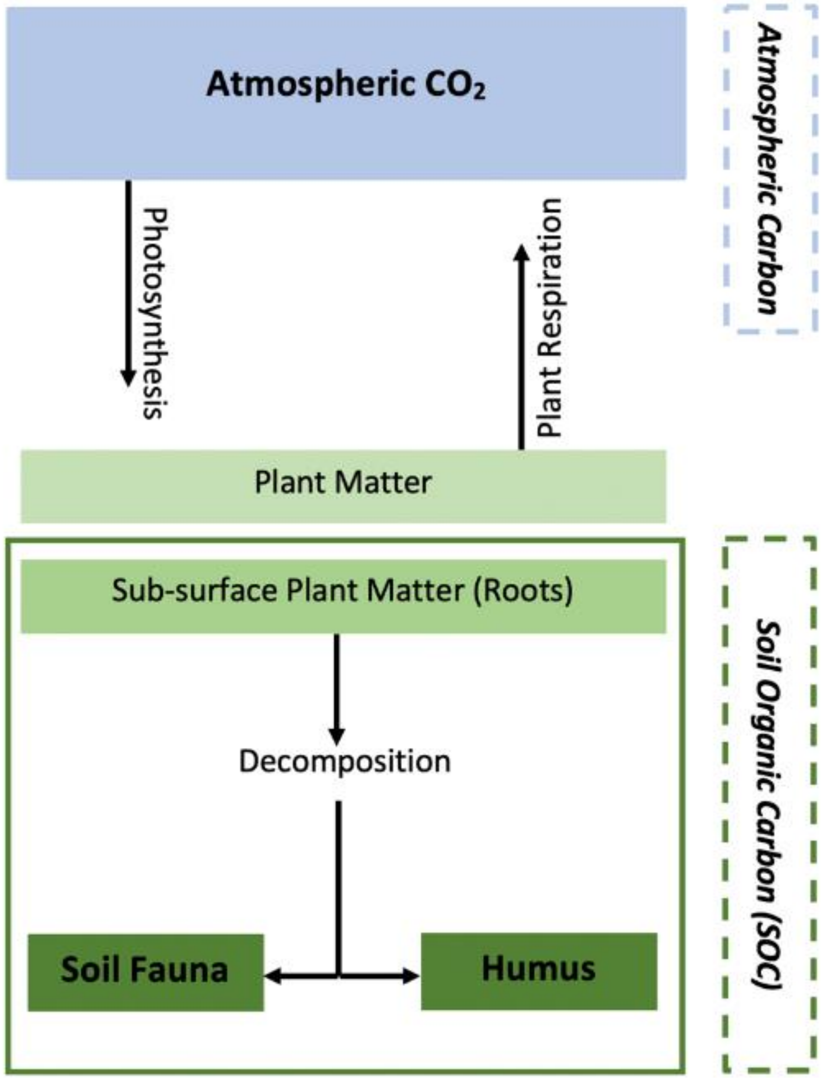
Outscaling mechanized micro WH



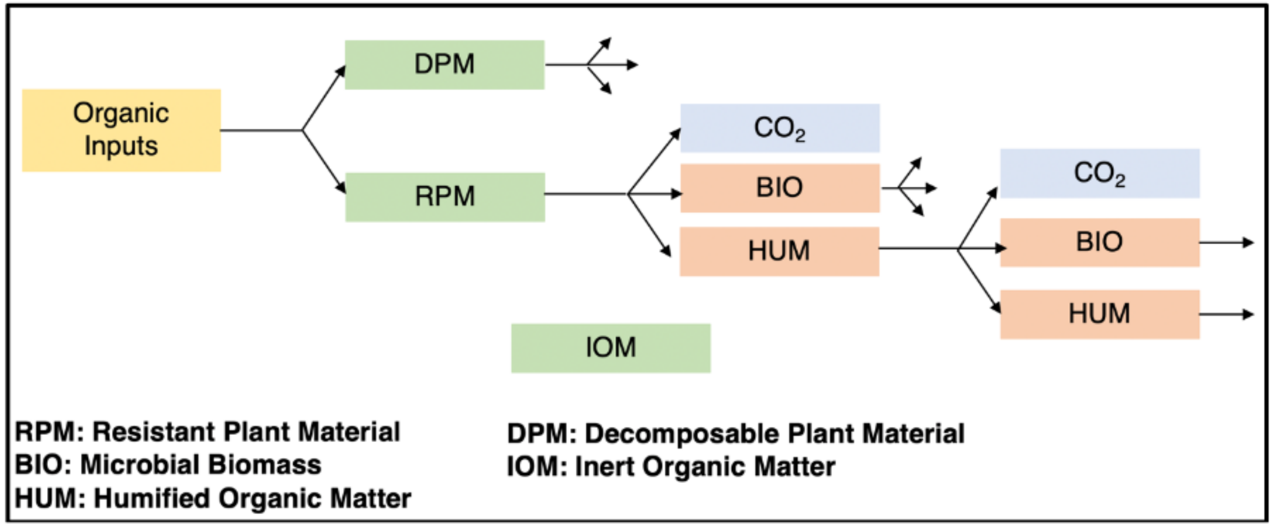
- GIS based site suitability (preliminary assessment)
- Climate, topography, soil, land cover/use
- Large atmospheric array simulation using RAMS

Acknowledgement: Joint MSc of Utrecht University, National and Kapodistrian University of Athens, and ICARDA.

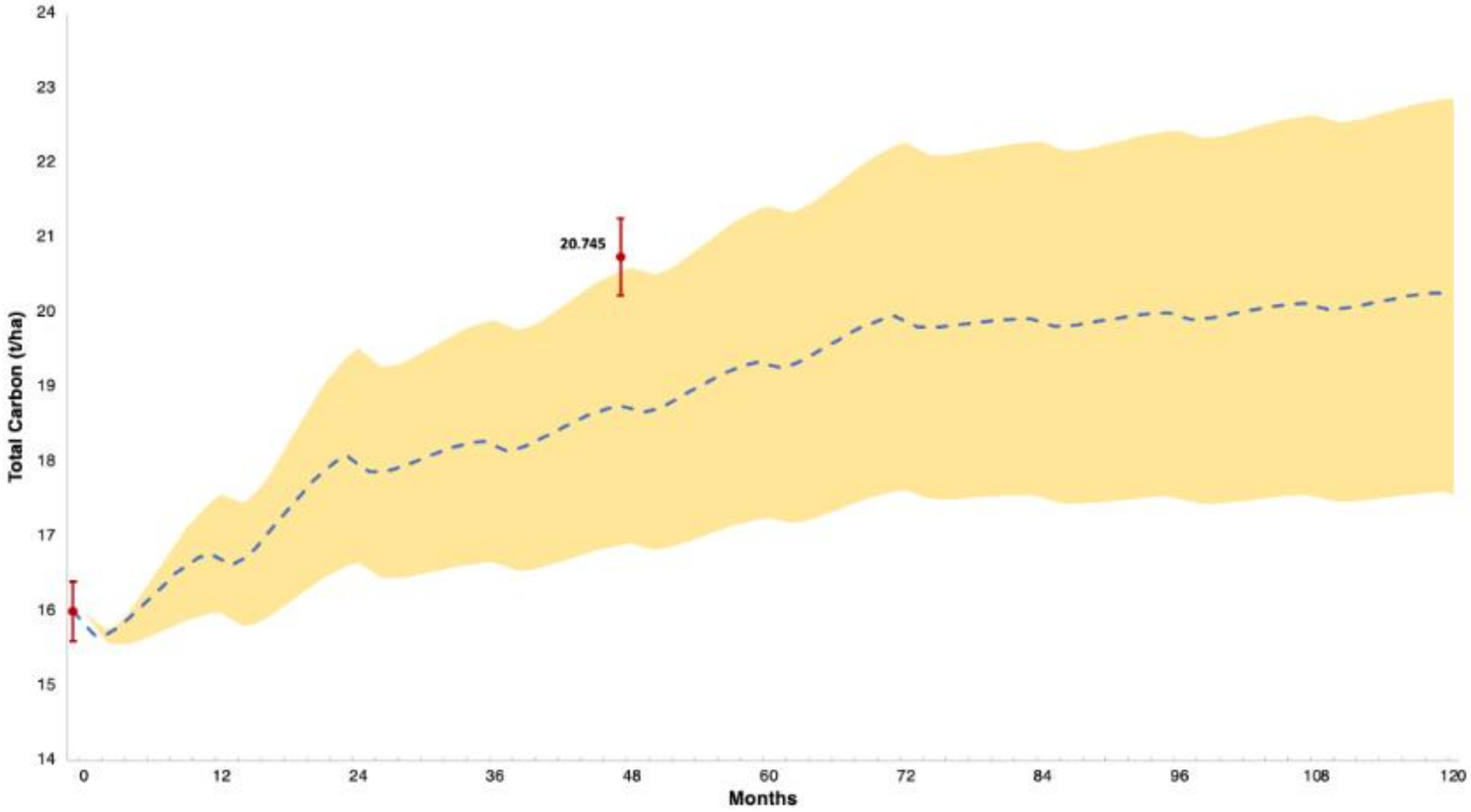




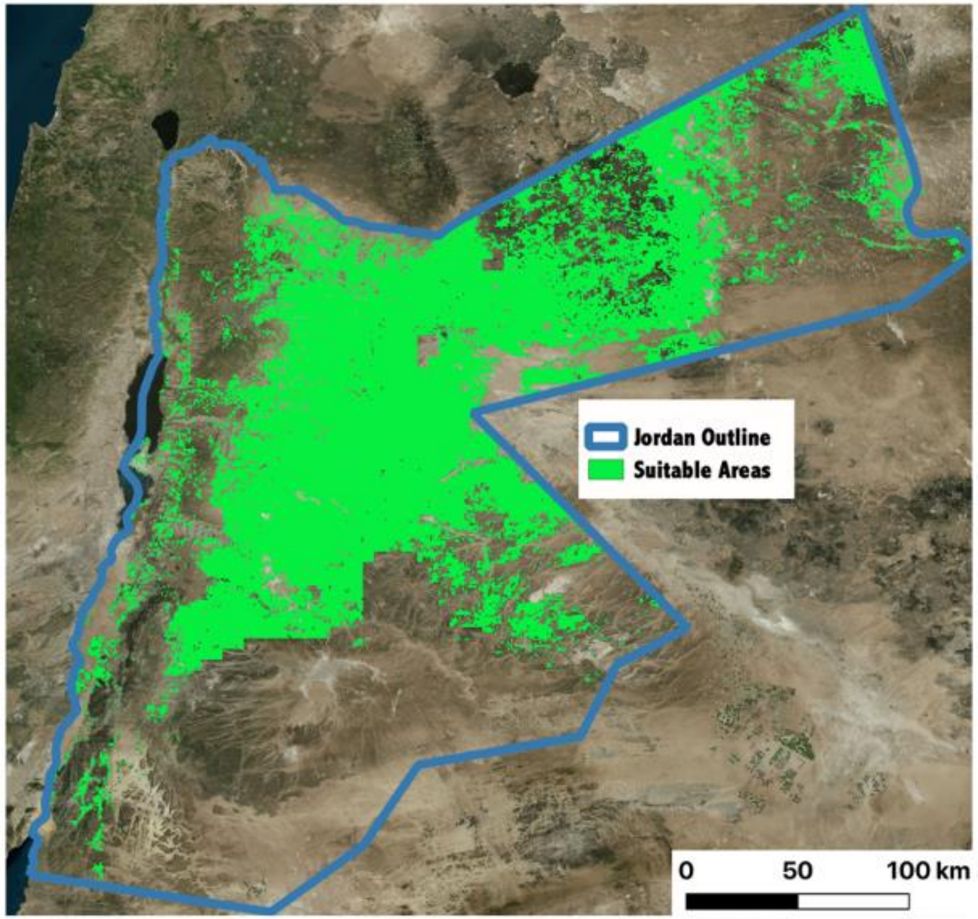
Modeling using RothC



Modeling carbon stocks



Economic value of carbon



Scenario	1	2	3	4
Carbon Price ($/ton)	30	55	80	120
Total Suitable Area (ha)	4,574,000			
Implementation Cost ($/ha)	95			
Total Carbon Sequestered (tons)	2,973,100			
Total Costs ($)	434,530,000			
Total Benefits ($)	89,193,000	163,520,500	237,848,000	356,772,000
Cost-Benefit Result ($)	*345,337,000*	*271,009,500*	*196,682,000*	*77,758,000*
Offset Cost ($/ha)	*75.50*	*59.25*	*43.00*	*17.00*

Benefits of marginal dryland rehabilitation beyond biomass
The ecosystem services approach

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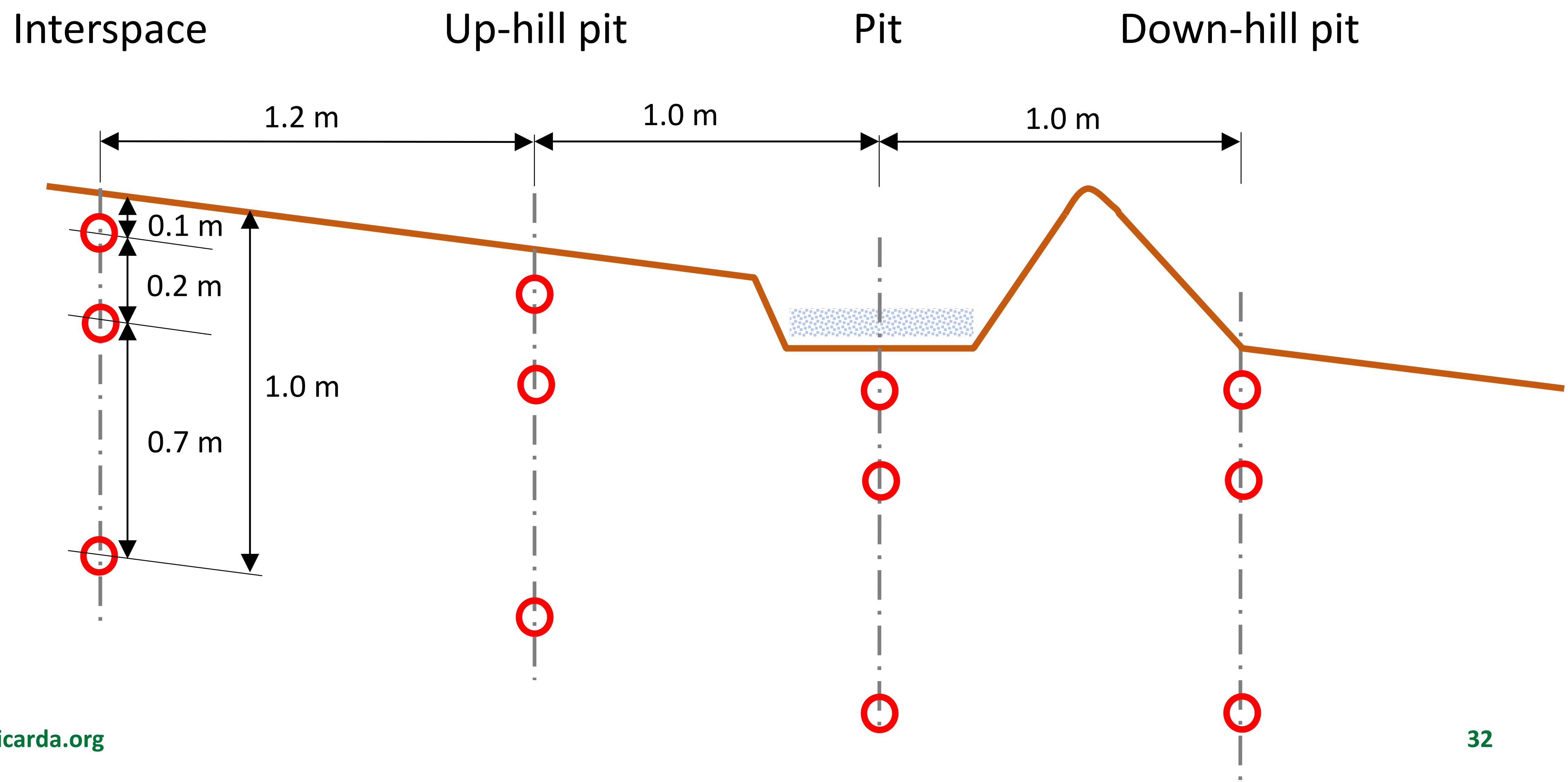
Testing and out-scaling in situ water harvesting approaches in Palestine

… enhanced capacities on water-food-ecosystem services nexus implications of in situ water harvesting based orchard agriculture will eventually increase local stakeholders' preparedness for uptake and out-scaling…

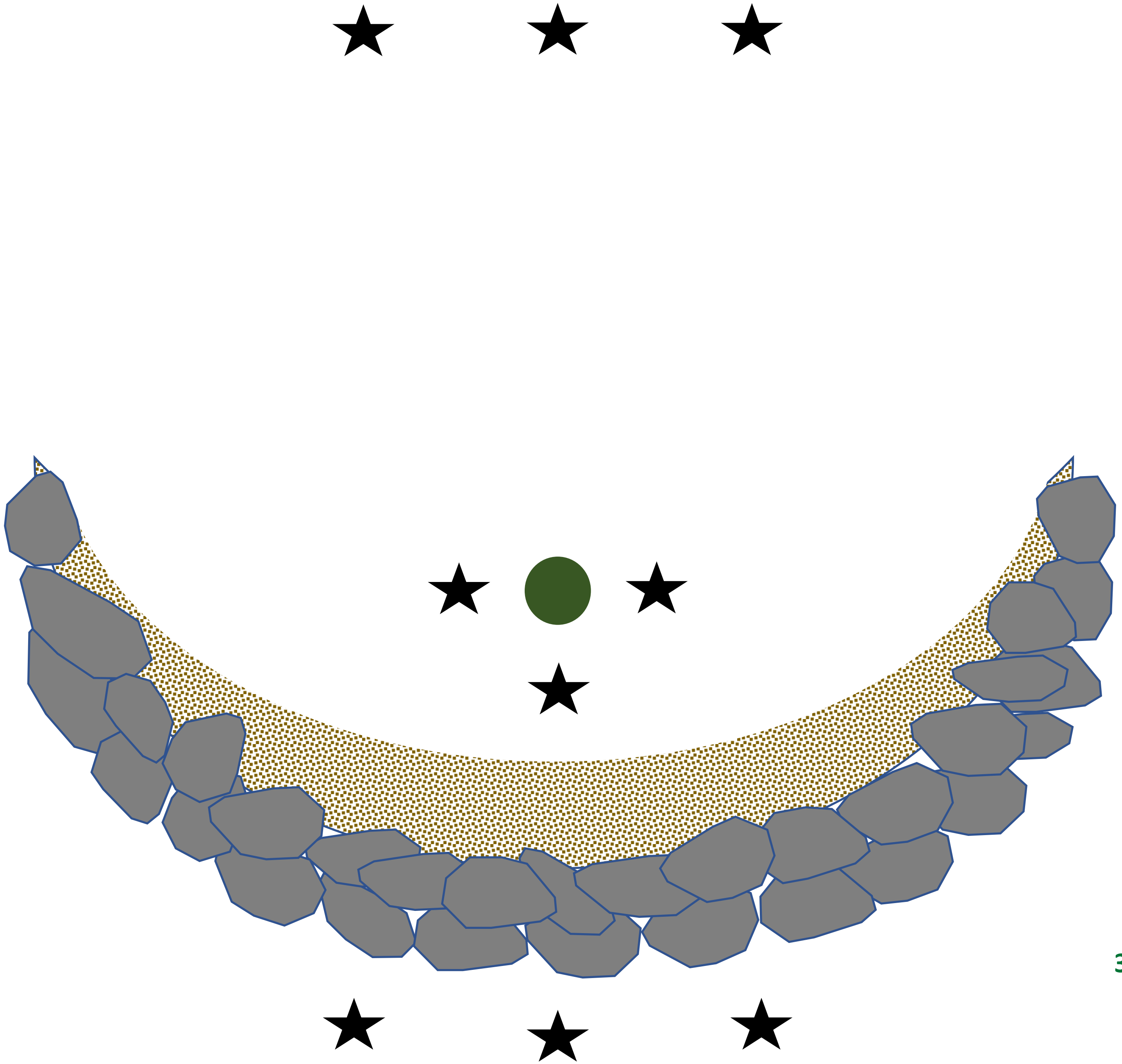
Water
Food
Ecosystem services

Monitoring
- Rainfall
- Runoff?
- Soil moisture

Modeling
- Surface runoff
- Soil water (states/stress)


Interspace
Up-hill pit
Pit
Down-hill pit
1.2 m
1.0 m
1.0 m
0.1 m
0.2 m
1.0 m
0.7 m


Acclima
True
TDR-315L



<u>Monitoring</u>

- Olive yield
- Other species/herbs?
- Silvo-pastoral grazing considerations?

-> farmers questionnaires?

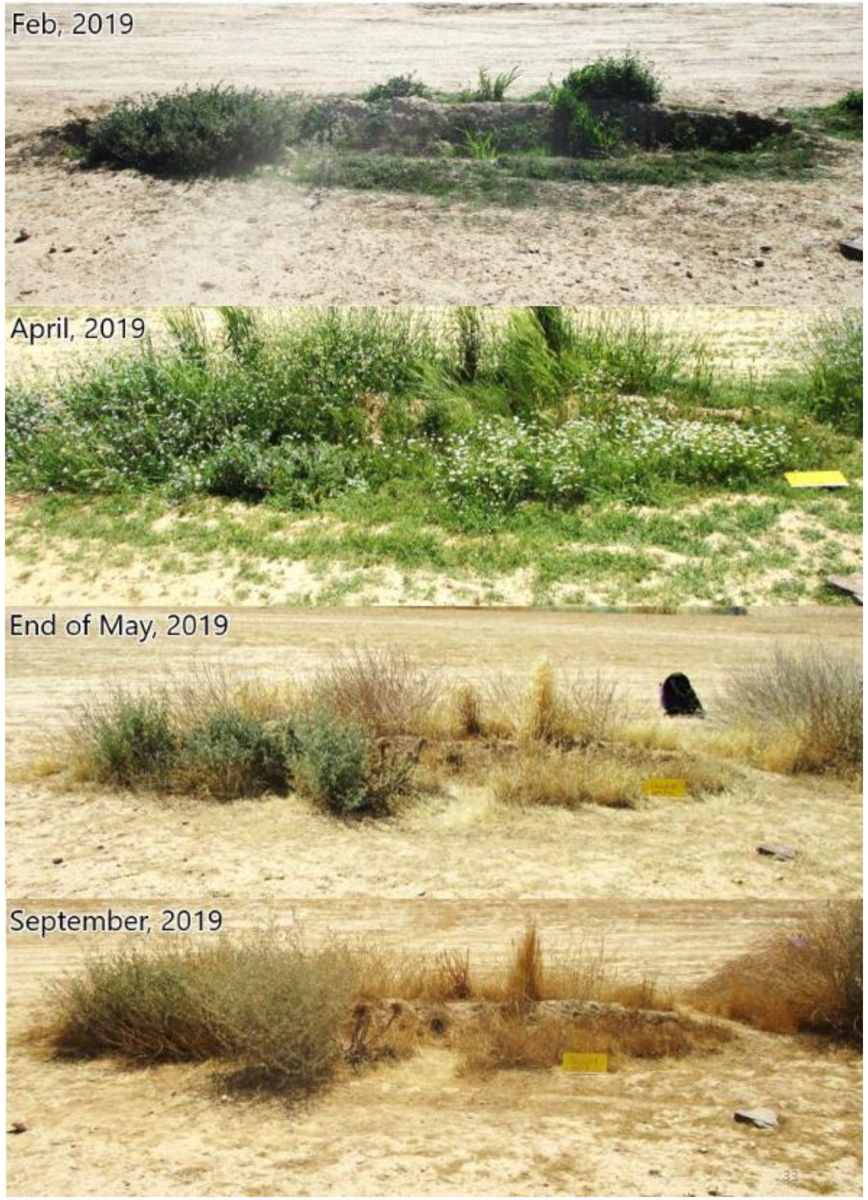
PLANT | SOIL | WATER

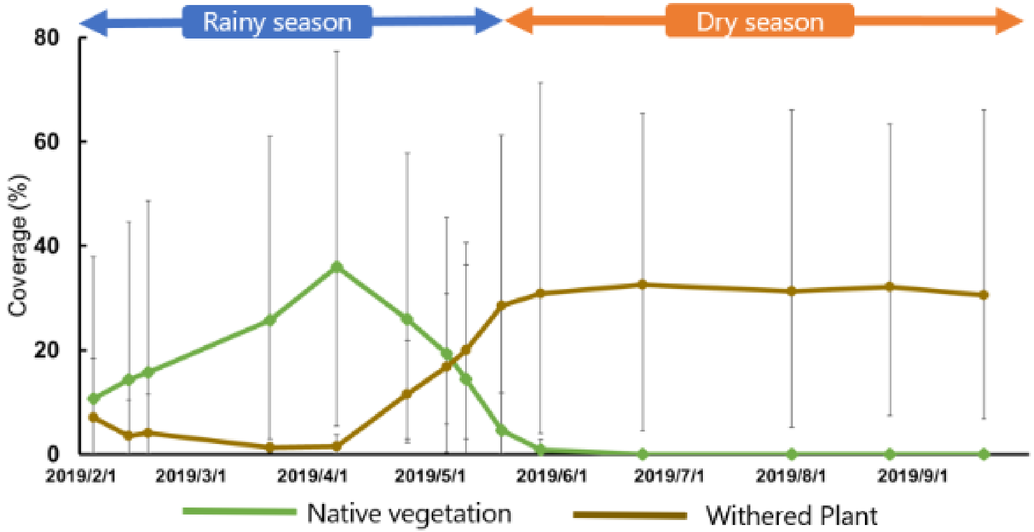
Monitoring
- Plant
- Soil

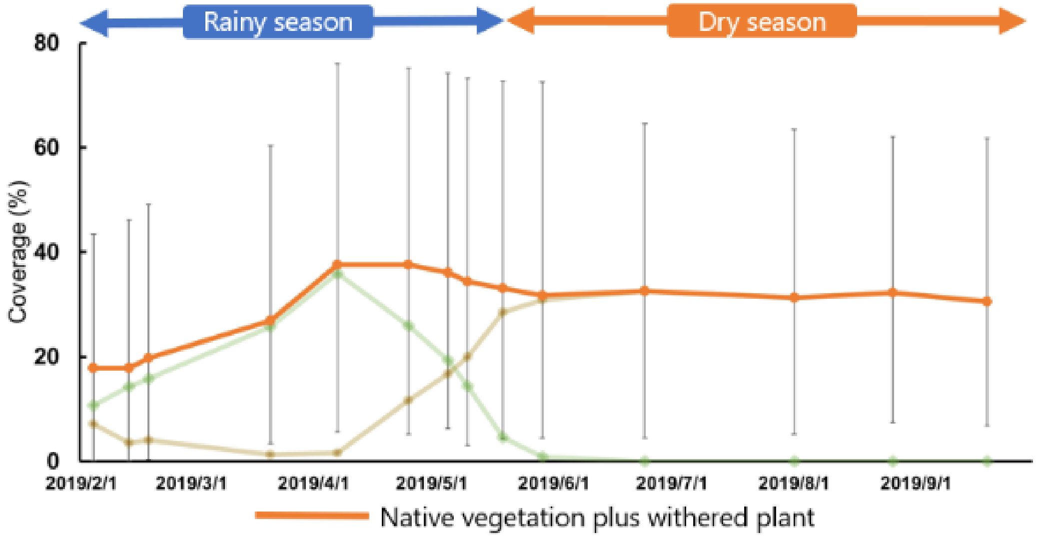
PLANT I SOIL I WATER

Monitoring

- Target plant biomass -> food
- Target plant status monitoring (survival rate, height, stem diameter)
- Biodiversity
- Vegetation cover (space & time)
- ….


Feb, 2019
April, 2019
End of May, 2019
September, 2019


Rainy season
Dry season
80
60
40
20
0
Coverage (%)
2019/2/1
2019/3/1
2019/4/1
2019/5/1
2019/6/1
2019/7/1
2019/8/1
2019/9/1
Native vegetation
Withered Plant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80
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Coverage (%)
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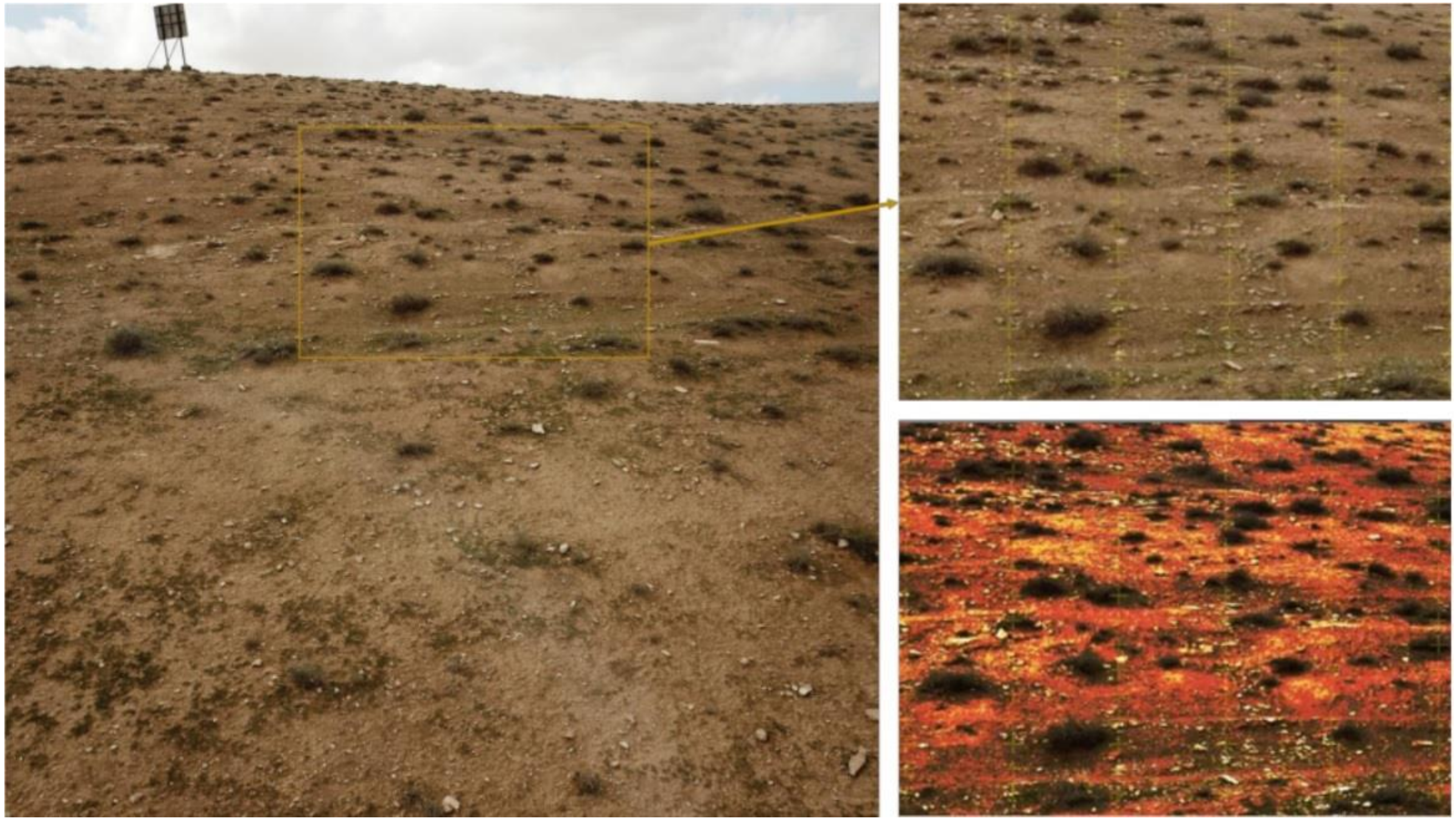
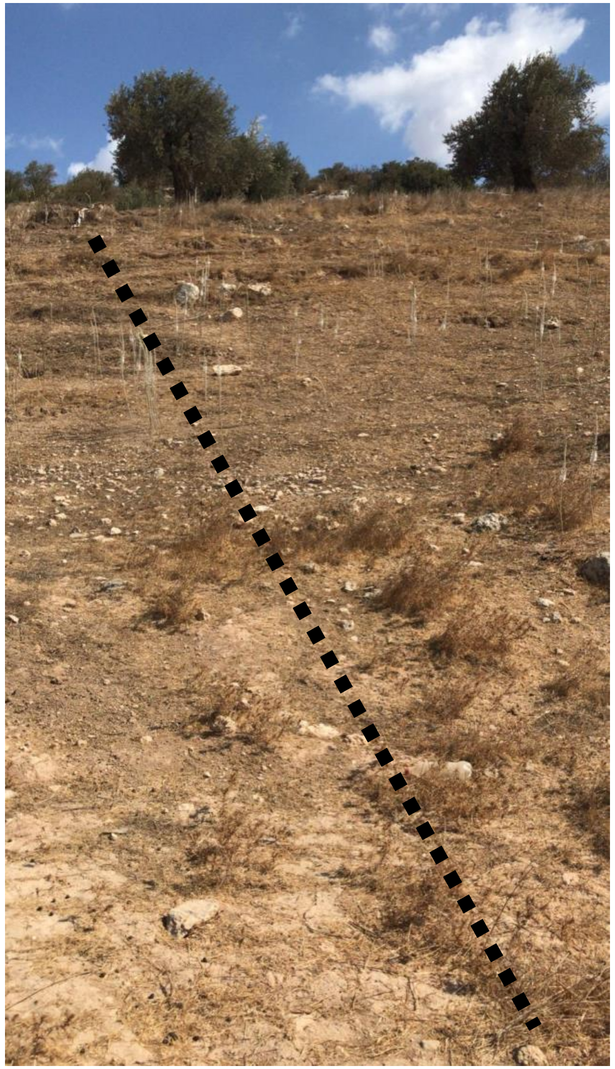
2019/4/1
2019/5/1
2019/6/1
2019/7/1
2019/8/1
2019/9/1
Native vegetation plus withered plant

ECOSYSTEM SERVICES: Plant

Image analysis through software: frequent and citizen sciences based



Transect analysis



Step Number	Cover			Bare Ground	Step Number	Cover			Bare Ground
	Veg.	Rock	Litter			Veg.	Rock	Litter	
1					26				
2					27				
3					28				
4					29				
5					30				
6					31				
7					32				
8					33				
9					34				
10					35				
11					36				
12					37				
13					38				
14					39				
15					40				
16					41				
17					42				
18					43				
19					44				
20					45				
21					46				
22					47				
23					48				
24					49				
25					50				

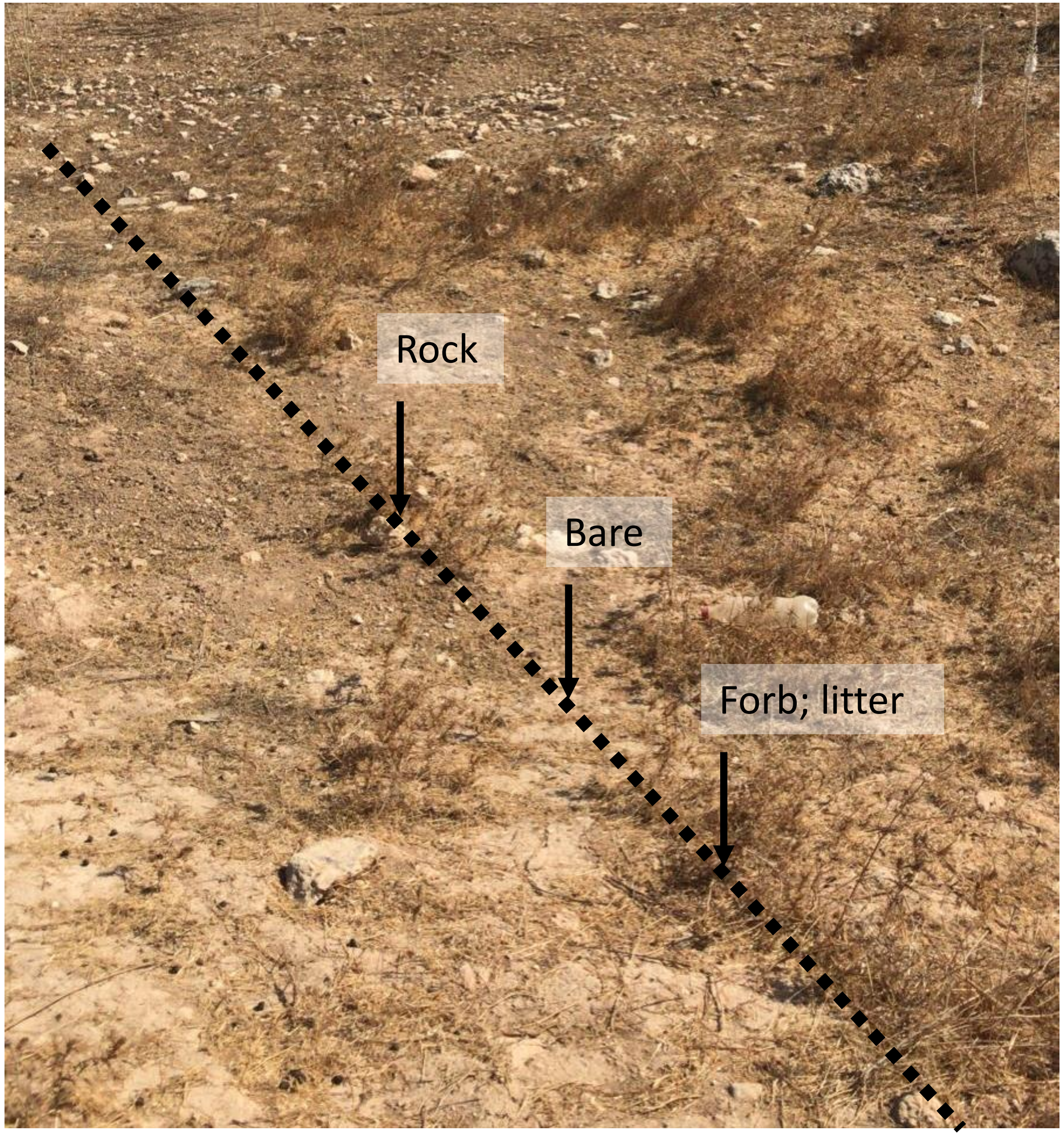
% Vegetative cover = ____ vegetation points X 2 = _____%

% Rock cover = ____ rock points X 2 = _____%

% Litter cover = ____ litter points X 2 = _____%

% Bare ground cover = ____ bare ground points X 2 = _____%

Transect analysis



PLANT I SOIL I WATER

Monitoring

- Surface marks (e.g. erosion rills)
- Surface crust analysis
- Disturbed soil samples (aggregates, texture, carbon, nutrients, …)
- Undisturbed (surface) samples (bulk density, pore space, water holding capacity (lab), hydraulic conductivity, ...)
- ….

Surface rill analysis

Weltz et al., 2021 (Rangeland Processes: Hydrology and Soil Erosion)

Soil Health Assessment

Soil health, or soil quality, describes the continued capacity of a soil to function as a vital living ecosystem that sustains plants, animals, and humans. Main services of a well-functioning soil are (Seybold et al., 1998):

1. Sustaining biological activity, diversity, and productivity
2. Regulating and partitioning water and solute flow
3. Filtering and buffering, degrading, immobilizing, and detoxifying organic and inorganic materials, including industrial and municipal by-products and atmospheric deposition
4. Storing and cycling nutrients and other elements within the earth's biosphere
5. Providing support of socioeconomic structures and protection for archeological treasures associated with human habitation

Quantitative soil health indicator list (adapted from: USDA NRCS, 2001)
Ranking: (1) highly feasible / highly recommended; (5) not feasible / not recommended (for discussion).

INDICATOR	CONTEXT	FEASIBILITY	RECOMM.
PHYSICAL			
Soil structure	Retention and transport of water and nutrients, habitat for microbes, and soil erosion	3	1
Depth of soil and rooting	Estimate of crop productivity potential, compaction, and plow pan	3	2
Infiltration and bulk density	Water movement, porosity, and workability	2	1
Water holding capacity	Water storage and availability	2	2
CHEMICAL			
pH	Biological and nutrient availability	2	1
Electrical conductivity	Plant growth, microbial activity, and salt tolerance	1	1
Extractable nitrogen (N), phosphorus (P), and potassium (K)	Plant available nutrients and potential for N and P loss	4	3
BIOLOGICAL			
Soil organic matter (SOM)	Soil fertility, structure, stability, nutrient retention, soil erosion, and available water capacity	4	2
Microbial biomass carbon (C) and N	Microbial catalytic potential and repository for C and N	4	4
Potentially mineralizable N	Soil productivity and N supplying potential	4	5
Soil respiration	Microbial activity measure	5	5

.... Lets brainstorm and draft