Webinar: Microclimate

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META META

JUSTDIGGIT

CGIAR | RESEARCH PROGRAM ON Water, Land and Ecosystems

3R MANAGING THE WATER BUFFER

Spate Irrigation Network

Microclimate in WLE fieldwork

“The forest land in the mountains is considered as God's daughter land. Under the shade of trees land is cool (temperature) compared to bare lands”.

“We can see now mist on the grass on the conserved area and also observe that moisture retention is higher there.”

“Due to the intervention the day temperature and night temperature are warmer and is less fluctuating, this is our indication that we will have good summer rainfall.”

Overview

- Why microclimate
- What is a microclimate
- Microclimate factors
- Towards a microclimate toolkit
- Practical examples by JustDiggIt

Why microclimate

- Changes to the landscape change the microclimate
- Microclimate changes are now often an ‘unintended’ by-product of other interventions > this should change
- Focusing on the microclimate can uncover methods to increase the resilience of a landscape
  - Help buffer (global) climate change and climate extremes
  - More productive landscapes
- Understanding of microclimate relationships at landscape level and their impacts in the field is missing

Microclimate management

- Microclimate management has been a factor in farming for thousands of years
    - Incan microclimate experimentation in Moray, Peru (~1440-~1530)
- Third way in CC – managing the micro-climate next to adaptation and mitigation

Endakomeni, Ethiopia

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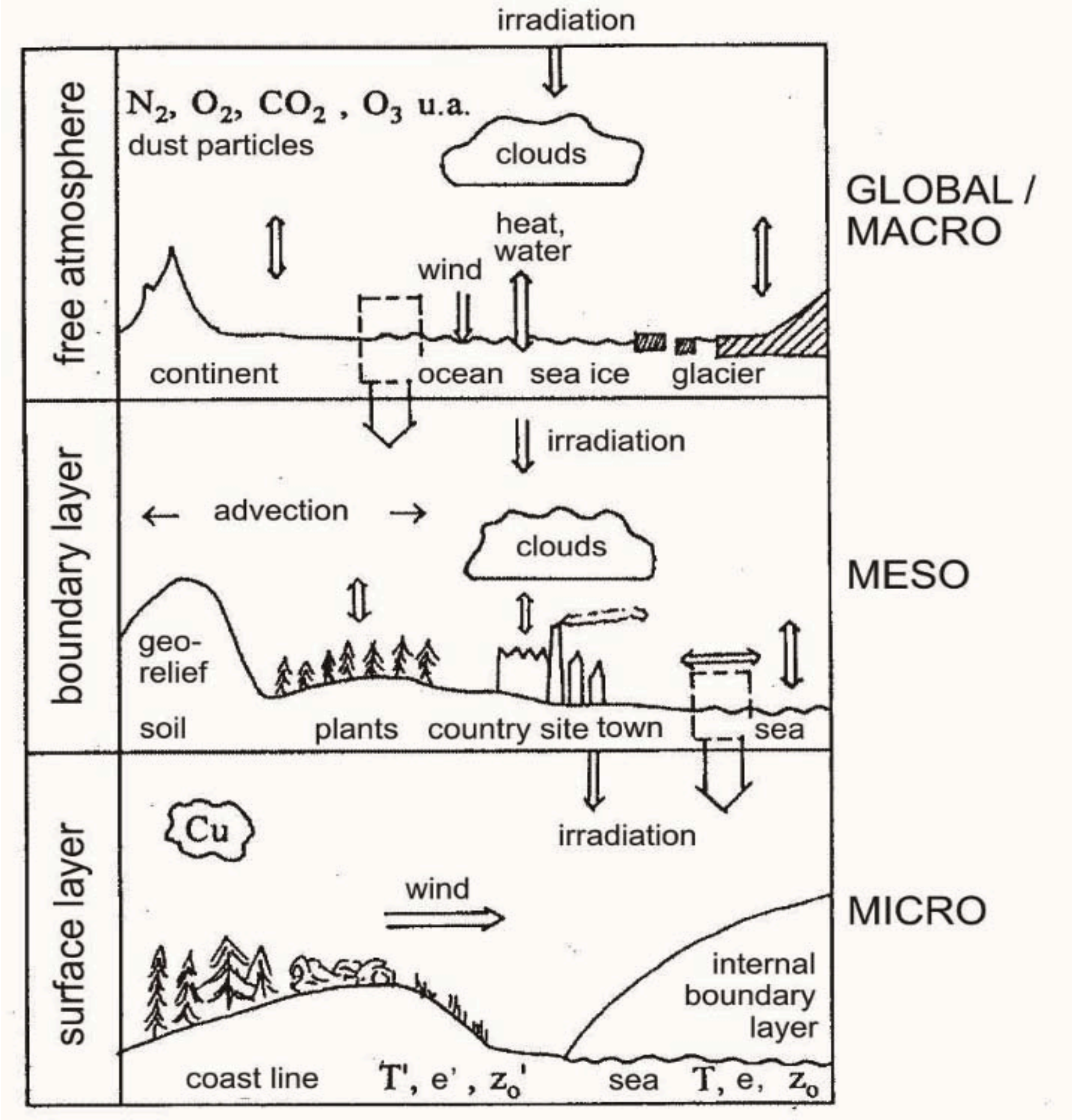
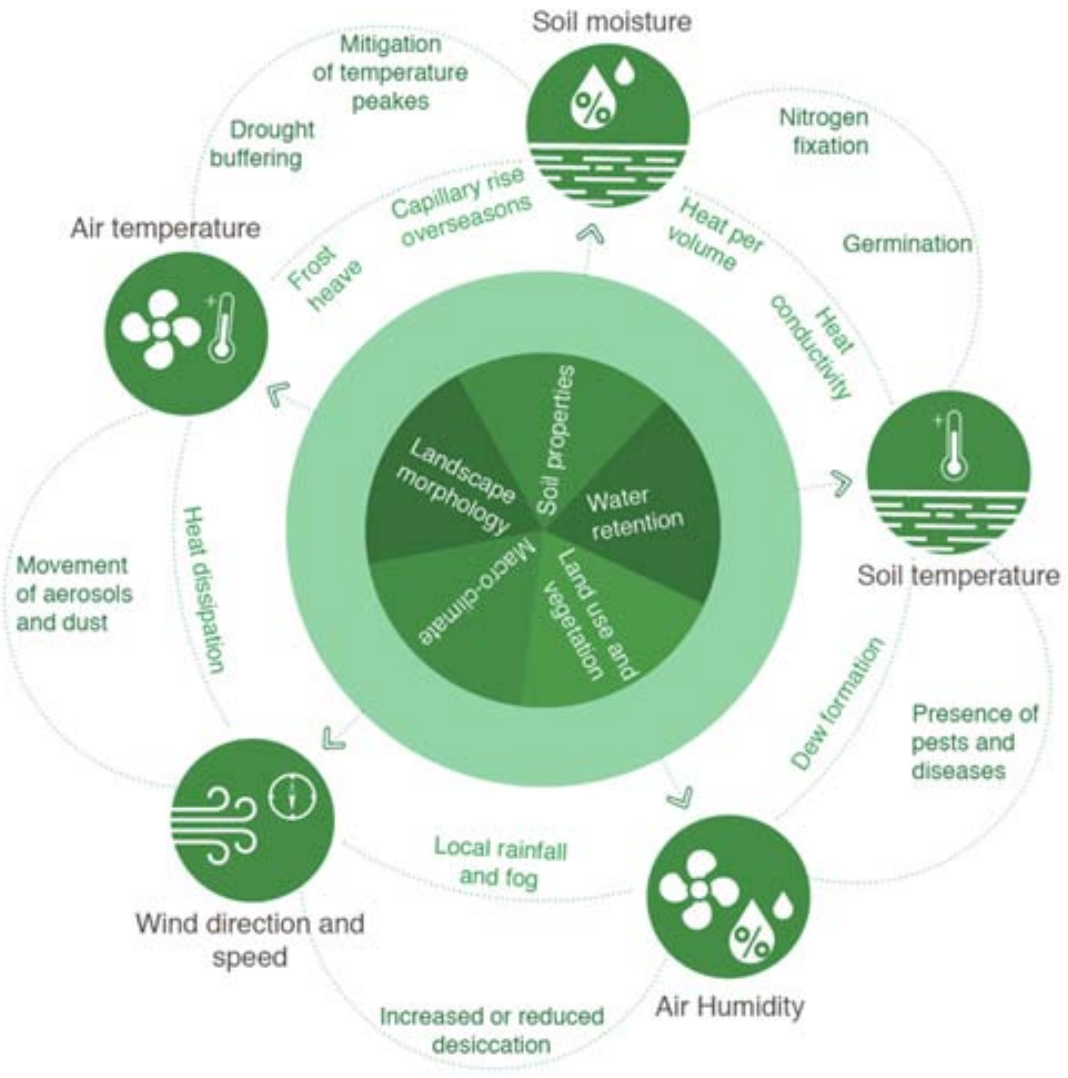
Messages

- The microclimate is a climate of a small area, from plant/field to **sub-watershed/ landscape scale**
- **It is where temperature, humidity and wind touch the ground and interact with vegetation, topography etc**
- The microclimate may be different from the regional climate – more fine-grained and richer
- Microclimate can affect neighbouring areas
  - E.g. increased water availability from exclosures
  - Transported humidity from a (large) body of water
- Microclimate can be managed!



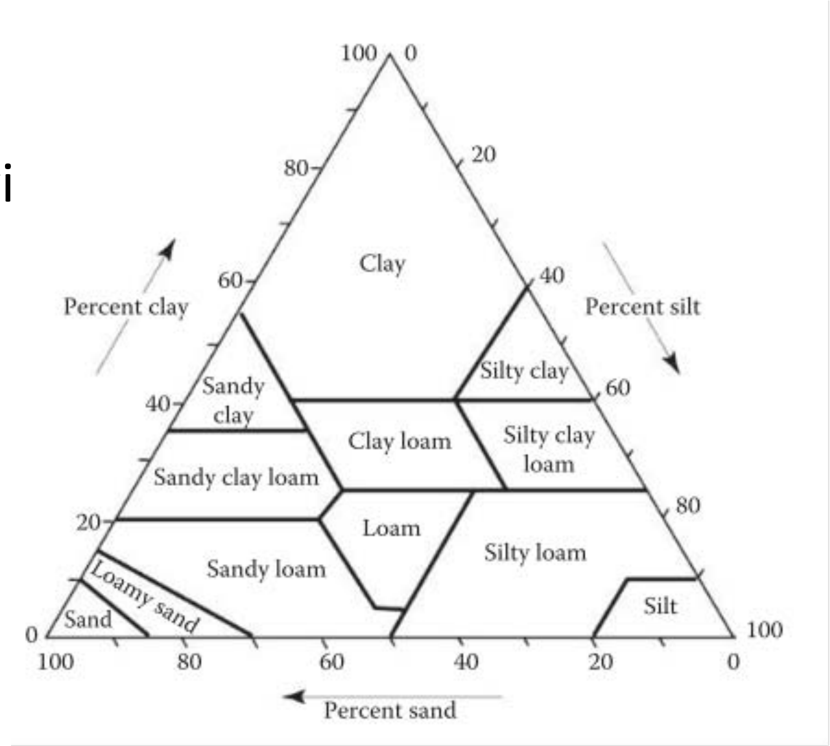
Microclimate factors

- Soil moisture
- Soil temperature
- Air temperature
- Air humidity
  - Incl dew, white frost
- Wind direction and speed



Soil moisture

- Determined by soil's water storage capacity and addition/loss of water
  - Texture, structure, depth, organic matter, biological activi
  - Soil texture influences capillary action
- Areas with available soil moisture have more balanced microclimate and conducive conditions
  - Buffers extreme heat
    - Wet soils take up radiation
  - Buffers frost
    - Wet soils stay warm longer than dry soils
  - More nitrogen fixation in the soil
- Landscape management can have medium term effects
  - Capillary action occurring in cold season (cold nights)

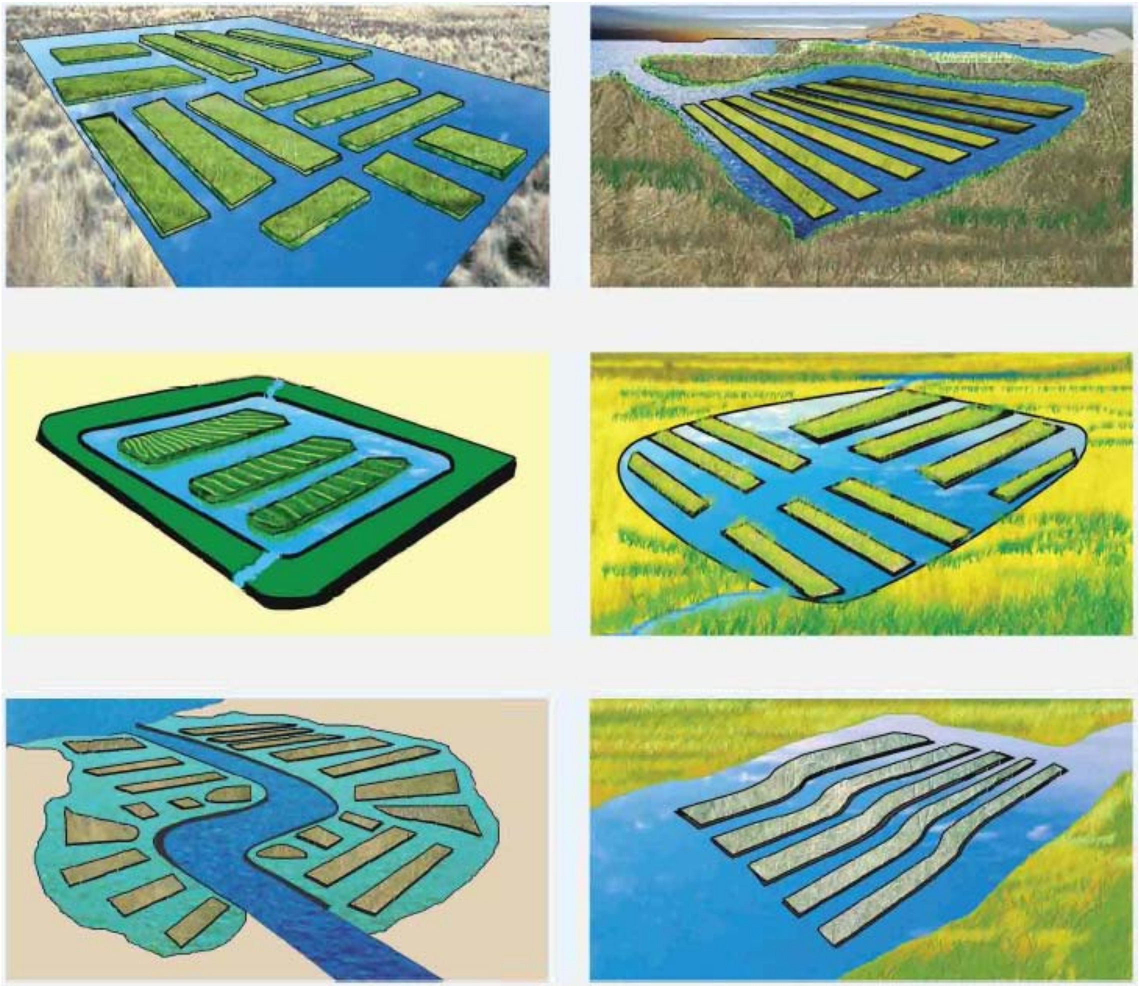


Waru Waru

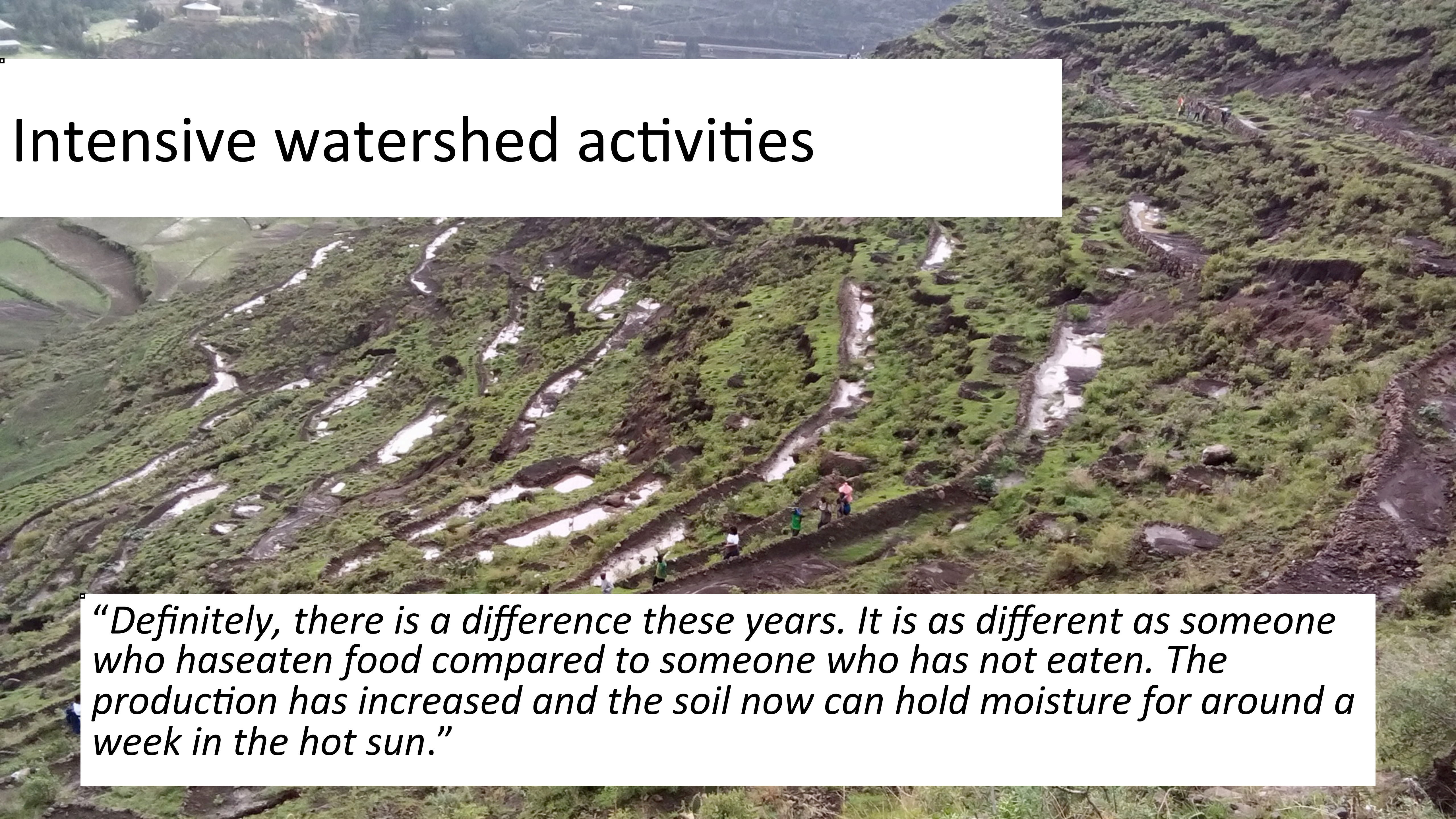
- From the Andes to Amazonia, raised fields known as Suka Kollus (Bolivia) and Waru-Waru (Peru) can be found, being an agricultural technique in flood-prone mountain plains that were used by pre-Columbian societies (Lombardo et al. 2011).

Waru Waru

- Ancient practice, recently revived
- Canals provide moisture during dry conditions
- Water acts as buffer against prevailing night frost
- Drainage prevents water logging



Intensive watershed activities



"Definitely, there is a difference these years. It is as different as someone who haseaten food compared to someone who has not eaten. The production has increased and the soil now can hold moisture for around a week in the hot sun."

Soil temperature

- Incoming radiation, thermal conductivity, heat capacity
- Depending on soil composition, organic material and humidity> can help balance temperature extremes
  - Day: takes up heat from air, lowering temperatures
  - Night: releases heat to surface
- Same process also occurs on longer time scales (summer – winter)
- Moderated soil temperature – helps germination and root development
- High soil temperatures diminish plant growth, biological processes

	Thermal conductivity (W m^{-1} K^{-1})	Heat capacity (MJ m^{-3} K^{-1})
Soil component		
Quartz	8.80	2.13
Clay minerals	2.92	2.38
Organic matter	0.25	2.50
Water	0.57	4.18
Air	0.02	0.0012
Sandy soil (porosity = 0.4)		
0%	0.30	1.28
50%	1.80	2.12
100%	2.20	2.96
Clay soil (porosity = 0.4)		
0%	0.25	1.42
50%	1.18	2.25
100%	1.58	3.10
Peat soil (porosity = 0.8)		
0%	0.06	0.5
50%	0.29	2.18
100%	0.50	3.87

Air temperature

- Radiation
  - Slope, albedo, shading
  - Evapotranspiration
- Conditions within a few meters of the surface change rapidly
- Strong influence from vegetation
  - Shading
  - Evapotranspiration
- Crops have optimum temperature range for growing
- Higher temperatures can aid spread of pests and diseases
- Affects thermic effects - rainfall

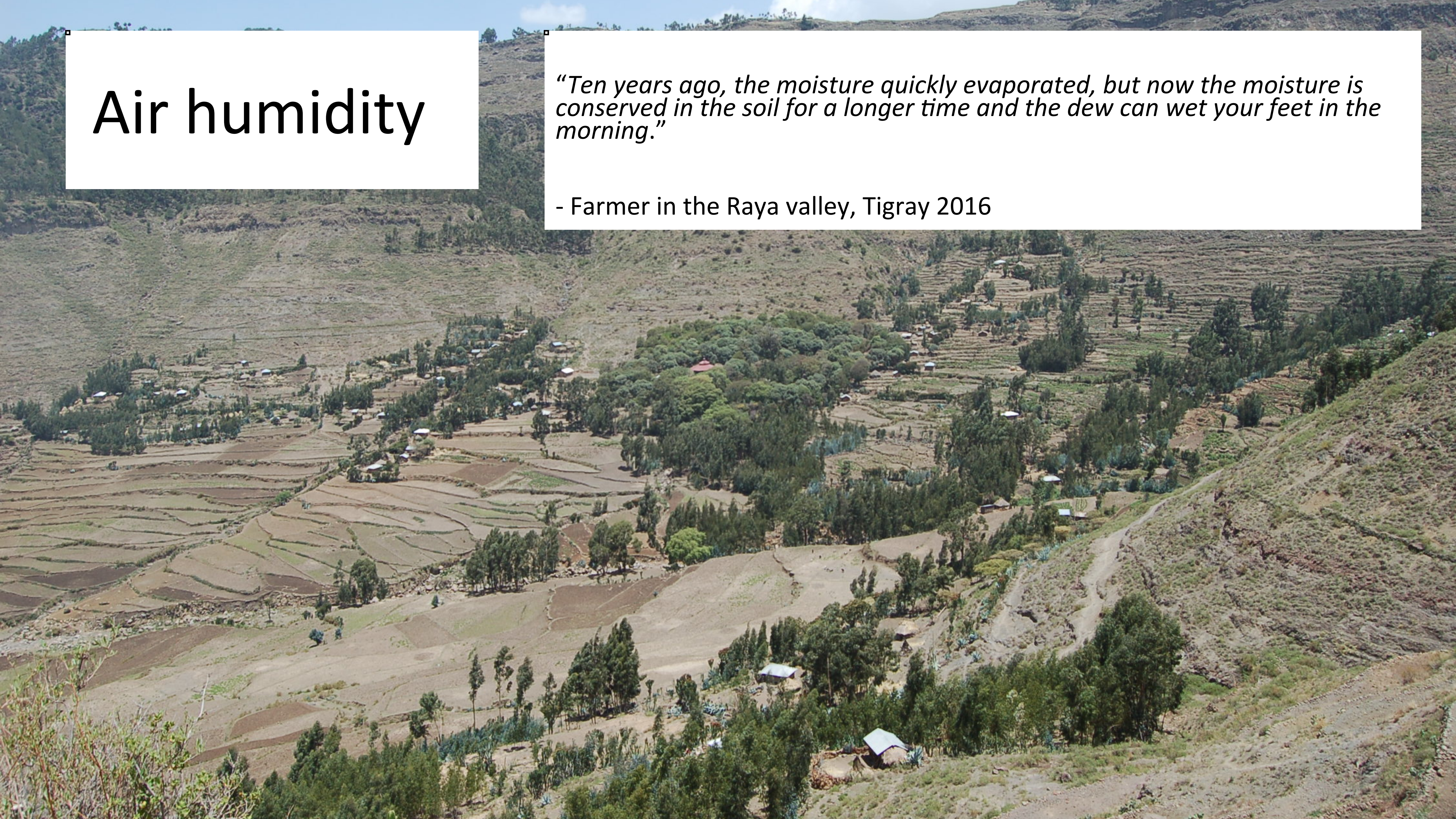
Air humidity

- Result of evapotranspiration from soil and plants, and transport from other areas
    - Temperature determines amount of water vapor air can hold
- High air humidity slows transpiration
- High air humidity helps dew formation
- Dew formation
    - When surfaces cool below the dewpoint, dew can form
    - Triggered by cooling surfaces (stones)
    - Dew can provide significant amounts of moisture in (semi-) arid ecosystems

Air humidity

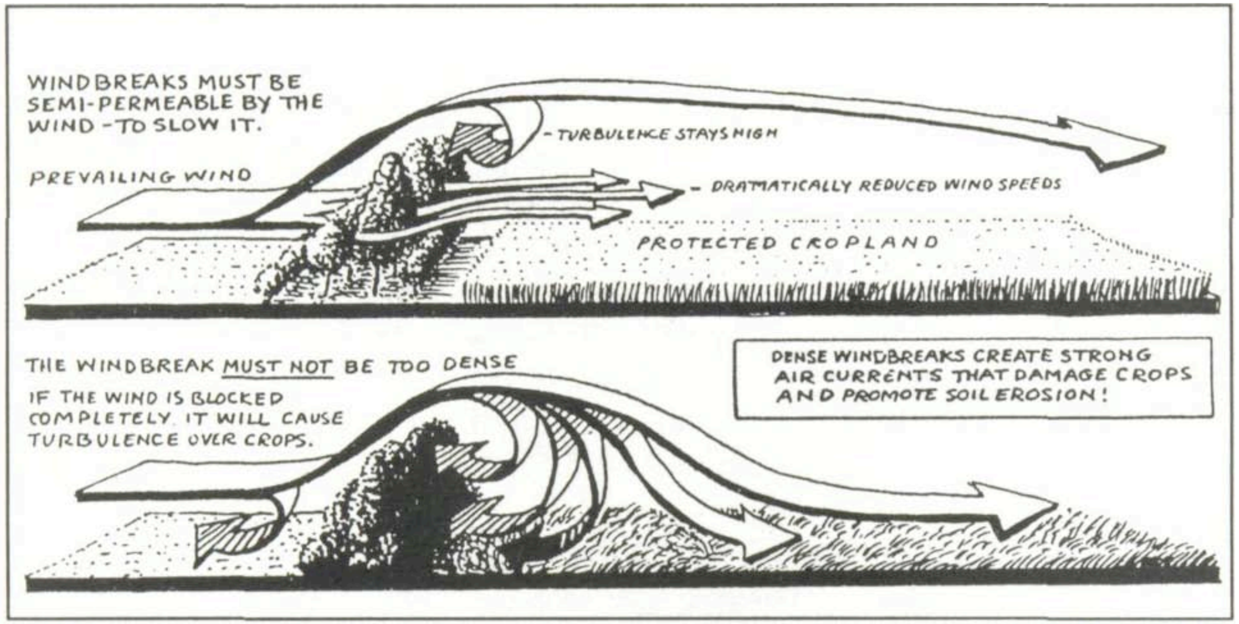
"Ten years ago, the moisture quickly evaporated, but now the moisture is conserved in the soil for a longer time and the dew can wet your feet in the morning."

- Farmer in the Raya valley, Tigray 2016



Wind direction and speed

- Guided by windbreaks and vegetation in general
- Cooling effect
- Increase water ET from plants
- Mixing of the atmosphere for o
  CO2)
- Negative effects
  - Wind erosion (fine soils, organix r
  - Damage to plants
  - Transport of diseases and pests



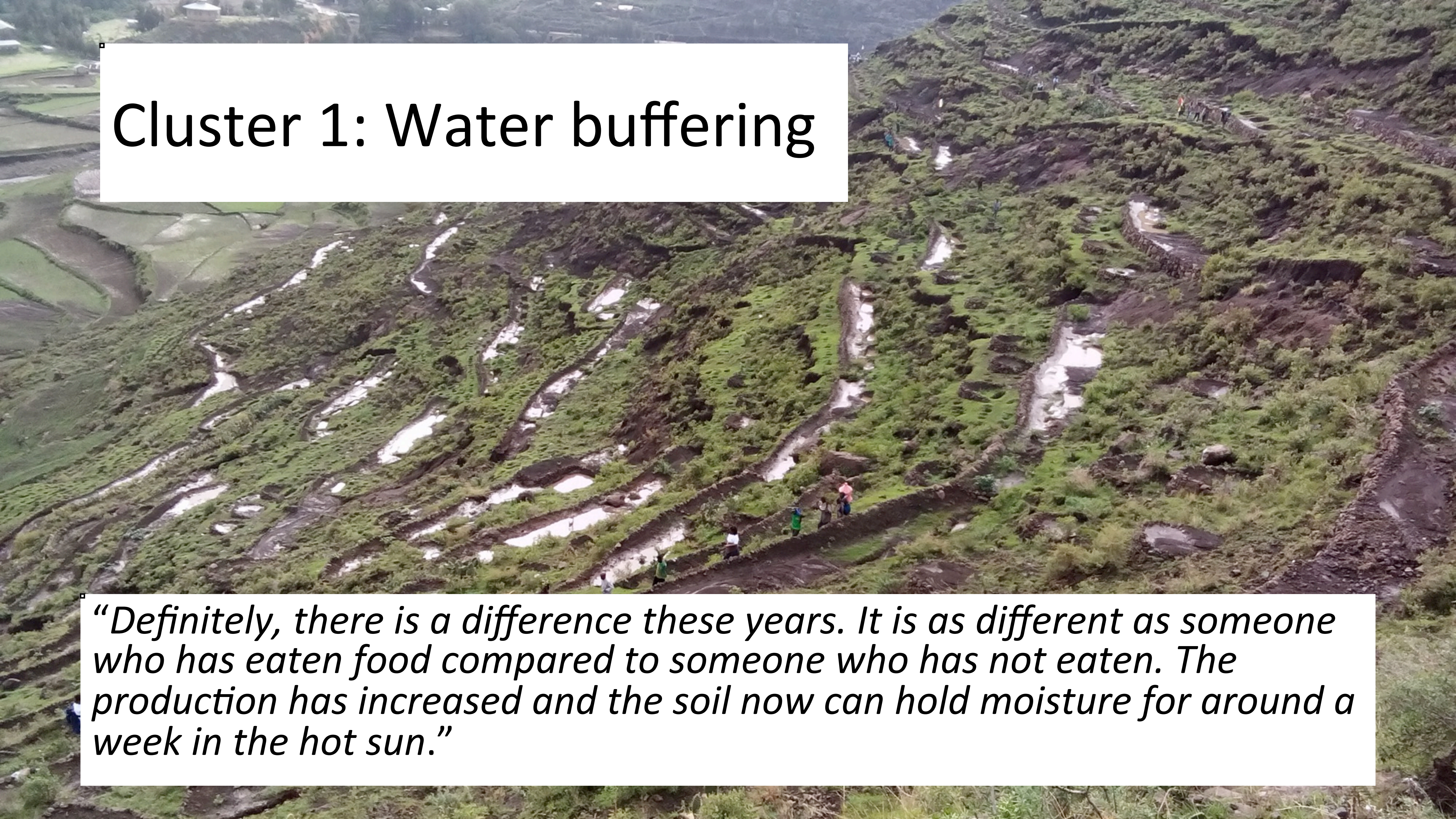
Wind direction and speed

Towards a microclimate toolkit

3 clusters

- Water buffering
- Re-greening
- Land use planning

Cluster 1: Water buffering



"Definitely, there is a difference these years. It is as different as someone who has eaten food compared to someone who has not eaten. The production has increased and the soil now can hold moisture for around a week in the hot sun."

Intensive landscape management

Roads for Water

- Capture surface water
- Increase water availability

Cluster 1: Water buffering

- Availability of moisture as key microclimate factor
  - Even out temperature peaks
  - Capillary action
- Effects of different techniques

Water buffering	Techniques in use	Effect on soil moisture	Effect on soil temperature	Effect on air humidity	Effect on air temperature	Effect on wind direction and speed
Open storage	Surface ponds and micro-dams	Limited - fringe effects dependent on seepage	Not significant	Significant - more rainfall, higher air moisture and more dew	Cooling effect of surface evaporation	Limited - causing local difference in temperature and hence air pressure
Soil moisture	Eyebrows, stone bunds, flood water spreaders, terraces, and gully plugging	Direct and significant impact on soil moisture	Soil temperature more balanced	Significant closer to the ground - more dew and white frost, increased air moisture	Some cooling effect	Not significant
Shallow groundwater	Infiltration trenches, infiltration ponds and wells	Delayed effect - contribute to soil moisture later in the season	Some delayed moderation effect on soil temperature	Not so significant	Not significant	None

Cluster 2: Re-greening

- Create and maintain microclimate conditions favourable to crops through re-greening
- Location of trees, shape of tree plantation, canopy, side functions
- Affects on thermic effects, wind direction, shade
- Farms are at a cross-section of microclimate processes that need to be integrated to increase resilience
- Examples:
  - Windbreaks
  - Agroforestry
  - Controlled regeneration
  - Reforestation

Objective	Example
Increase soil fertility	Soil structure / nutrient fixing trees (e.g. Faidherba albida) Windbreak trees (e.g. Azadirachta indica) Erosion control (e.g. Acacia senegal, Anacardium occidentale)
Increase availability of water, and reduced incoming radiation	Conservation agriculture (moisture retention) Shade trees to reduce evaporation and facilitate growth of shade-tolerant plants (e.g. Andansonia digitata, Azadirachta indica, Magnifera indica and Parkia biglobosa)

Cluster 2: Re-greening

Agroforestry types

Alley cropping

Farmer managed natural regeneration/ controlled grazing

Multistrata systems

Protective systems (windbreaks, shelterbelts)

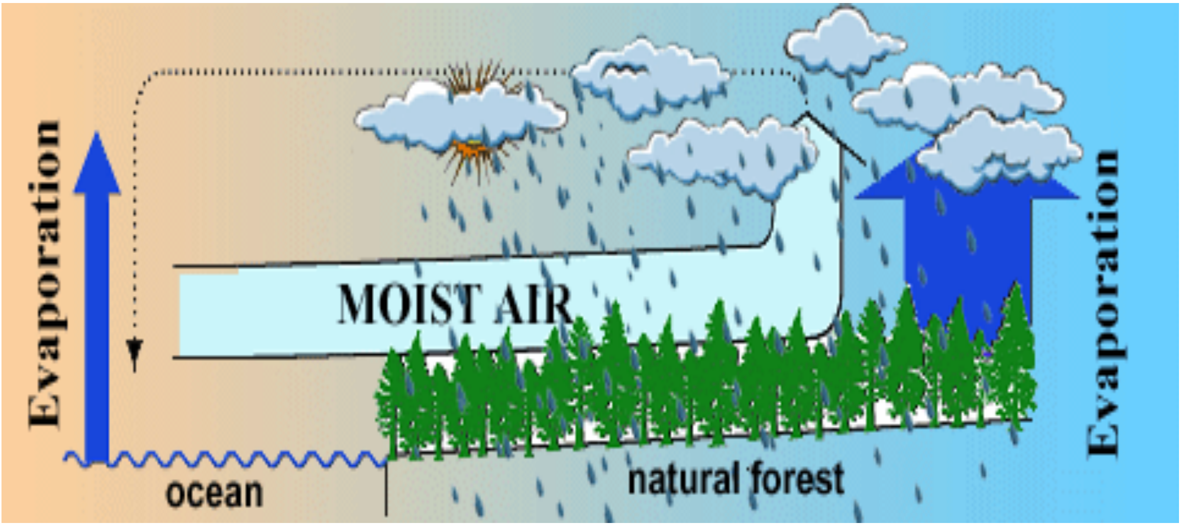
Silvopasture systems

Woodlots

Cluster 2: Regreening

Forestry and rainfall

- Reforestation can lead to rainfall
- Local evapotranspiration contributes to biotic pump and increases water cycle intensity
- Precipitation recycling raises likelihood of local rainfall events
- Transportation of moisture inland
- Role of forests in inducing rainfall
  - Humidity
  - Lower temperature
  - Aerosols



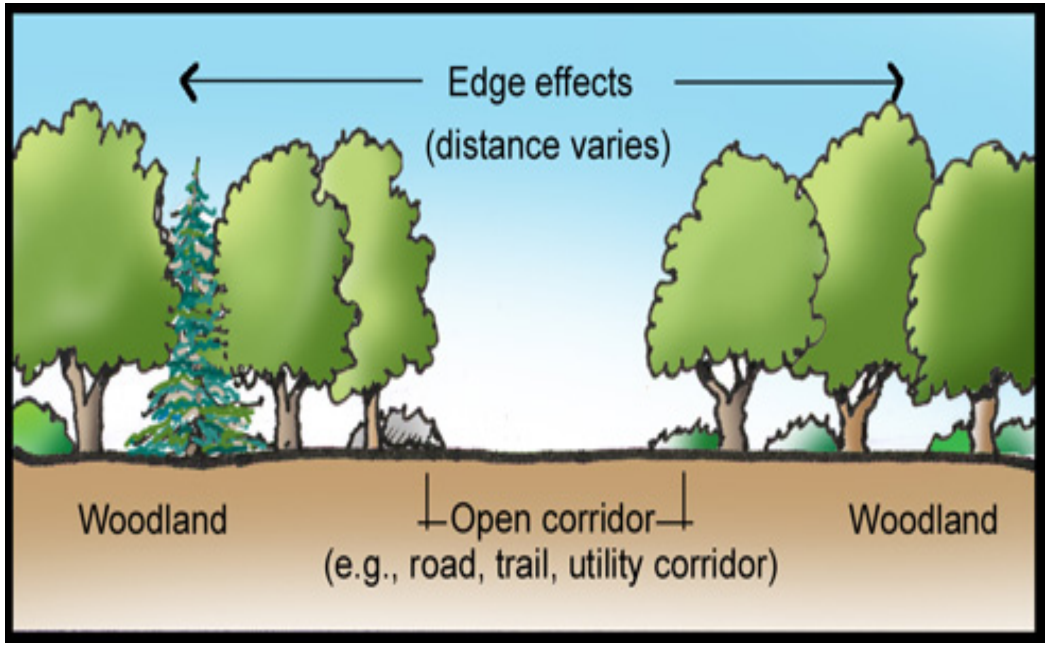
Cluster 2: Regreening

"The acacia trees that were regenerated due to the intervention are effective to conserve moisture and act as a wind break and as a living fence. They work as soil erosion prevention."

- Farmer in the Raya valley, Tigray 2016

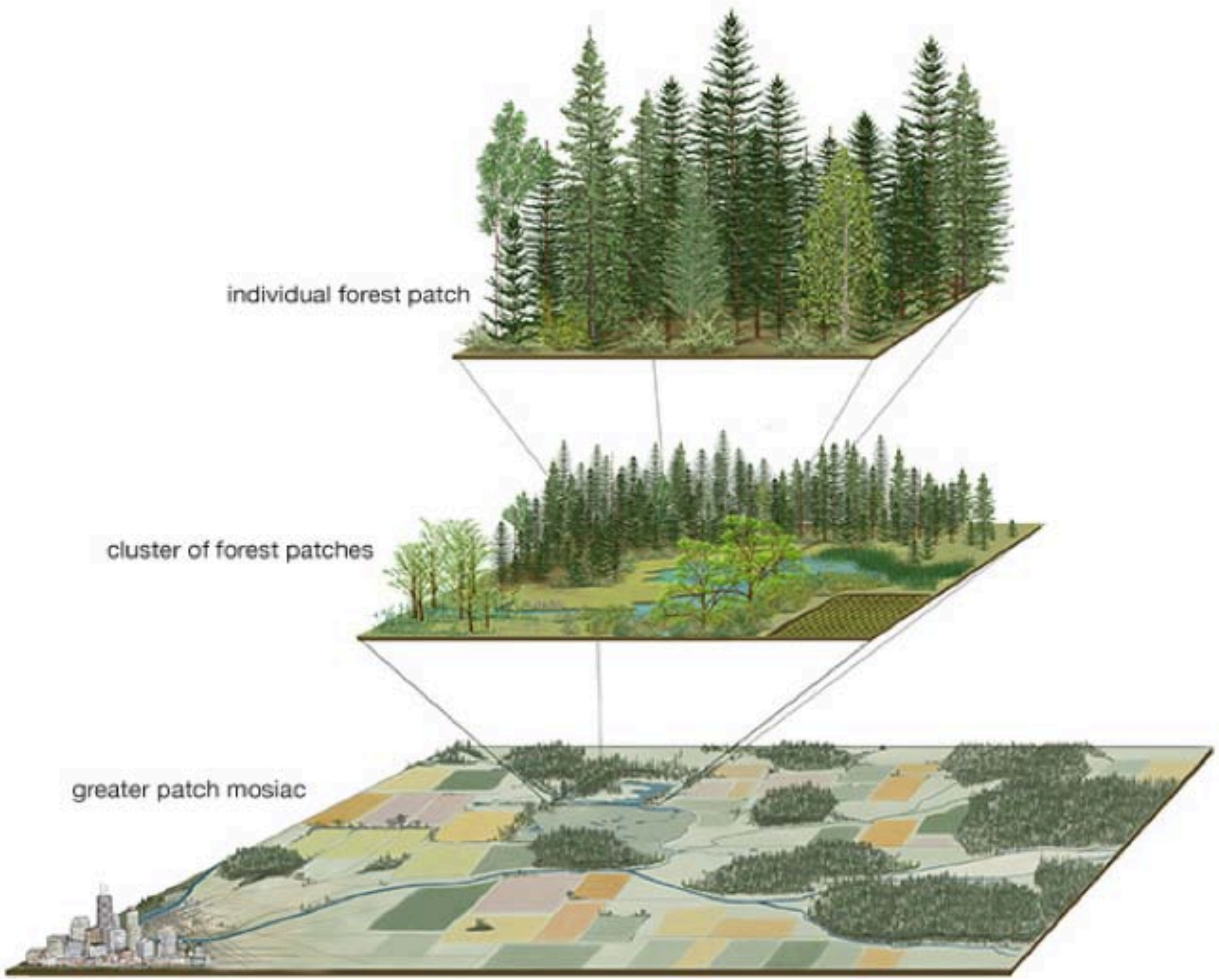
Cluster 3: Land-use planning

- Microclimate dynamics related to landscape components
  - Vegetation
  - Corridors, such as streams, roads and powerlines
- Microclimate variance high in transitional zones between adjacent ecosystems



Cluster 3: Land-use planning

- Insights into the microclimate can help explain ecological processes, develop management options for a landscape



Cluster 3: Land-use planning

- Promotion and protection of existing forests can benefit local microclimate and surrounding areas
- Area closures, reforestation

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From regional to local

- Focusing on microclimates does justice to climate on the ground
  - The effects of global and regional change will be felt at small scales
- Should be an instrument not side effect or second thought
  - For productivity, multi-functionality and climate resilience

From local to regional

- Microclimate management can lead to regional changes
- Hydrological corridors >

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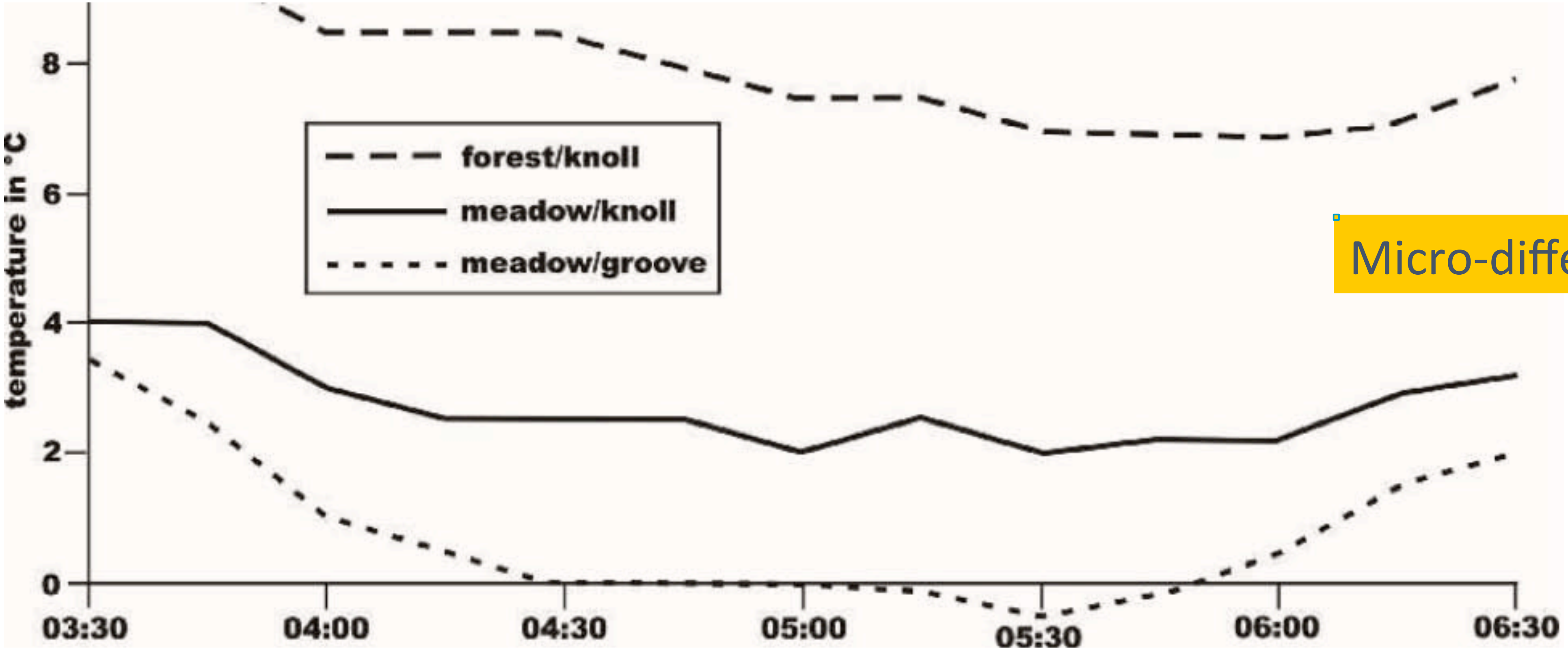
Final thought – is micro-climate management the third and most pro-active way to address climate change?



Micro-differences matter