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# Applying cross-scale insights of SDG achievement in Kenya



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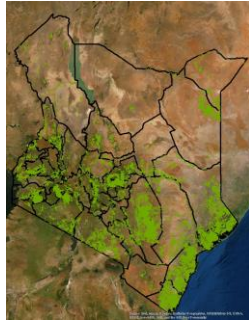
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**Historic baseline  
tree cover  
(~6%)**



**Future tree  
cover goal  
(10%)**



# Project Goal

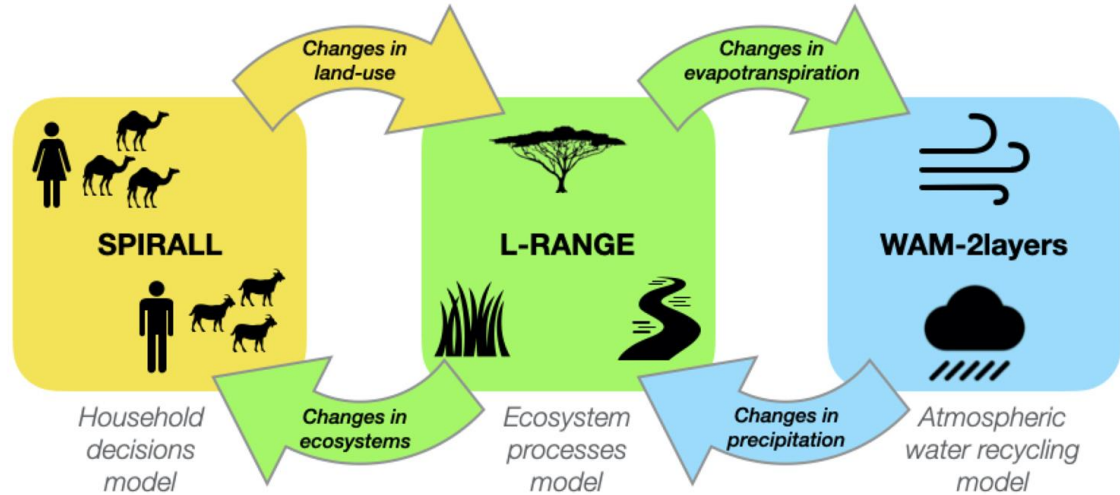
What are the consequences for people, the land and the atmosphere if Kenya achieves its SDG 15 forest cover goals?

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# Project overview

- “Cross-scale dynamics of **SDG15 achievement in Kenya.**” (under the Biological Diversity and Ecological Forecasting program)
- Currently in **final year** of project
- COVID threw a wrench in the international dimension of this project...
- Working on **Applied augmentation**

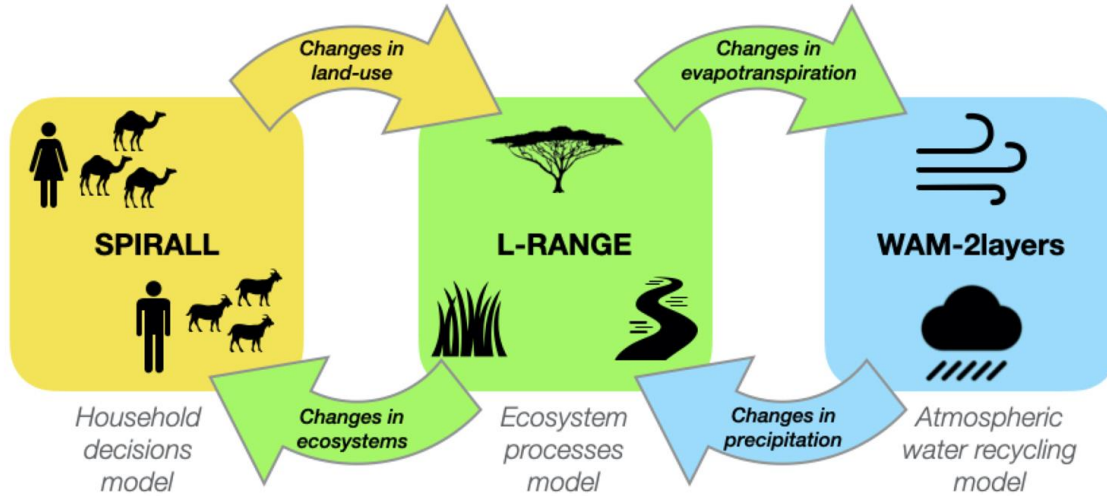
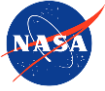






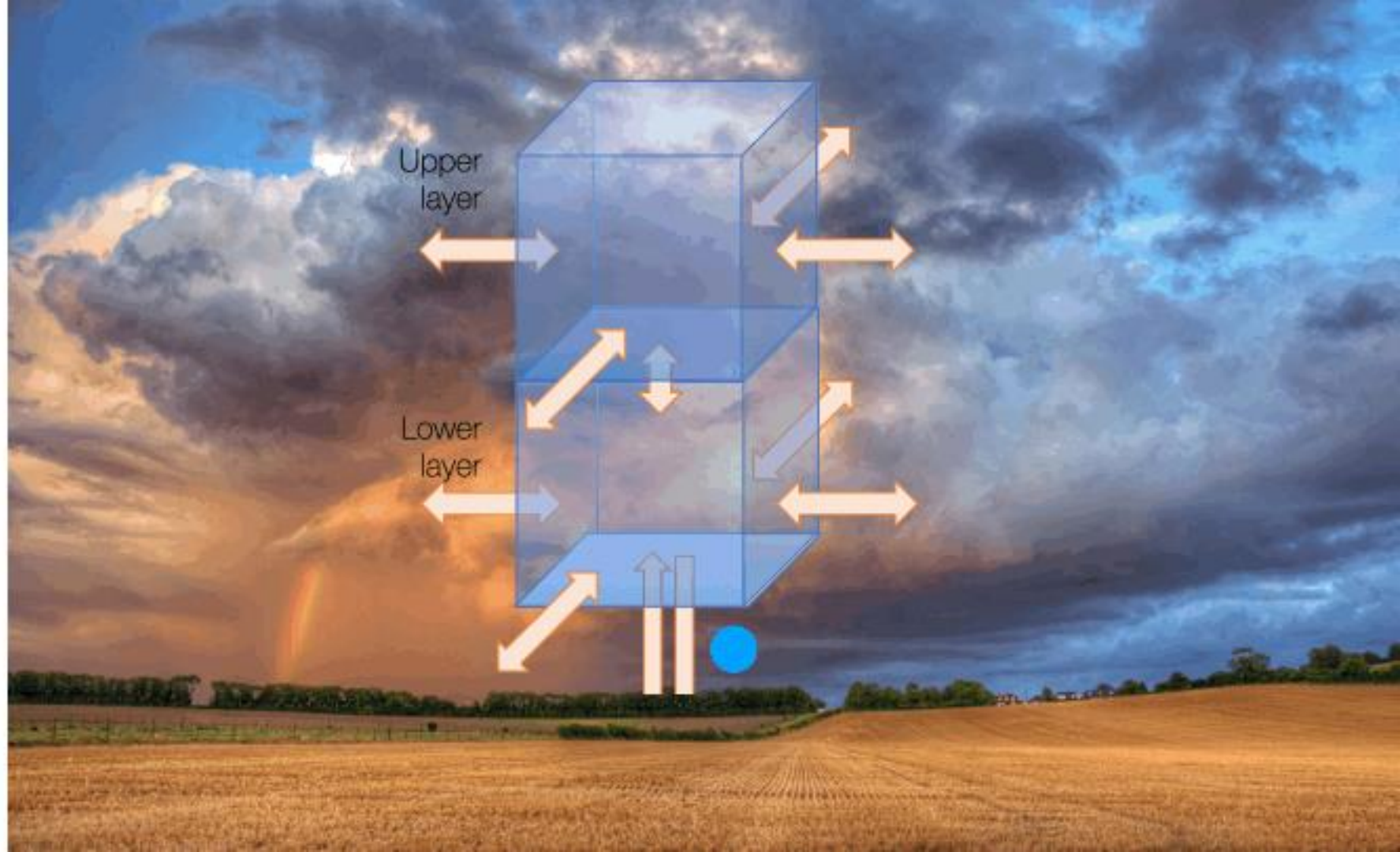
# Summary

- Research outcomes
  - New version of WAM-2layers moisture tracking model for MERRA2 data
  - New agent-based model, SPIRALL, simulating rural livelihoods
  - Kenya-specific version of ecosystem model L-RANGE
  - Three published papers, One under review, Three In prep.
- Applied outcomes
  - Web Application exploring forest cover change scenarios under climate change
  - Co-Development w/ SEI-Africa and Kenya Forest Research Institute (KEFRI)



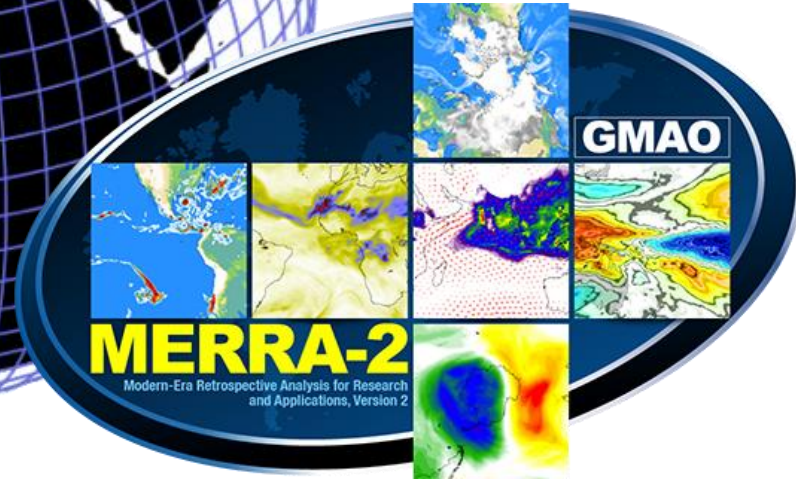
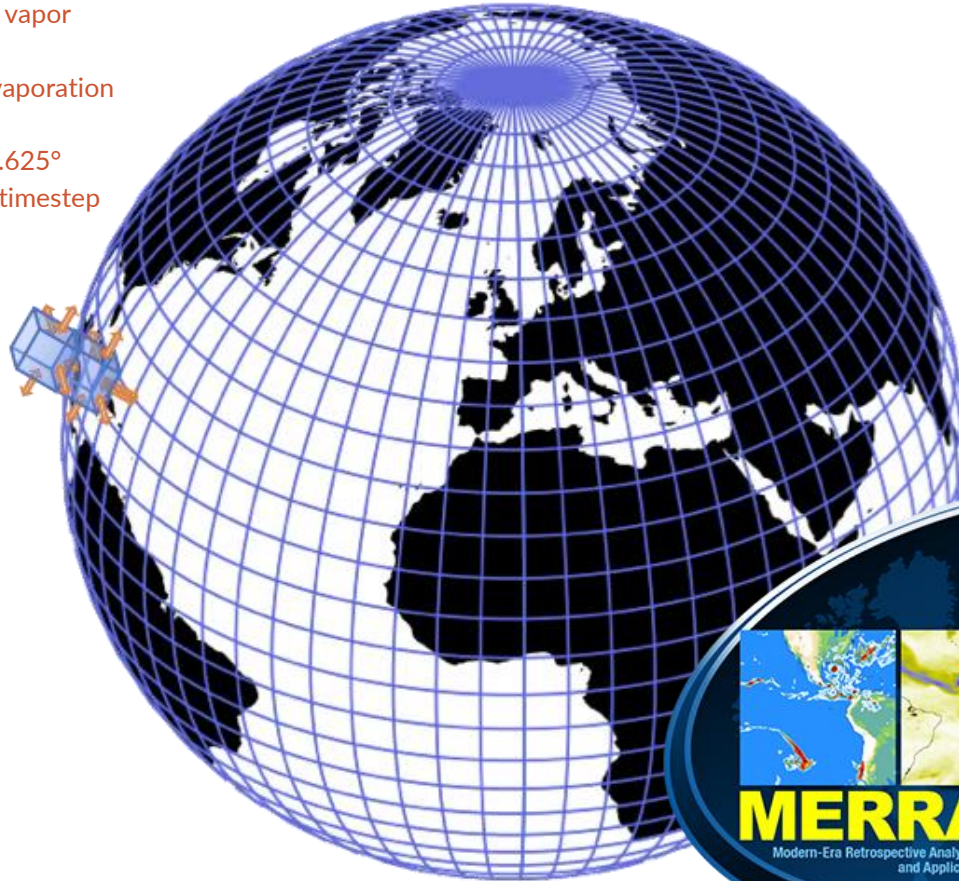
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# Atmospheric moisture tracking

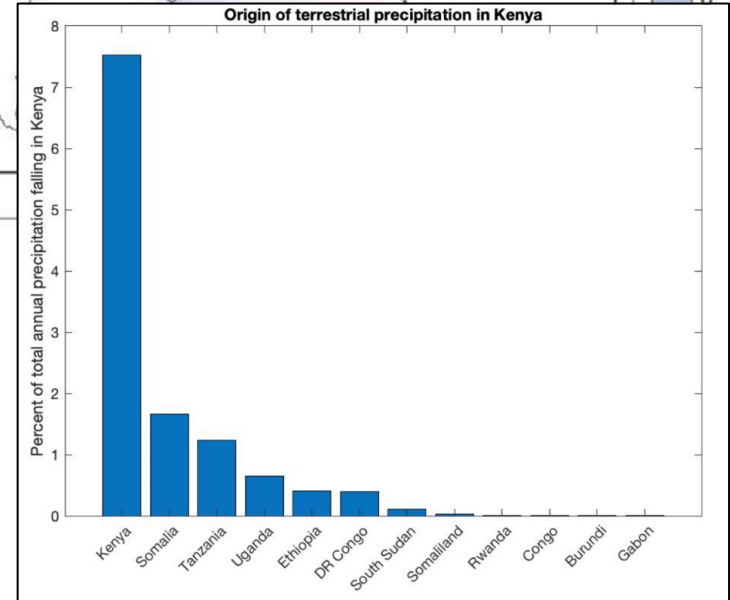
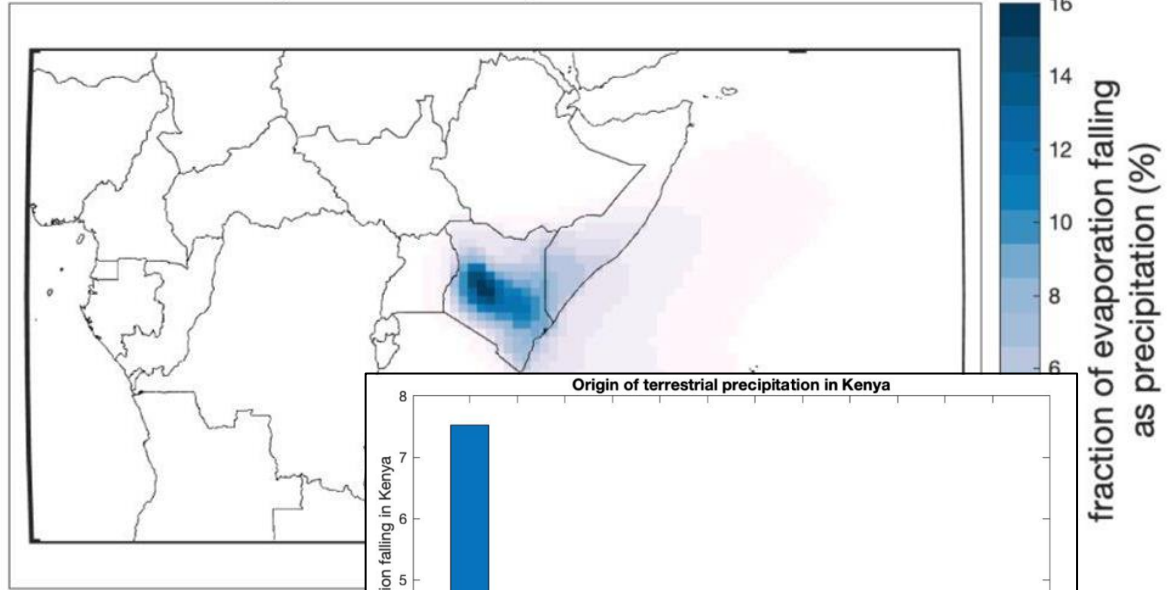




- MERRA2 data from 1980-2018
- 3 hourly winds (U,V), surface pressure, specific humidity, integrated vapor fluxes
- 1 hourly precipitation and evaporation
- Model-levels
- Model run globally at  $0.5^\circ \times 0.625^\circ$  resolution at the 7.5 minute timestep for 40 years.



## Annual mean precipitation shed for Kenya using MERRA2 data, from 1980-2019

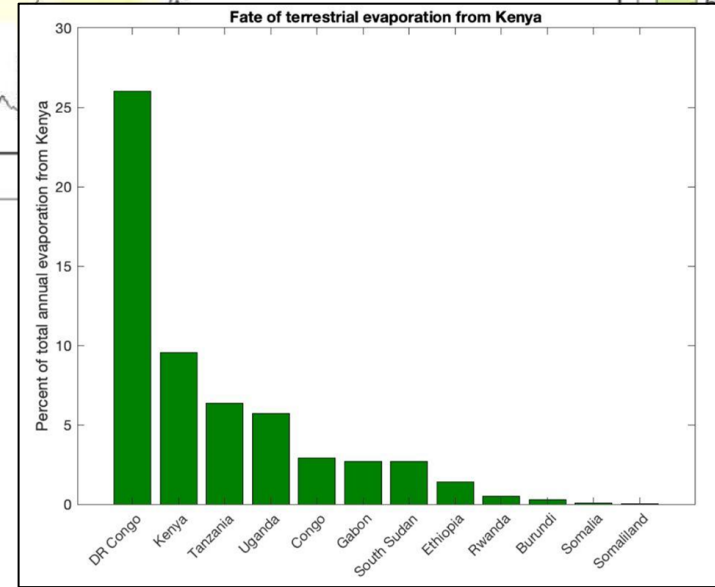
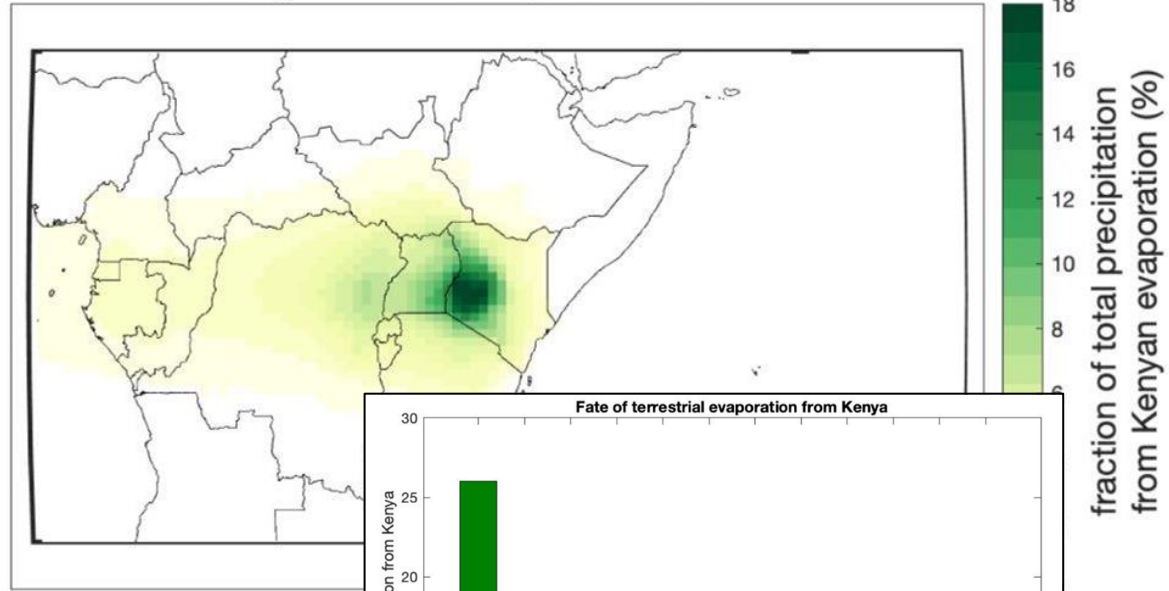


Kenya receives most of its precipitation from the ocean

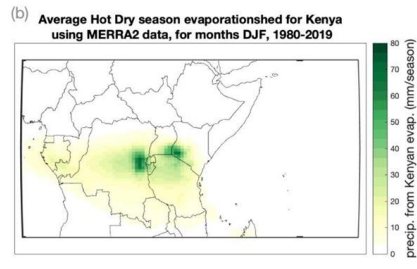
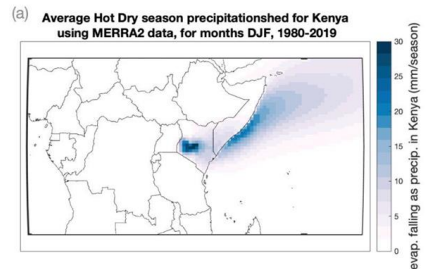


# Kenya recycles substantial moisture across Africa

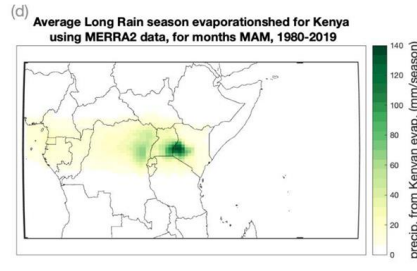
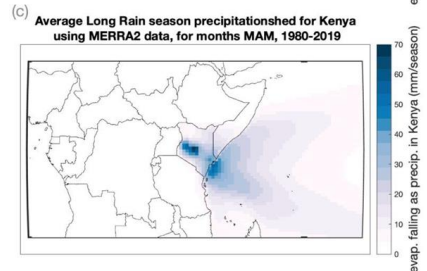
Annual mean evaporation shed for Kenya using MERRA2 data, from 1980-2019



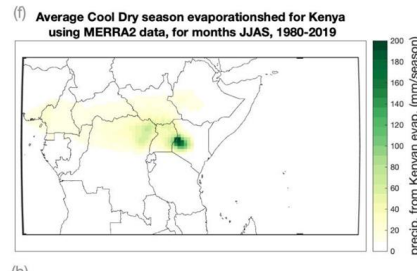
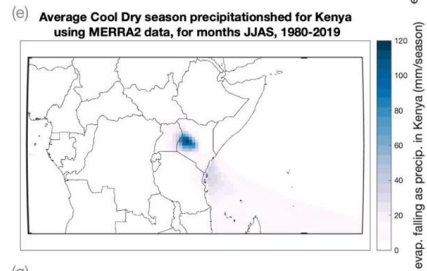
Hot, dry  
*DJF*



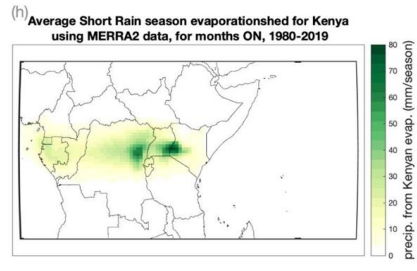
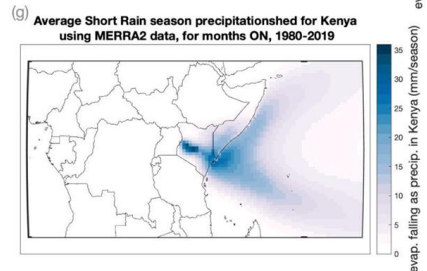
Long, rainy  
*MAM*



Cool, dry  
*JJAS*



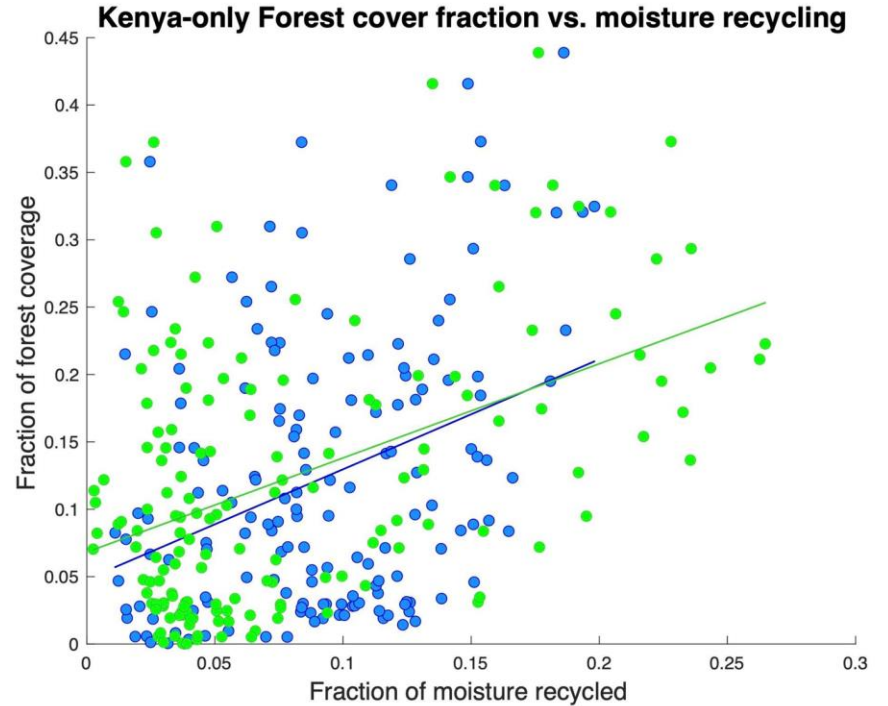
Short, rainy  
*ON*





# Key Findings

- Most of Kenya's precipitation originates from oceanic sources
- More than half of Kenya's evaporation rains out in nearby countries
- Forests are correlated with increasing moisture recycling ratios (...something for future work)



# SPIRAL and L-RANGE

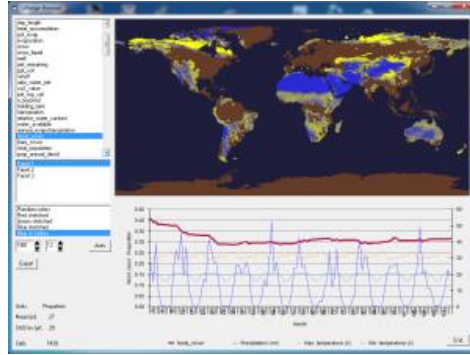


## SPIRALL

Behavior of people on the  
landscape

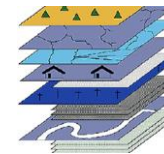
- Agents - households
- Patches - 100 km<sup>2</sup>
- Timestep - monthly

G-Range



L-Range

Eastern Africa ecosystem model



Soil  
Trees; Shrubs;  
Herbs  
Land cover  
Ecoregion  
Fire (MODIS)

Updated  
climate, land &  
disturbance  
data



Models

Carbon flows  
Plant growth  
Grazing effects  
CO<sub>2</sub> fertilization  
N<sub>2</sub> fertilization



# SPIRALL + L-Range

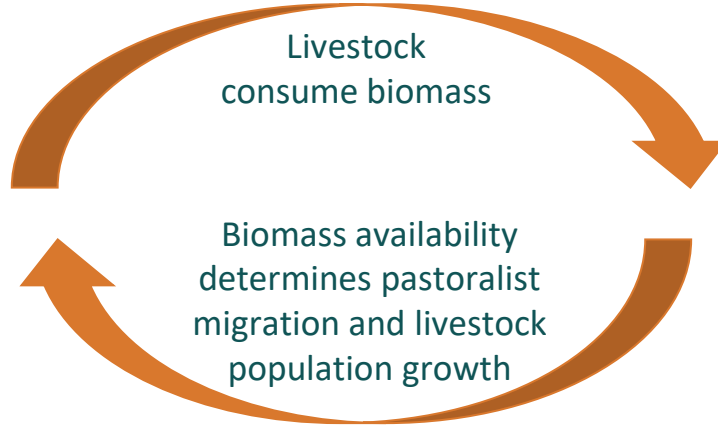
## A coupled socio-ecological model for Kenya



### SPIRALL

Behavior of people on the landscape

Monthly livestock herd performance



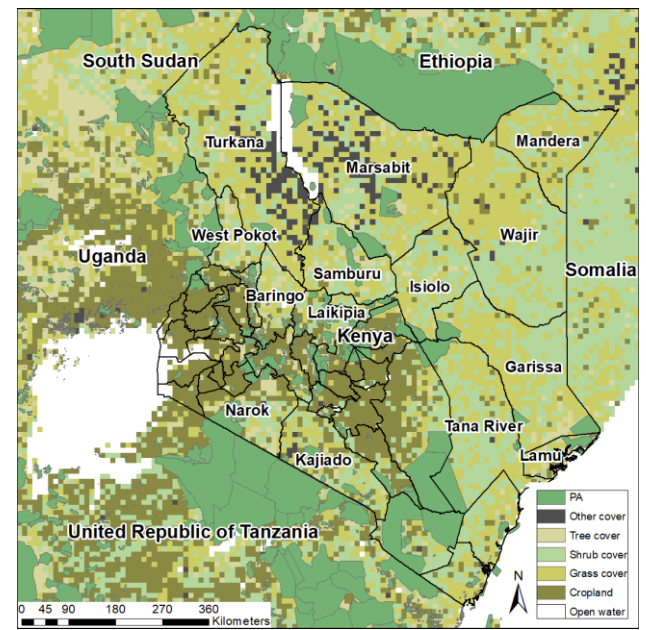
### L-Range

Eastern Africa ecosystem model

Monthly household food security and debt

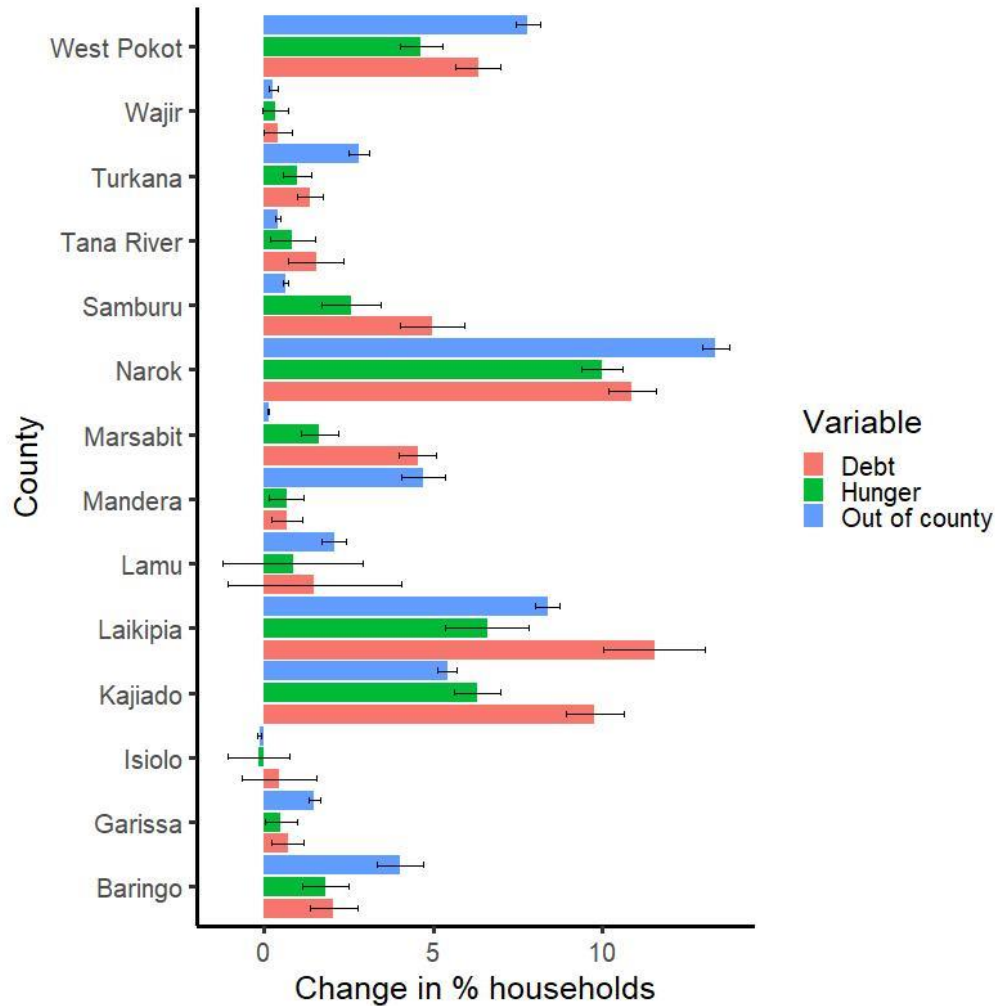
Changes in household wealth (e.g., sales, non-herd income)





# Simulating enforced exclusion of protected areas





# Following loss of PA access, households experience substantial hunger, debt and out of county movements.

Large changes occur in small counties bordering large protected areas and strategies such as agropastoralism (Narok) and non-sedentarism (West Pokot) do not buffer against loss of key resources in PAs. Out of county movements in border counties can result in international conflicts as are common on the Kenya-Uganda border (West Pokot, Turkana) and the Kenya-Ethiopia border (Mandera)

# Key Findings



- Strict exclusion of protected areas may threaten human well-being
- Achieving 10% forest cover extent for the long-term depends on specific management choices, such as fire suppression

# Models

WAM-2layers  
(MERRA2 version)



SPIRALL



G-Range (L-Range  
distribution forthcoming;  
contact me for more info!)





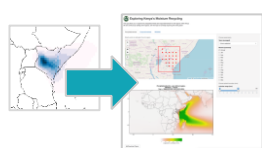
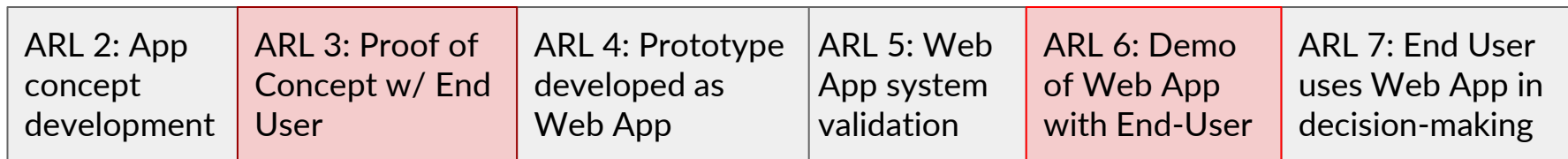
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# 1-yr Applied blitz

- Convert **Research** project into an **Applied** project, that can inform SDG achievement
- SEI-Africa is an **ideal bridging organization** to connect us with the best in-country, end-users who are making practical decisions toward the achievement of SDG15



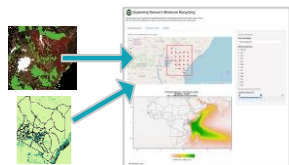
# Timeline



Project team



End User



Project team

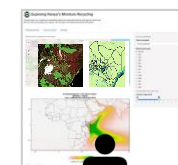


Project team  
End User



Project team  
End User

Other partners



End User



## Phase 1 & 2

- ✓ Kenya Afforestation Web-App prototype
- ✓ Web-based dialogue with End-Users; discuss App prototype
- ✓ Characterization of End-User decision processes
- ✓ Summary of prototype application viability from End-User

## Downscaled CMIP6 Monthly Climate Data

Precipitation  
Min Temperature  
Max Temperature

Scenarios:  
Historic (1980-2014)  
Future (2015-2100)  
SSP1-2.6; SSP2-4.5  
SSP-7.0; SSP5-8.5

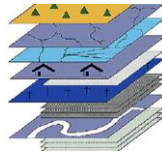


### Management

Do Nothing  
Control Fires  
Control grazing



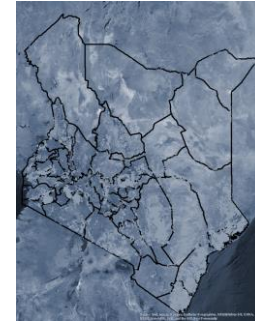
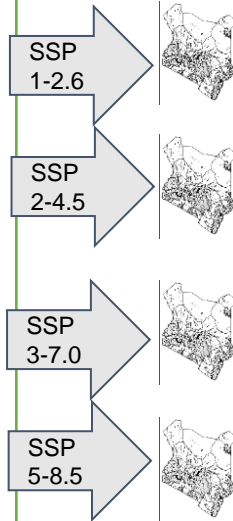
L-Range  
The Global Rangelands model  
(G-Range) adapted for Eastern  
Africa



Soil  
Trees; Shrubs;  
Herbs  
Land cover  
Ecoregion  
Fire (MODIS)

### Models

Carbon flows  
Plant growth  
Grazing effects  
CO<sub>2</sub> fertilization  
N<sub>2</sub> fertilization



Historic baseline  
tree cover

Change in  
deciduous and  
evergreen tree  
cover due to  
climate change  
and management



## Kenya Afforestation Decision Support Tool

Optimistic Scenario

Middle of the road

Pessimistic Scenario

How will climate and existing forest cover change in the future?

Which afforestation measures will persist into the future?

### Pick a future timeperiod:

- Near term (2030)  
 Medium term (2050)  
 Long term (2100)

### Pick a course of action:

Deciduous forests augmented

### Additional measures:

None

### Pick a county to generate report:

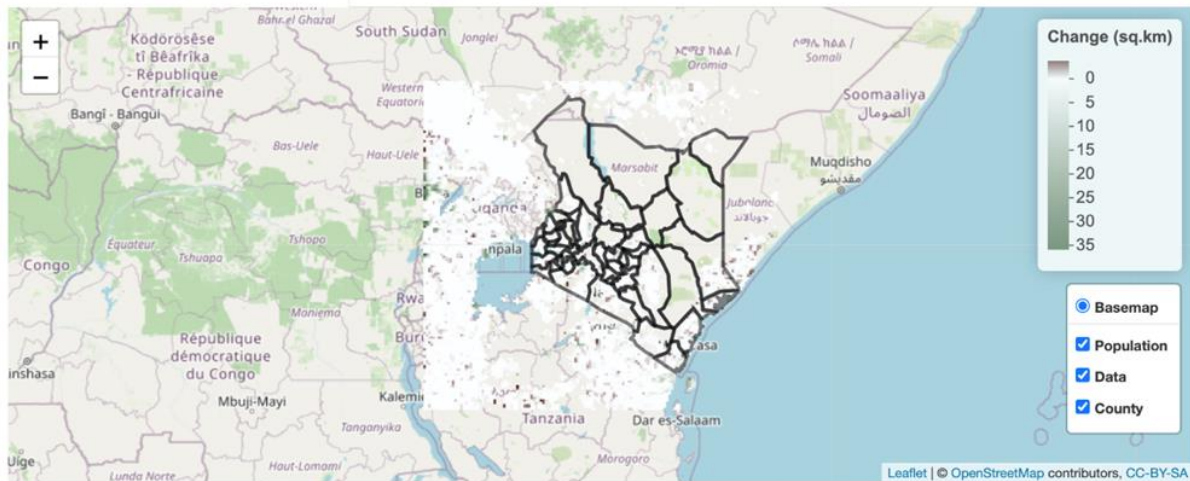
Baringo

 Generate report

Large maps may take a few seconds to render.

Click on a pixel within Kenya to see the county name and pixel value.

Click [here](#) to see how these data were generated and to learn more about caveats (under construction)



County:

In the selected area the deciduous tree cover changes by NA sq.km relative to 2014 and the human population changes by NA persons / sq.km relative to the year 2000

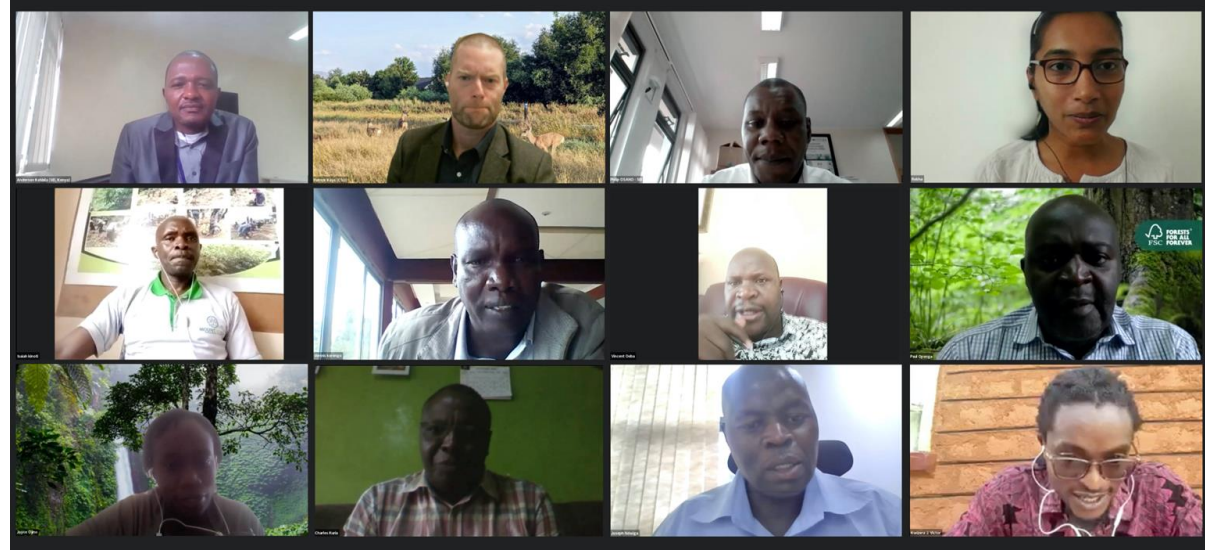
In this scenario forest cover is increased to 10% by increasing deciduous forest cover. Within the selected time period this forest type increases by 1130.6 sq.km





# Climate change and afforestation

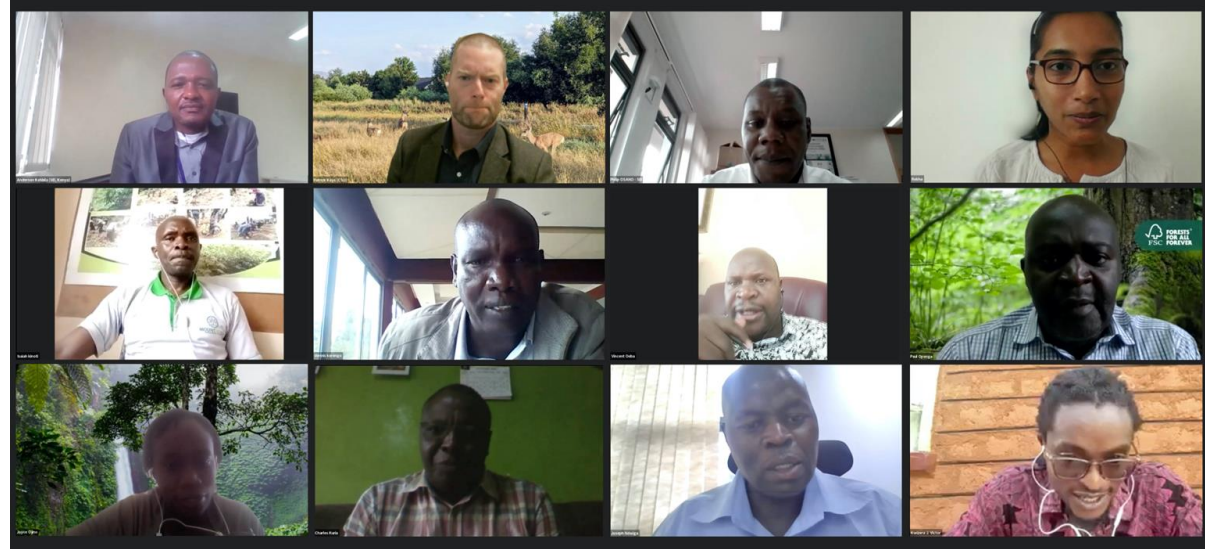
- Broad initial participation in End-user workshop (~20 participants)





# Climate change and afforestation

- Broad initial participation in End-user workshop (~20 participants)
- Wide range of SDG connections





## Phase 2 & 3



- ✓ Integrate feedback into App design
- ✓ Develop guidance materials with Geospatial Centroid

- ❑ Map End-User decision-processes
- ❑ Success metrics identified
- ❑ In-country training workshop w/ Assoc.
- ❑ End-user reports on how the App is integrated into G-related activities.



Tomorrow morning!



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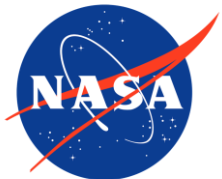
## End of project goal?

To be actively supporting in-country decision making for **SDG15** around afforestation projects



Kenya Forestry Research Ins...  
@KEFRIHQ

World Environment Day  
2022...Only One Earth



**COLORADO  
WATER CENTER**  
COLORADO STATE UNIVERSITY



# Thank you



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