UNDERTAKING A BIOPHYSICAL BASELINE SURVEY AND ANNUAL TRACKING OF ECOSYSTEM HEALTH FOR THE KENYA CEREAL ENHANCEMENT PROGRAMME-CLIMATE RESILIENT AGRICULTURAL LIVELIHOODS WINDOW

Report: August 2021

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World Agroforestry (ICRAF)
9-September 2021

I. Background on the Land Degradation Surveillance Framework (LDSF)

The project will identify and measure key indicators of land and soil health in order to understand drivers of degradation, and monitor changes over time using the Land Degradation Surveillance Framework (LDSF) methodology (http://landscapeportal.org/blog/2015/03/25/the-land-degradation-surveillance-framework-ldsf/). The LDSF provides a field protocol for measuring indicators of the "health" of an ecosystem.

The LDSF was developed by the World Agroforestry (ICRAF) in response to the need for consistent field methods and indicator frameworks to assess land health in landscapes. The framework has been applied in projects across the global tropics, and is currently one of the largest land health databases globally with more than 30,000 observations, shared at http://landscapeportal.org. This project will benefit from existing data in the LDSF database, while at the same time contributing to these critically important global datasets through on-going data collection. Earth Observation (EO) data will be combined with the LDSF framework to develop the outputs for the project, including land degradation and soil health.

II. Specific Activities on the ICRAF Component as Stated in the Agreement

1. Develop survey methodology detailing study design, methodology, tools, work plan and timelines documented
2. Procure of assorted LDSF Field Survey equipment
3. Conduct five LDSF surveys across the KCEP-CRAL action areas
4. Process, analyse and **document the soil samples**
5. **Conduct Earth Observation-based assessment of biophysical indicators over time**

6. Conduct capacity development opportunities with members of the PCU M&E staff and Government counterparts on LDSF field methodology

7. Share outputs and data from the LDSF

III.   Timeline of Activities

1. The MoU between the Government of Kenya and ICRAF was signed 23 July 2018

2. A partner meeting between the KCEP-CRAL PCU, FAO and ICRAF held at ICRAF to discuss and share details on the field survey methodology and collaboration.

3. The LDSF methodology was approved by IFAD, KCEP-CRAL and partners in September 2018.

4. LDSF sites were co-located with HH Baseline surveys in Nov 2018. Household survey coordinates were shared with ICRAF and five LDSF field sites were randomized to be co-located with household surveys across the KCEP-CRAL project action sites (see map below).

5. Procurement of equipment from Aug- Dec 2018.

6. LDSF field surveys and trainings commenced in November 2018 with Muminji and finished in June 2019 in Chasimba (see below). In each site, government authorities and KCEP-CRAL representatives were consulted and engaged. These in-the-field trainings contributed to the capacity building aspect of the project.

7. Presentation of LDSF results to KCEP-CRAL project team during IFAD mission in May 2019.

8. Submission of Annual Report to PCU of KCEP-CRAL, July 2019, available here: https://www.dropbox.com/s/l79h9ka3k9afxm5/v3ICRAF_Annual%20Report%20to%20KCEP-CRAL%20July%202019.pdf?dl=0

9. Participation in IFAD mission in October 2019. The ICRAF presentation is available here: https://www.dropbox.com/s/i1ucsv86g0ws050/ICRAF_KCEP-CRALUpdate%20October2019.pptx?dl=0

10. Participation in EU mission (Dario Cipolla and David Coombs) 10 October 209

11. Prepared presentation for the IFAD mission in 9 Dec 2019

12. Analysis of the 740 topsoil and 720 subsoil samples by Dec 2019

13. Submission of biannual report to PCU 14 Dec 2019 available here: https://www.dropbox.com/s/8r7grkxi9c6wm0k/ICRAF_Report%20July-Dec%202019_KCEPCRAL.docx?dl=0

14. Spatial assessments of soil properties May 2020

15. Submission of report on spatial assessment of soil properties. 12 May 2020

16. Engagement with Makueni county of the decision dashboard June – Dec 2020 https://wle.cgiar.org/thrive/2021/01/26/how-online-decision-dashboards-can-make-evidence-more-accessible-decision-makers

17. Spatial assessments of vegetation November 2020

18. Compilation and sharing of the soil data collected. January 2021

19. Presentation for the KCEP-CRAL meeting in Machakos Jan 2021: https://www.dropbox.com/s/72jp8mryvacyni8/ICRAF_KCEP-CRALUpdate%20January%202021v1.pptx?dl=0

20. Presentation for the KCEP-CRAL meeting May 2021: https://www.dropbox.com/s/k62mzhtsb9a8vwd/ICRAF_KCEP-CRALUpdate%20May%202021v1_sm.pptx?dl=0

21.Annual assessments of vegetation cover conducted for 2018, 2019 and 2020- all maps shared in dropbox: https://www.dropbox.com/sh/3o4y7dip9gocyyd/AABI4T-xlL4RP_mOmsFK75ywa?dl=0

22. Makueni Resource Hub is online: https://dashboards.icraf.org/app/makueni_resource_hub
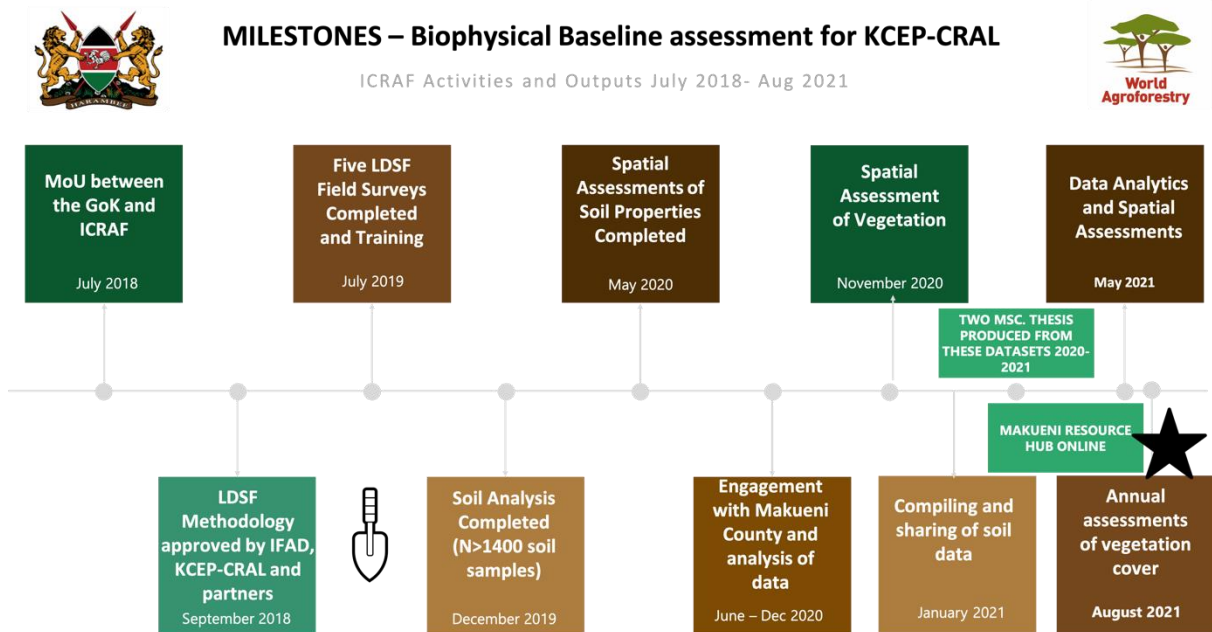

Figure 1: Milestones to date (January 2021).

IV. Big highlights of this report

Three Big Highlights in this Report

Three exciting achievements in this report

2021 — Engagement with the regional NRM partners, IFAD and EU missions.

2021 — All soil data have been shared in a citable online data repository.

2021 — Vegetation Assessments for all Counties for three years (2018, 2019, 2020) have been completed and shared!

Figure 2: Three big highlights in the report for 2021.

V. Annual assessments of Vegetation Cover

Fractional vegetation cover is an assessment of vegetation across 12 months. This map was produced using Landsat 8 at 30-meter resolution. Note the high variability across the counties. The low areas are in need of increased productivity.

As part of the August 2021 report we are reporting on the annual assessments of vegetation cover, each year 2018,2019, and 2020, for each county.

The geotiff files are all available here:

1. 2018 Vegetation Assessment:
   https://www.dropbox.com/sh/m7ou4y28rp6vwjl/AAApV8bN3fKI4712Tu4ide6va?dl=0
2. 2019 Vegetation Assessment:
   https://www.dropbox.com/sh/icittm2zlmc1g1g/AACK8hapmGuGgQepvTxfn-zaa?dl=0
3. 2020 Vegetation Assessment:
   https://www.dropbox.com/sh/z9b6osymyiaqb4p/AAD69jovAVBoB1Z-D1ia3wRva?dl=0
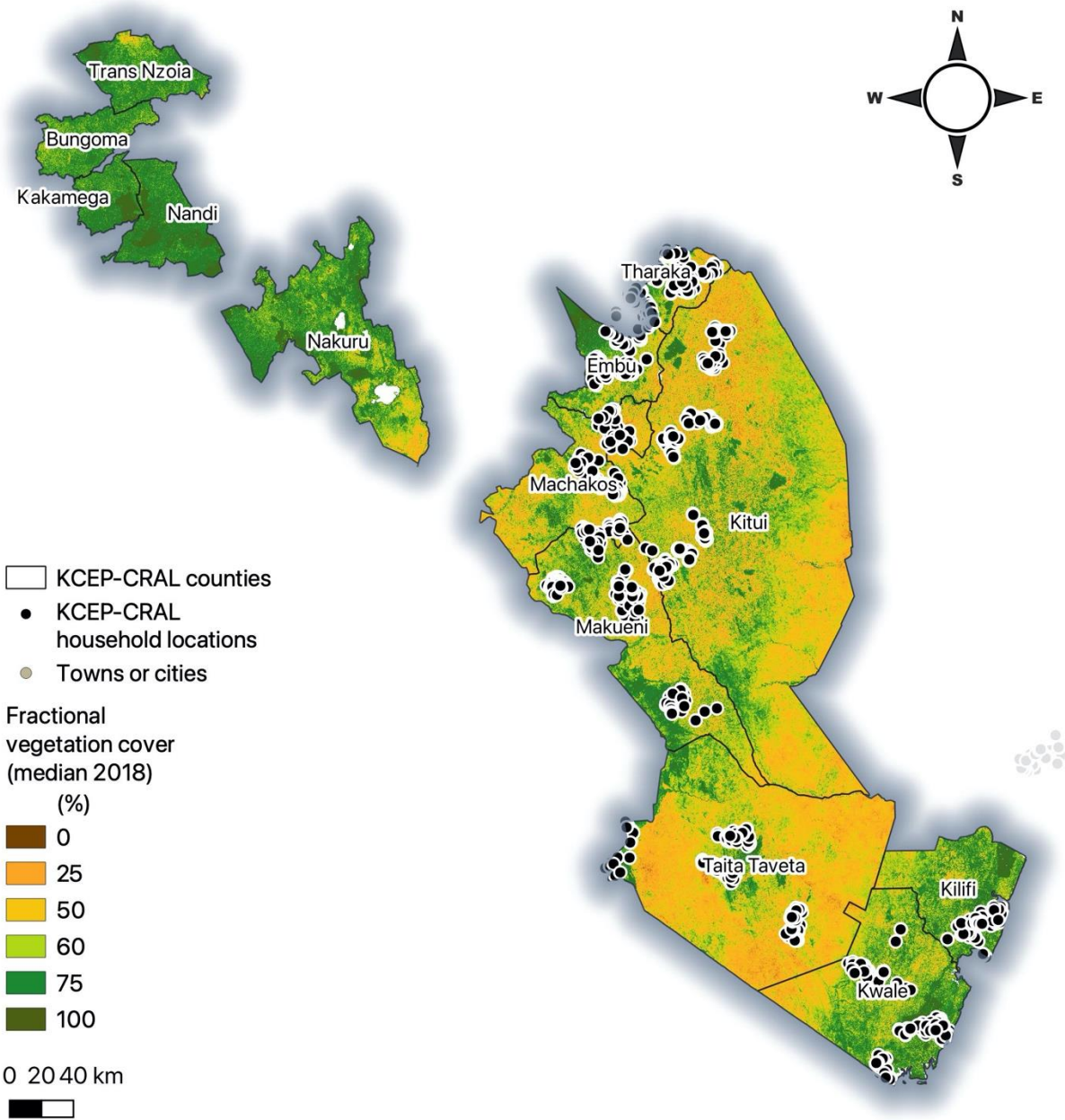
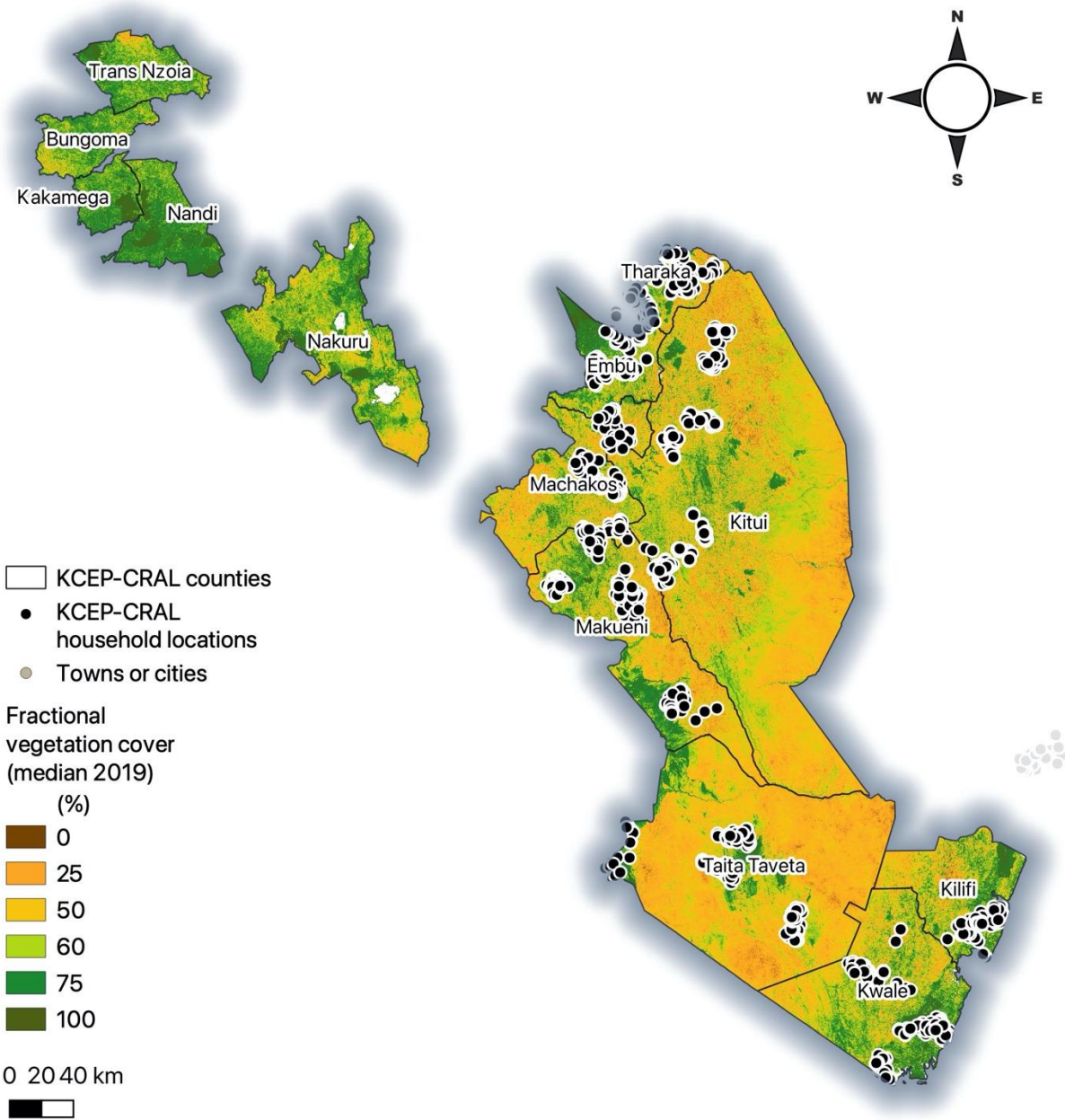*Figure 3: Fractional vegetation cover for 2018.*

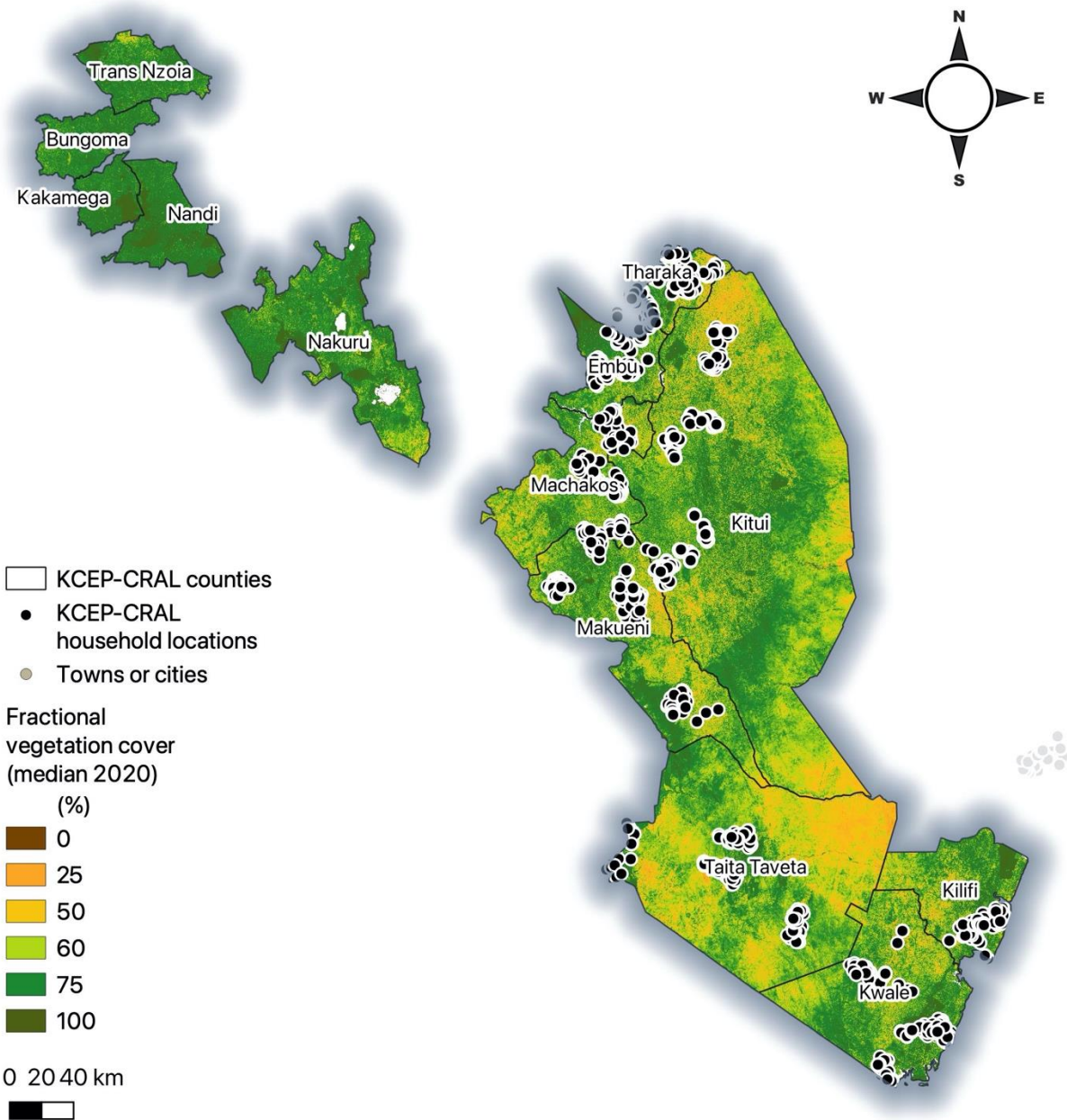*Figure 4: Fractional vegetation cover for 2019.*

Figure 5: Fractional vegetation cover for 2020.

In addition, all of the jpeg maps are available here:
1. Maps of vegetation for each project counties (2020):
   https://www.dropbox.com/sh/hf27fikpzarqthq/AADcZt22umulgpnxtNO4j9F8a?dl=0
Below is a sample of a few of the counties.
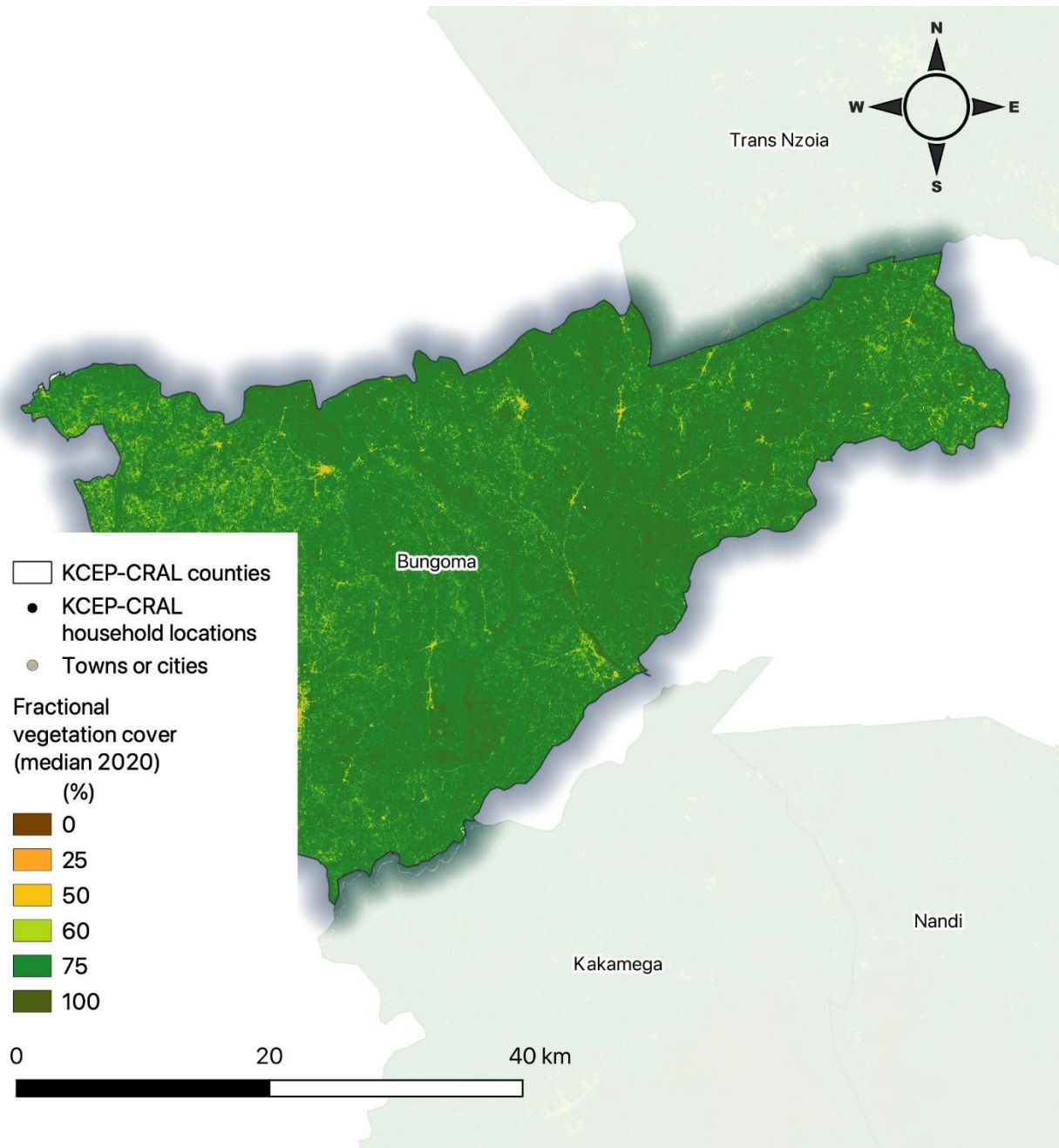
Figure 6: Vegetation assessment in Bungoma 2020.
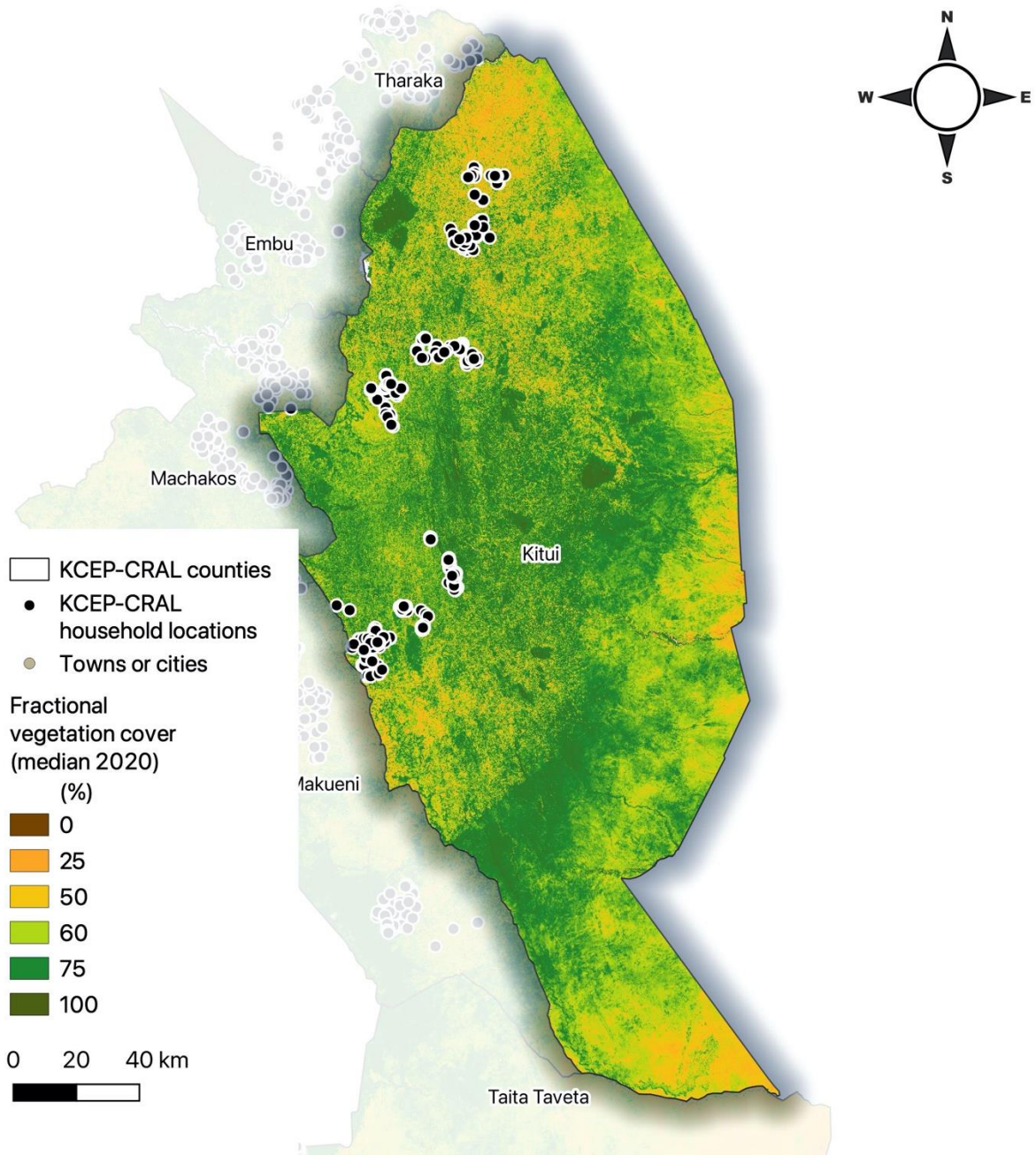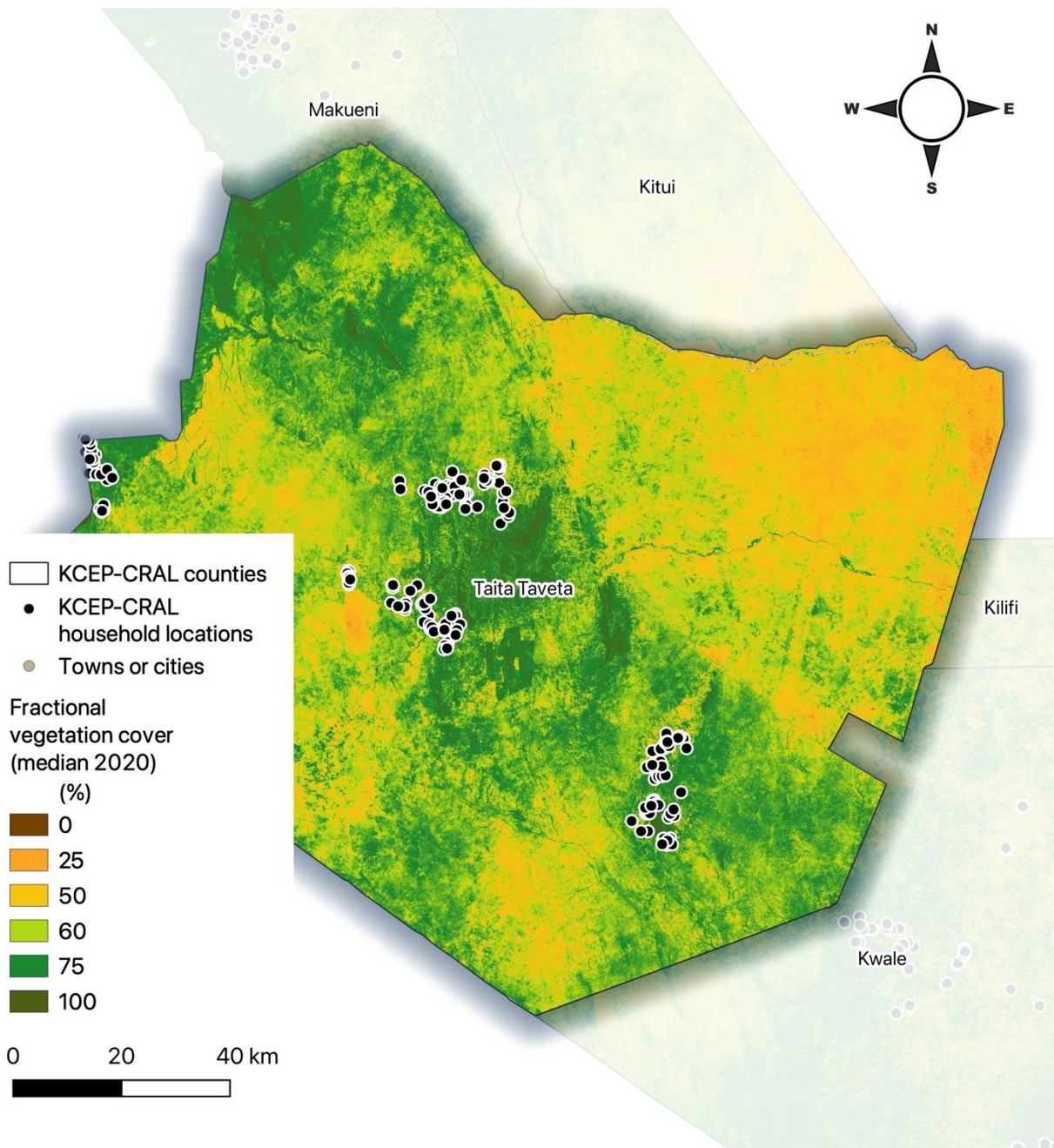
Figure 7: Vegetation assessment in Kitui: 2020.

Figure 8: Vegetation assessment Taita Taveta: 2020.
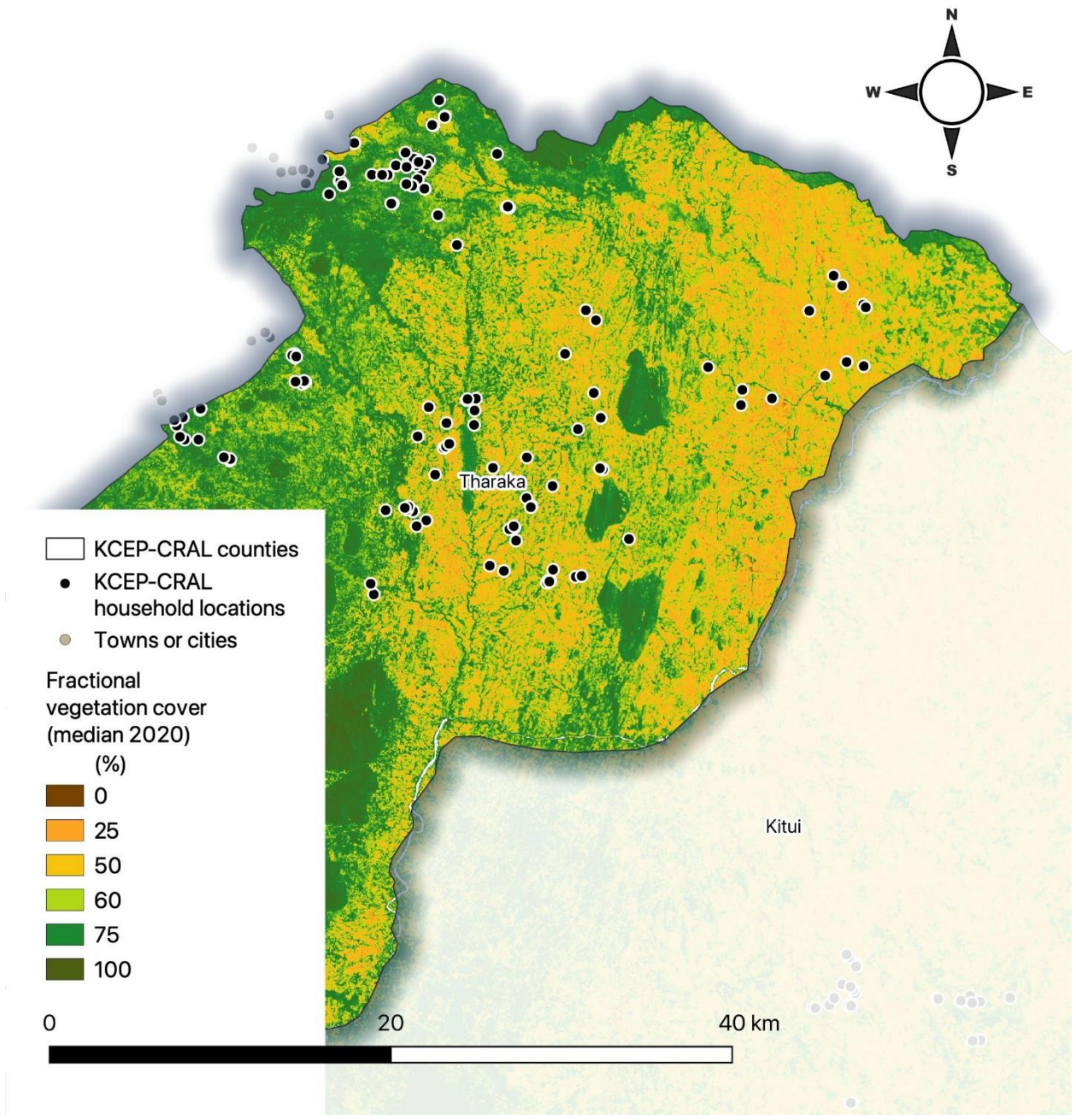
Figure 9: Vegetation assessment in Tharaka Nithi: 2020.
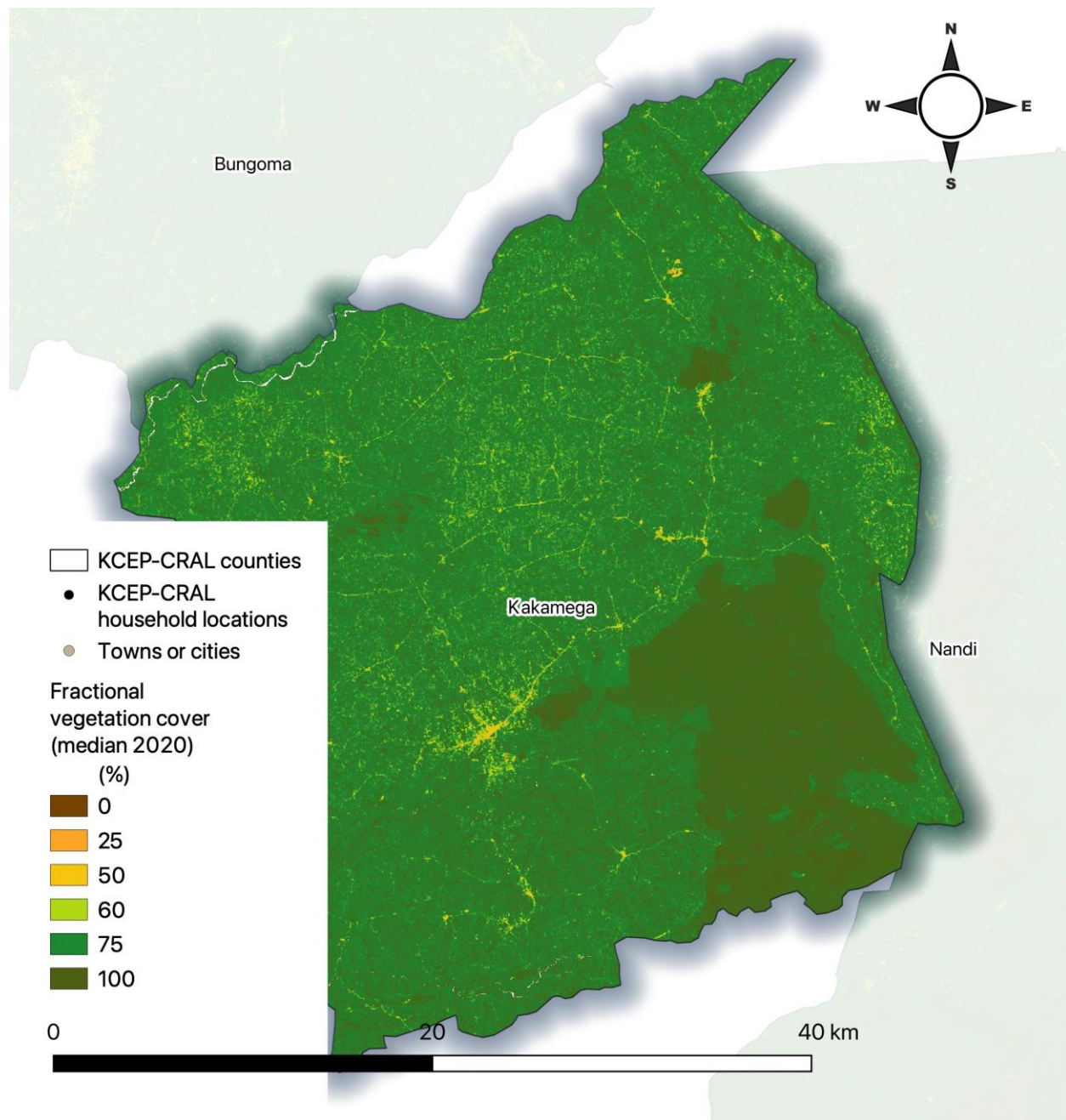
Figure 10: Vegetation assessment in Kakamega: 2020.

VI. Mapping Biophysical Indicators of the KCEP-CRAL

Assessment and surveillance of land degradation dynamics are key to the prioritization and spatial targeting of land management options and to monitoring of the effectiveness of such interventions. Also, the type of evidence provided through such assessments are of critical importance to decision making around investments in and scaling of land management interventions.

The project will identify and measure key indicators of land and soil health in order to understand drivers of degradation, prioritize areas for interventions and monitor changes over time. Indicators for assessment and monitoring of land degradation should be: 1) Science based; 2) Readily measurable (quantifiable); 3) Rapid; 4) Based on field assessment across multiple scales (plot, field, landscape, region); and 5) Representative of the complex processes of land degradation in landscapes.

Baseline assessments of key soil properties, including soil organic carbon (SOC), soil pH and soil erosion prevalence were conducted across all of the KCEP-CRAL action counties (Figure 1). Maps of each indicator were produced using the global network of LDSF sites, including the five LDSF sites sampled as part of this project (Figure 2), coupled with Earth Observation (EO) data. These baseline maps are for 2018, at a resolution of 30meters, using Landsat 8.
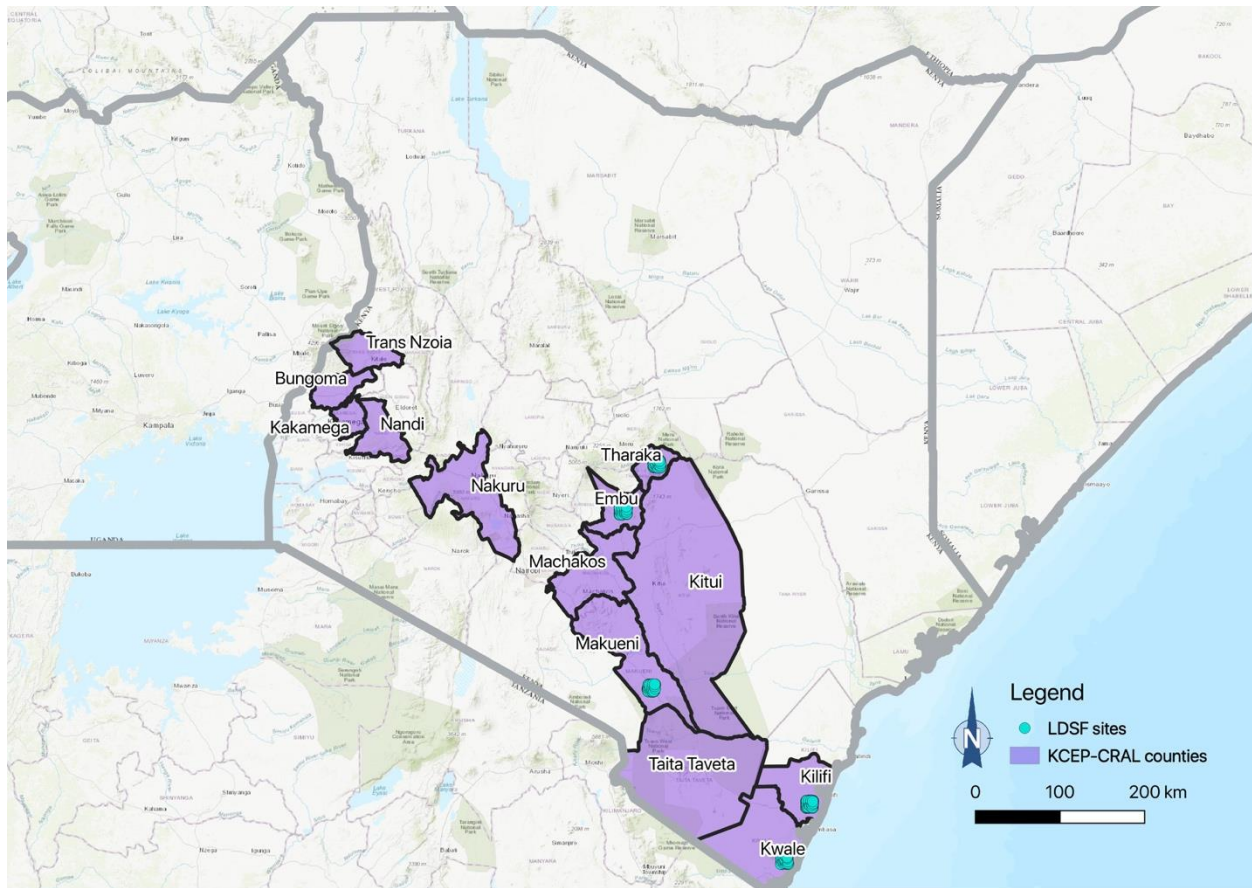

Figure 11: The 13 action counties for KCEP-CRAL and the location of the five LDSF sites sampled in 2019.

Soil organic carbon (SOC)

Soil organic carbon (SOC) is a key indicator of soil health as it influences the water holding capacity of the soil, cation exchange capacity, soil fertility, among other key soil properties, as well as a number of other ecosystem services provided by soil. It is responsive to land management and vegetation shifts and hence an important indicator to assess in terms of the effectiveness of land management efforts. Maps of SOC were developed using ICRAF's georeferenced database of ecosystem health indicators coupled with remote sensing imagery[1]. Figure 3 shows the spatial distribution of the SOC across thirteen counties in Kenya. These data will be used to track land management efforts over the lifetime of the project. In order to compare the SOC content across the 13 counties, we randomly sampled 100,000 points and extracted the SOC values for each point (Figure 4). Table 1 shows the mean and median SOC values for each county. The below density plots show the variation of SOC across the counties (mean SOC was 17.3 gC/kg soil and median was 14.4 gC/kg soil) (Figure 5).

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[1] Vågen, Tor-G., Winowiecki, L., Tondoh, J.E., Desta, L.T. and Gumbricht, T. 2016. Mapping of soil properties and land degradation risk in Africa using MODIS reflectance. Geoderma. http://dx.doi.org/10.1016/j.geoderma.2015.06.023
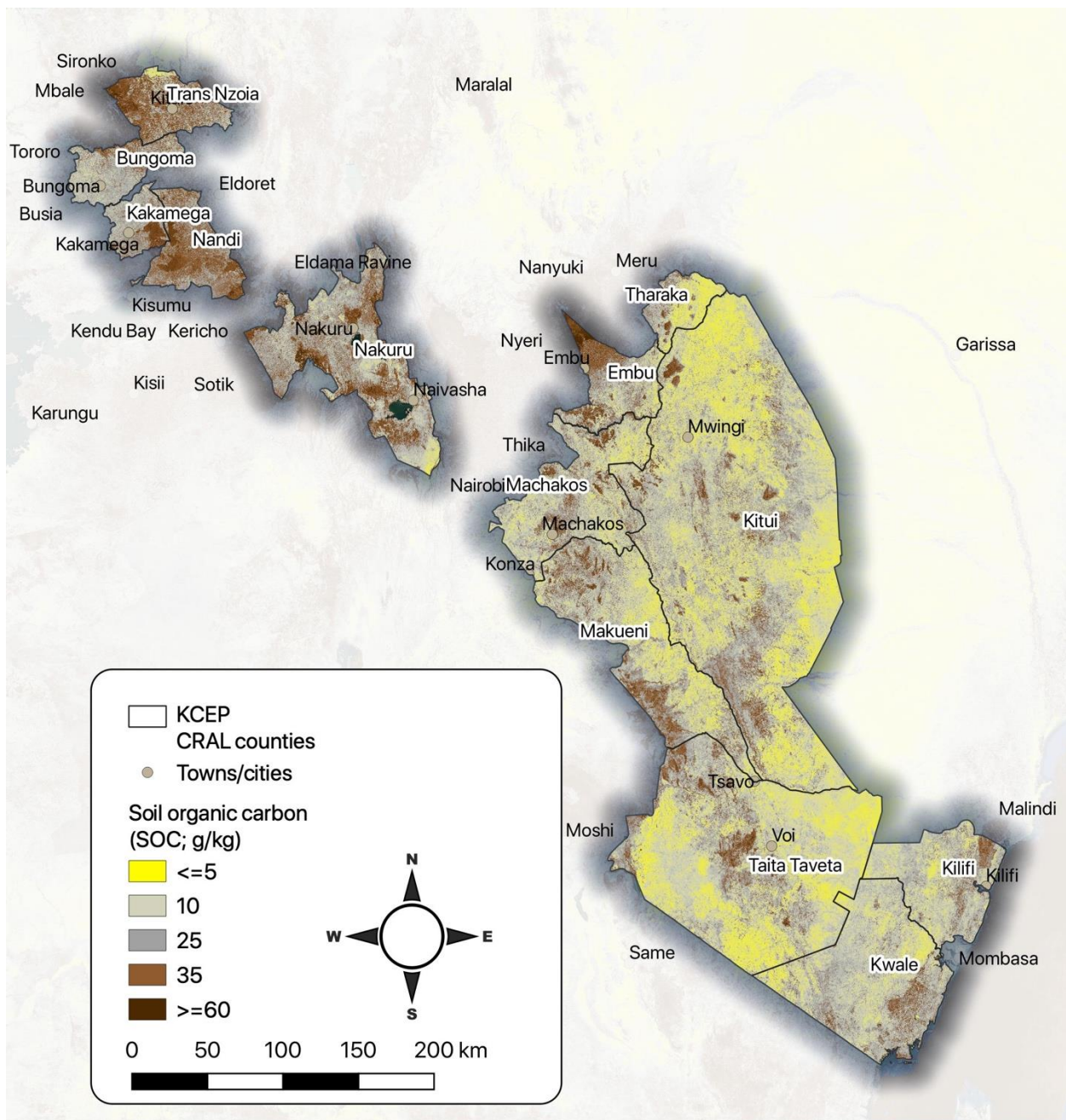
Figure 12: Soil organic carbon (SOC) content at 30 meter resolution.
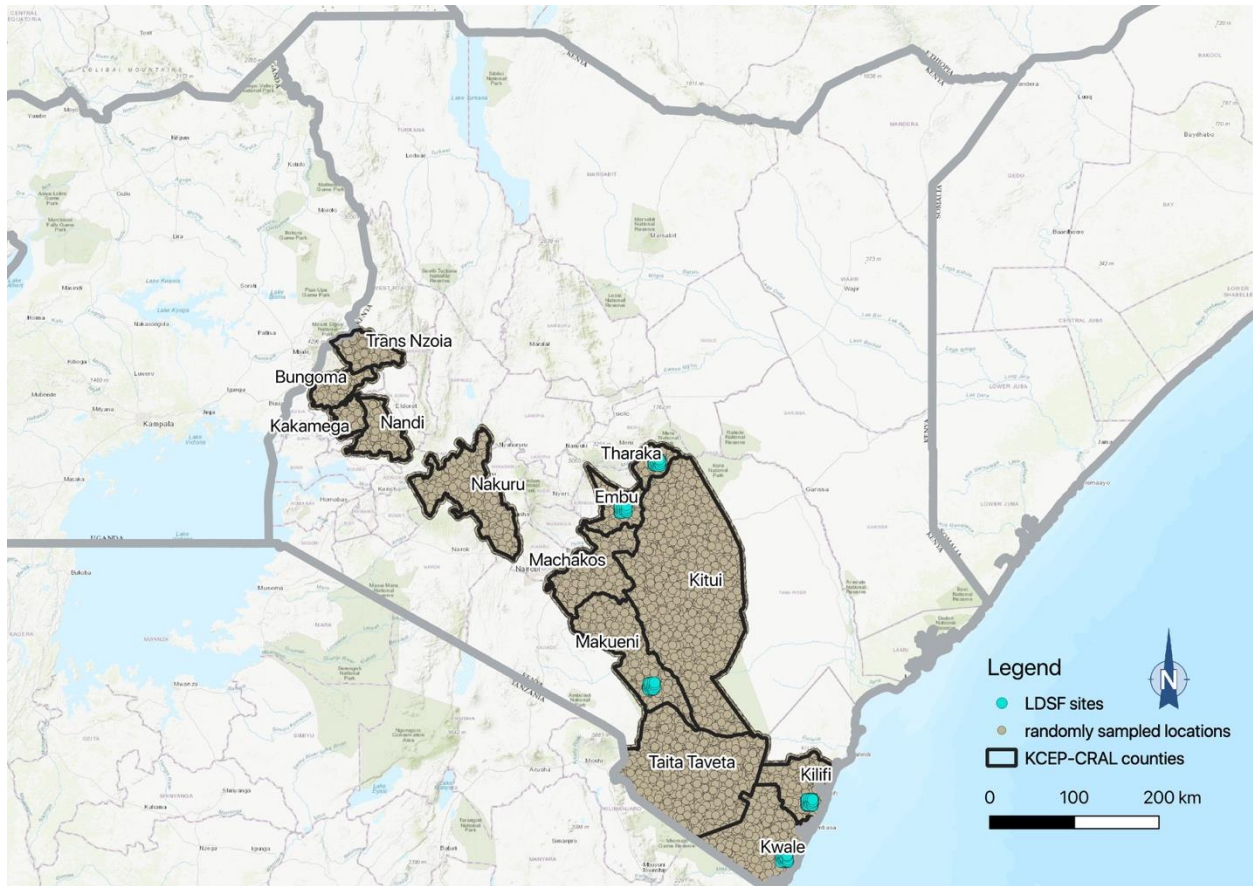
Figure 13: Randomly sampled points (n=100,000) across the 13 counties for SOC analysis.

Table 1: Mean and median SOC values for each county.

County	SOC (mean g/kg)	SOC (median g/kg)
Bungoma	21.9	21.2
Embu	25.9	23.9
Kakamega	25.1	24.3
Kilifi	16.1	14.3
Kitui	14.1	11.4
Kwale	16.2	14.4
Machakos	17.2	14.3
Makueni	17.7	15.1
Nakuru	24.0	23.3
Nandi	31.7	31.5
Taita Taveta	13.8	10.8
Tharaka	14.4	10.0
Trans Nzoia	30.2	31.4

Density plots show the distribution of SOC for each county. The high peak for Tharaka Nithi around 10 g/kg indicates there is a high density of points around that value with some SOC values extending to 50 g kg. Embu county had no sharp peaks and high variation across the county. Overall, the counties in western Kenya had higher SOC content compared to the eastern counties. This could be due to a number of factors- including climatic differences as well as differences in inherent soil properties (soil texture, for example). These data will be used to compare baseline to endline SOC values for the project area.
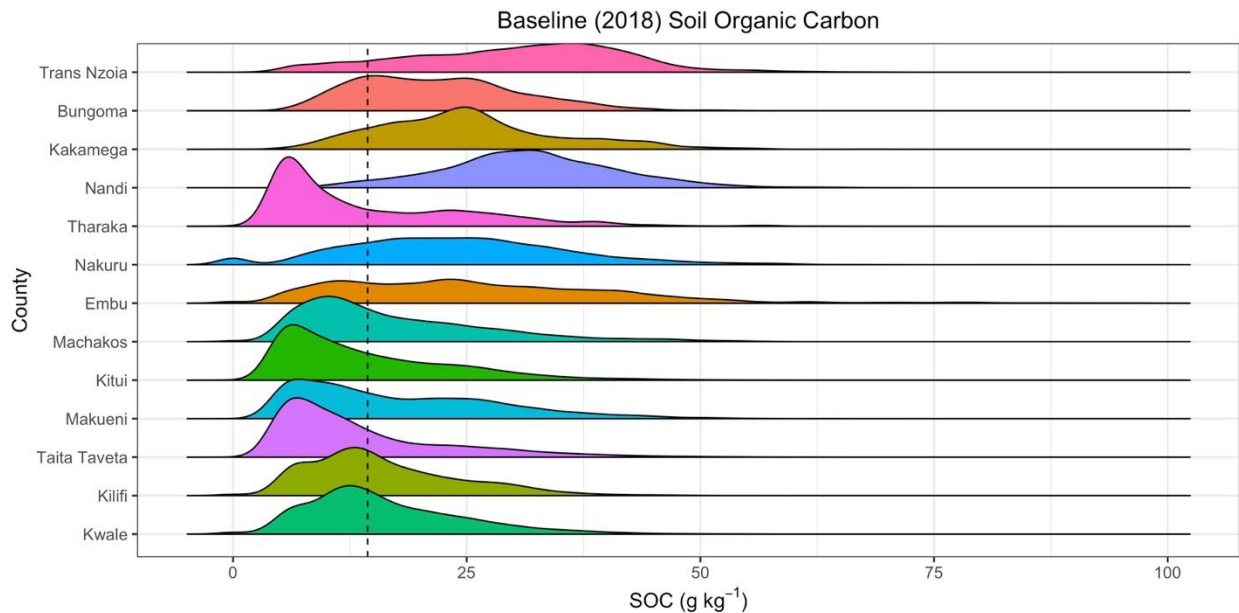
Figure 14: SOC values of 100,000 randomly sampled points across the 13 counties.

Soil erosion prevalence

Erosion is the most widespread form of land degradation. During the LDSF field surveys, erosion was scored and classified in each subplot (n=4) per plot. Plots that had three or more subplots with erosion were classified as having severe erosion. The below graphic demonstrate the erosion prevalence across the sites. KuboSouth had the lowest erosion prevalence, only 5% of the sampled plots, followed by Thange (32%). In contrast, Chasimba had 65% of the site with severe erosion. The average erosion across the sites was 41%. The diagram to the right demonstrates how to interpret a boxplot. Figure 6 shows the variation of erosion across the five LDSF sites.
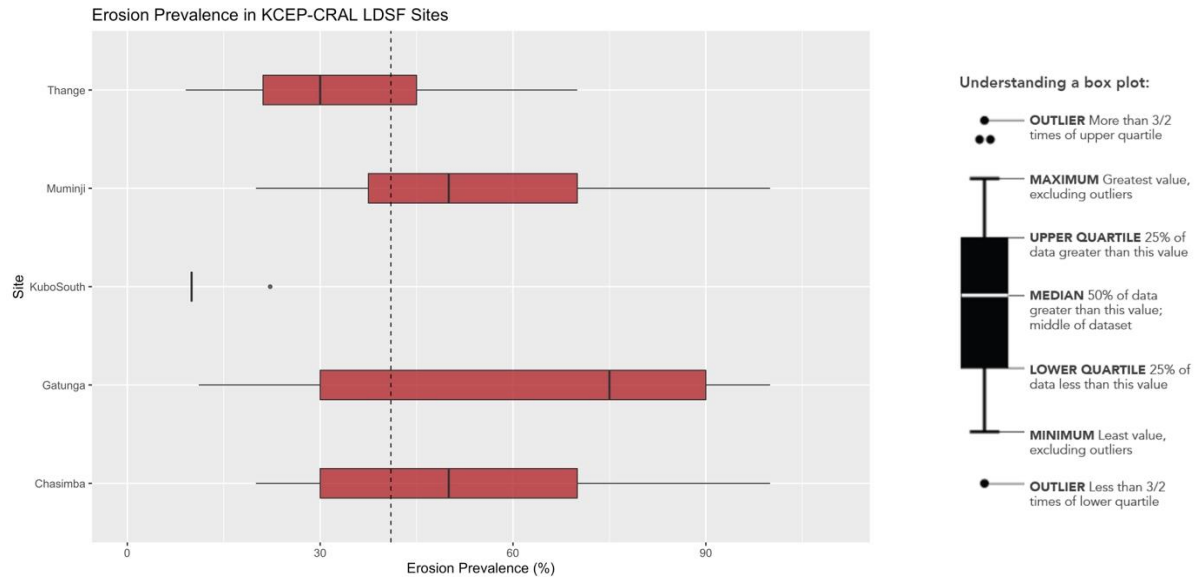
Figure 15: Boxplots of the erosion prevalence across the LDSF sites.

Soil Water Conservation (SWC) measures observed in the five LDSF sites

Soil water conservation (SWC) measures were classified and counted at each plot. Examples of SWC measures could be stone bunds or zai pits (labelled as structural), contour tree planting (labelled as vegetative), or a combination of both vegetative and structural (labelled as both). The below graphic demonstrates the **overall low use of SWC measures** across the sites. Thange had the highest number of SWC measures and Chasimba had the lowest. These data have implications for soil erosion and opportunities to employ options to curb erosion prevalence.

Figure 16: Prevalence of soil water conservation measures across the five LDSF sites.

Spatial assessment of soil erosion prevalence

Soil erosion is a key indicator of land degradation. Maps of SOC were developed using ICRAF's georeferenced database of ecosystem health indicators, including the LDSF data collected in this project, coupled with remote sensing imagery[2] at the same spatial resolution as the maps of SOC above (30 meter resolution). An erosion prevalence higher than 50% is considered high, while values higher than 75% indicate severe soil erosion. Note that erosion prevalence was higher in the eastern counties compared to western counties (Figure 6).

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[2] Vågen, T.-G.; Winowiecki, L.A. Predicting the Spatial Distribution and Severity of Soil Erosion in the Global Tropics using Satellite Remote Sensing. *Remote Sens.* **2019**, *11*, 1800. https://www.mdpi.com/2072-4292/11/15/1800
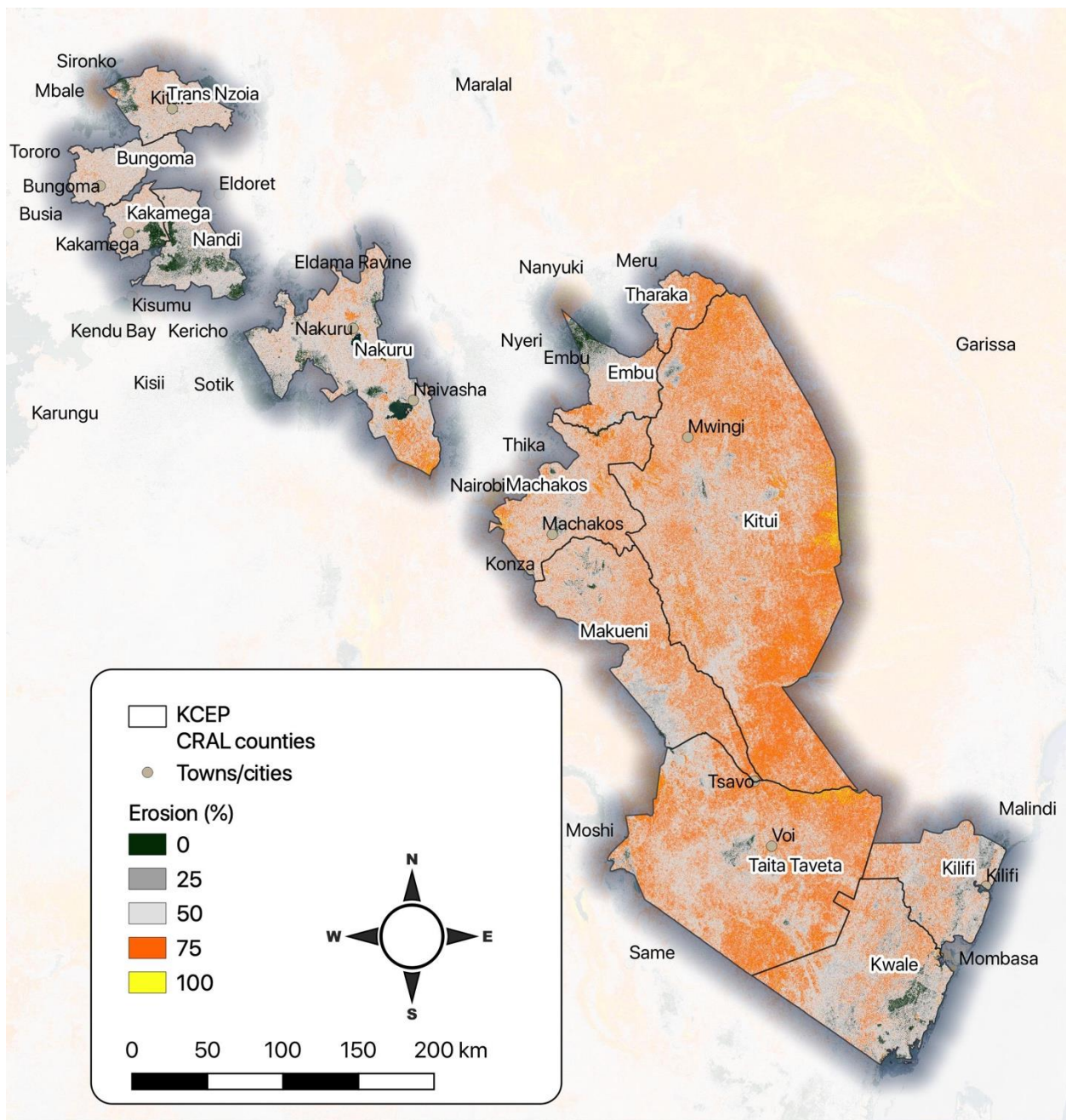
Figure 17: Soil erosion prevalence (2018) using Landsat 8 (30 m resolution).

Soil pH

Soil pH is an indicator of soil acidity. At low soil pH values (< 5.5) there is a risk of aluminum and magnesium toxicity. At high soil pH (> 8.3), there can be induced phosphorous and micronutrient deficiency which may also indicate high sodium levels. Figure 9 shows the spatial variation of soil pH across the 13 counties, indicating high variation. In the eastern counties there are pockets of high pH (pH>7) which in western counties there are pockets of low pH (pH > 5).
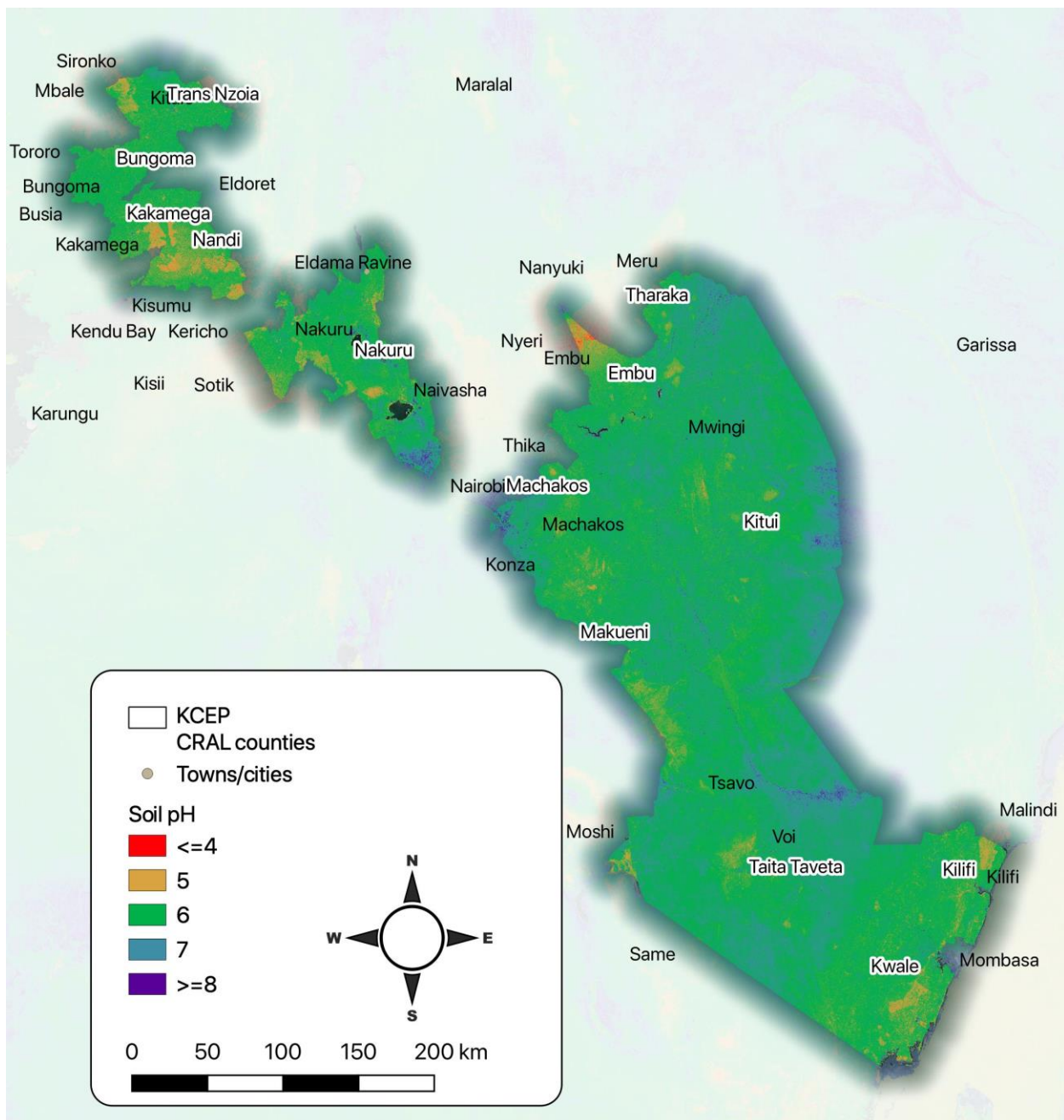
Figure 18: Soil pH maps for the 13 KCEP-CRAL counties, using Landsat 8 at 30 meter resolution.

VII.   Sharing of Soil Data

These data have been collated and organized. They are uploaded to Dataverse:
https://data.worldagroforestry.org/dataset.xhtml?persistentId=doi:10.34725/DVN/CBHCKS

This is a citable, open access dataset that can be re-used and referenced. 1500 soil samples analyzed and collated. Six variables from 787 LDSF Plots.

Here is the citation for the dataset:

Winowiecki, Leigh Ann; Vågen, Tor-Gunnar; Tobella-Bargues, Aida; Magaju, Christine; Muriuki, Justin; Mwaniki, Alex, 2021, "Biophysical baseline assessment within the KCEP-CRAL action areas in Kenya, using the LDSF", https://doi.org/10.34725/DVN/CBHCKS, World Agroforestry - Research Data Repository, V1, UNF:6:yOb7hDKxCflV/SrDQyOgLw== [fileUNF]

Figure 19: Screenshot of the online data.

Table 2: Summary of the plots sampled and shared online.

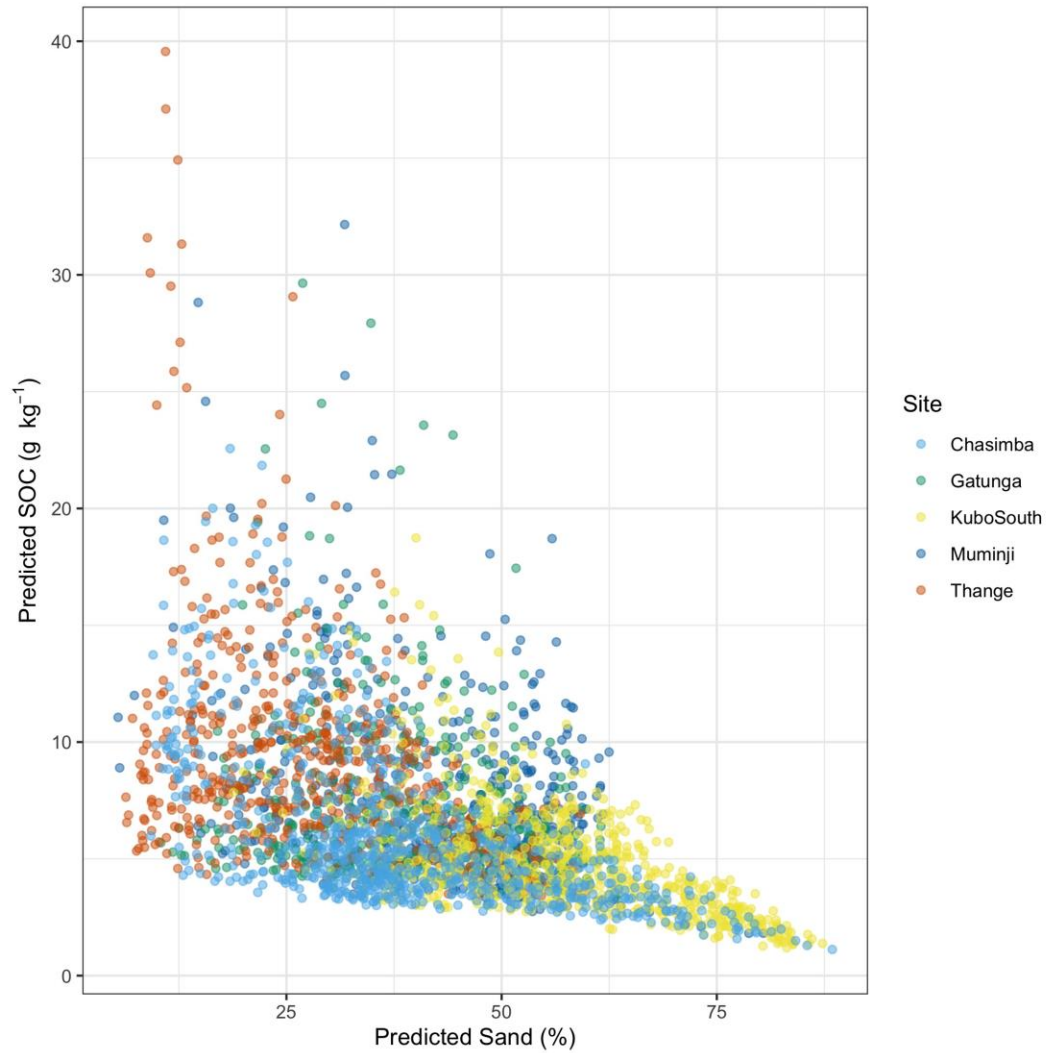| Site	Number of plots
Thange	158
Muminji	158
KuboSouth	153
Gatunga	159
Chasimba	159

Figure 20: Relationship between soil organic carbon and sand at the five LDSF sites.

VIII. Engagement with Makueni County

Integration of KCEP-CRAL data and inclusion of spatial maps into an online and open access Resource Hub. The Hub will be launch in March 2021, ACTION: Hope the KCEP-CRAL PCU will join the launch of the Dashboard in March 2021.
https://wle.cgiar.org/thrive/2021/01/26/how-online-decision-dashboards-can-make-evidence-more-accessible-decision-makers

NEW: The resource hub is online here: https://dashboards.icraf.org/app/makueni_resource_hub
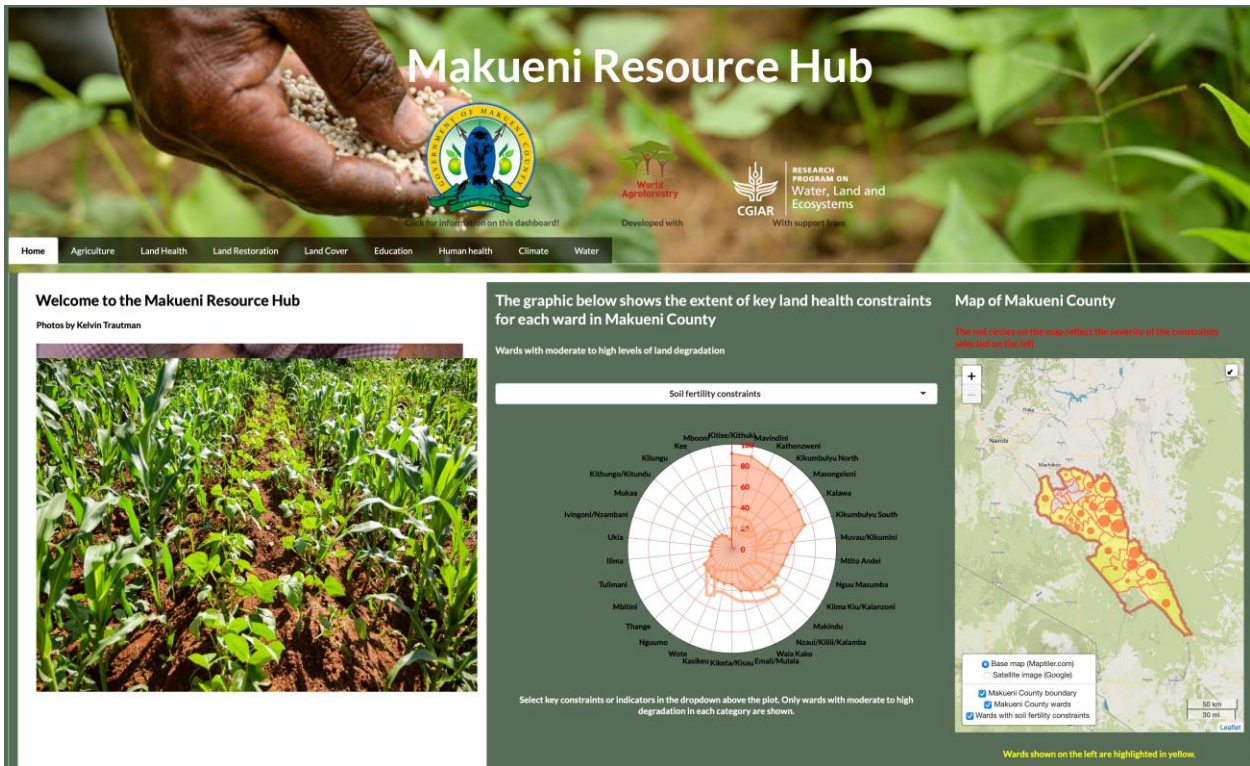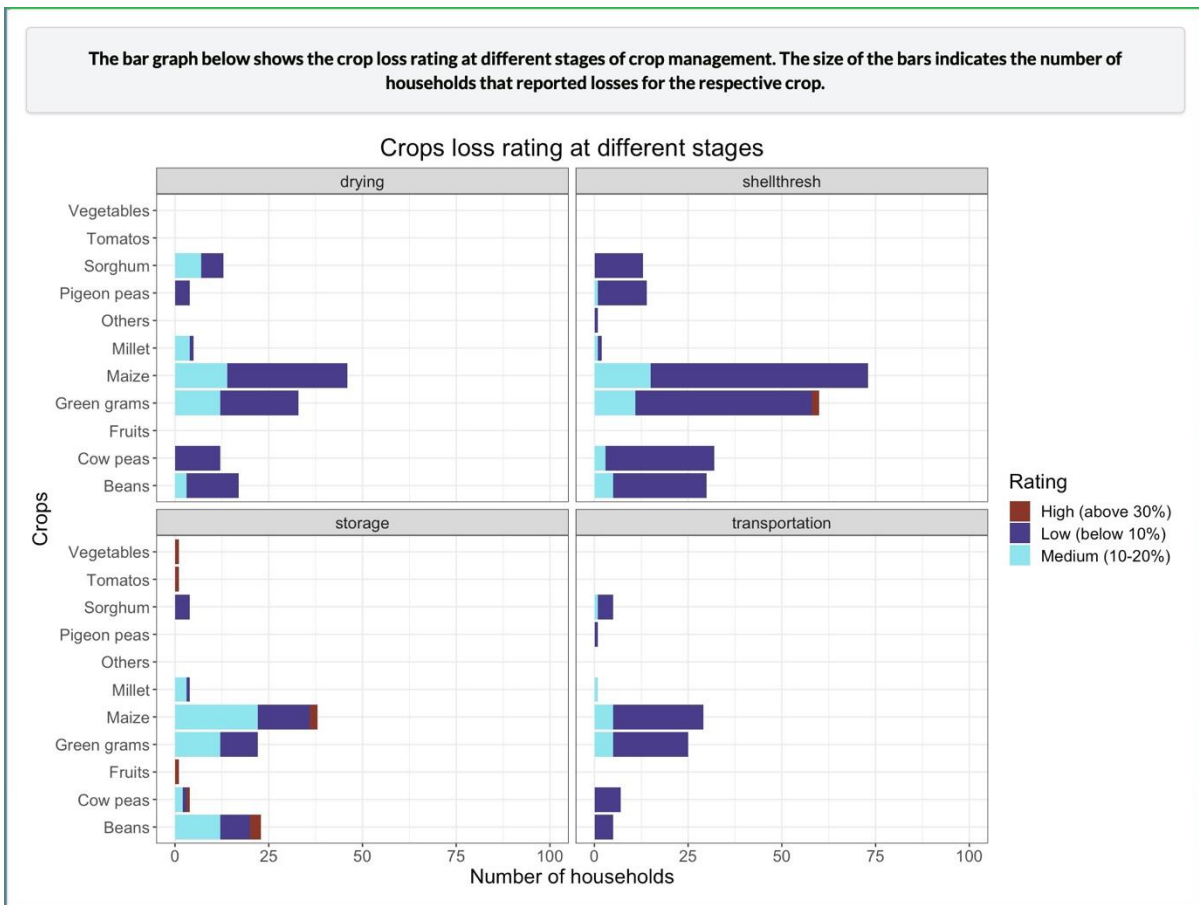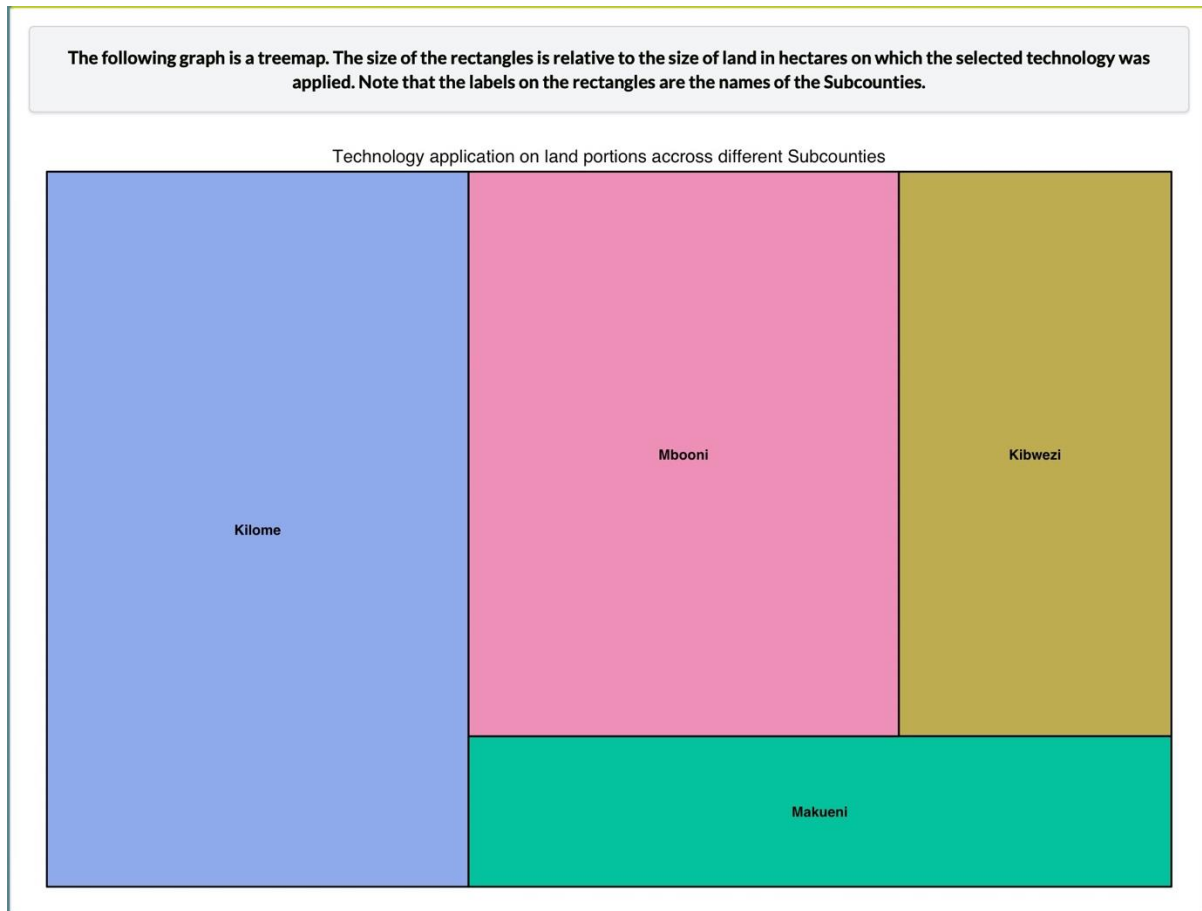
Figure 21: Screenshot of the Makueni Resource Hub.

The bar graph below shows the crop loss rating at different stages of crop management. The size of the bars indicates the number of households that reported losses for the respective crop.

Figure 22: Example of graphics of KCEP-CRAL HH dataset integrated into the Makeuni Resource Hub.

IX. Next Steps

- Spatial assessments of indicators across time.
- Discuss with IFAD & PCU on how to communicate these outputs, including on the IFAD podcasts, blogs, etc.
- Discuss with PCU on the GPS coordinates of the project farmers to track interventions over time.
    - Do we have field coordinates and their interventions
- Statistical analysis linking soil properties with LDSF field data for the Annual Report-
- Data analysis workshop – to plan with NRM partners and PCU
    - Analyzing LDSF data with partners
- Should we have a remote video call with partners on these data?

Quarterly Progress in implementation of Annual Work Plan and Budget					
Finalized in quarter (Y/N)	Activity planned to be finalized in quarter? (Y/N)	AWPB Ref. Code	Activity (include only activities from AWPB planned to take place in quarter)	Status (Pending initiation, On-going[3], Finalized	Comments
Status of planned activities in quarter (as per AWPB) and any activities with delayed completion from previous quarter(s)[4]					
Y	Data analytics		Data analytics	ongoing	
Y	Spatial baseline assessment – using Earth Observation		Earth observation based assessment of biophysical indicators	finalized	
Y	Capacity development		Virtual training events with stakeholders and partners	On-going	Capacity development activities will take place in the final quarter of 2021 and in 2022.
Y	Annual assessments		Annual assessments of key indicators to evaluate impact of program.	On-going	Submitted for 2018, 2019, and 2020. 2021 will be submitted next year.
Y	Soil data collation		Soil data curated and shared in an open access online data repository.	Finalized	
Sum of Y1	Sum of Y2				
% of planned activities to be completed in quarter that were actually finalized in quarter[5]:					
General Comments: The project is ontrack.					

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[3] In On-going activities, please include a % of achievement

[4] In Quarter 1, no activities with delayed completion from previous quarter(s) will be reported

[5] Number of activities planned to be completed in the quarter that were actually finalized divided by Number of activities planned to be completed in the quarter multiplied by 100 (to get %)