NASA - CI PARTNERSHIP: MAPPING ECOSYSTEMS IN SUB-SAHARAN AFRICA

Dr. Miroslav Honzák Pretoria, October 2019

CONSERVATION INTERNATIONAL



PARTNERSHIP GOALS **CONSERVATION** INTERNATIONAL



- Support the Gaborone Declaration for Sustainability in Africa ecosystem extent at the national scale
- Pilot the methodology in four GDSA countries (i.e., Liberia, Gabon, Botswana, and TBD)



(GDSA) countries in Natural Capital Accounting by developing a repeatable and easy-to-implement method for mapping of



Natural Capital Accounting - integrate the value of nature into decisions and policies Sustainable Development - sustainability reflected in national plans and production systems **Environmental-Economic Monitoring** - ensure decisions reflect change towards sustainability **Corporate Leadership** - accelerate the transformation to sustainability

GDSA TARGETS



gaborone declaration for sustainability in africa







REQUIREMENTS

 The maps should be directly applicable and support the development of other SEEA accounts

implement at low cost



 Ecosystem extent maps need to move beyond land-cover and capture the underlying ecosystems that provide services

The methods need to be replicable, transferable and easy-to-



Lead: Woody Turner **Coordinator: Keith Gaddis Technical Team:**







Dr. Lola Fatoyinbo









APPROACH

3 Steps

- Data preparation
- Binary classification •
- Map composition







NASA TEAM

Why Google Earth Engine™?

Relatively "unlimited" computational • power;

Easily reproducible by any user with • a computer and access to the internet;

Ultimately transfer this methodology • to empower nations to maintain and monitor their natural capital resources.



Our goal is to develop an approach that yields great quality products.

Robustness and Quality of the repeatability final product

LIBERIA

Land cover classes

- Literature review.
- 10 initial land cover/ land use classes.



Secondary Forest

All areas dominated¹ by broadleaved trees^a with evidence of human disturbance and or logging history.

Mixed Vegetation

All areas dominated¹ by broadleaved trees^a, shrubs, bushes and herbaceous vegetation.



Primary Forest

All areas dominated¹ by broadleaved trees^a relatively intact or no clear visible indication of human activity.

Grasslands

All areas dominated¹ by hearbaceous type of cover.



Croplands

All areas dominated¹ by non-natural vegetation. Usually followed by harvest and baresoil and/or grasslands.



Ecosystem Complex

All areas of sand beaches and intertidal zones.



All areas characterized by bare rock and/or exposed soil with little or no "green" vegetation.

¹ Presence equal or greater than 50% within a 30-m pixel (900 m²) ° Woody vegetation with height equal or greater than 5 meters.

Water bodies are all areas of open water.



All areas of vegetative cover where the soil is saturated with or covered with water.



Artificial Surfaces

All areas dominated¹ by buildings and other man-made structures.





LIBERIA

Land cover classes

Water bodies
Mangroves and Wetlands
Artificial Surfaces
Barren Land
Ecosystem Complex
Croplands
Grasslands
Primary Forest
Secondary Forest
Mixed Vegetation







Attendees were part of the Environmental Protection Agency (EPA), Conservation International Liberia (CI - Liberia), Forestry Development Authority (FDA), Ministry of Agriculture, Ministry of Finance and Developing Planning, Liberia Institute of Statistics and Geo-Information Systems (LISGIS), National Fisheries and Aquaculture Authority, University of Liberia, Flora and Fauna International, Society for the Conservation of Nature of Liberia, among others.

Monrovia, Liberia September 2018

GABON

NASA - AGEOS

- NASA and the Agence Gabonaise d'Études et d'Observations Spatiales;
- Remote sensing analysists from AGEOS visited Goddard on June 2018;
- Training and capacity building; •
- Test the repeatability of our approach; •
- Land cover map for Gabon; ٠



GABON

Land cover classes

- Literature review.
- 9 initial land cover/ land use classes:

1 class was subdiveded into 2 sub-classes based on seasonal occurrence.



All areas dominated¹ by broadleaved trees^a relatively intact or no clear visible indication of human activity.



Secondary Forest

All areas dominated¹ by broadleaved trees^a with evidence of human disturbance and or logging history.



Water bodies are all areas of open water.



11 -

All areas dominated¹ by broadleaved trees[°] along rivers and streams subject to dramatic water fluctuations and seasonal flooding.

<u>م</u>ک Grasslands

All areas dominated¹ by hearbaceous type of cover.

Croplands

All areas dominated¹ by non-natural vegetation. Usually followed by harvest and baresoil and/or grasslands.

Hm

Barren land

All areas characterized by bare rock and/or exposed soil with little or no "green" vegetation.

¹ Presence equal or greater than 50% within a 30-m pixel (900 m²). ^o Woody vegetation with height equal or greater than 5 meters.

Mangroves & Wetlands Artificial Surfaces

All areas of vegetative cover where the soil is saturated with or covered with water.

All areas dominated¹ by buildings and other man-made structures.



GABON

Land cover classes

Water bodies
Mangroves and Wetlands
Artificial Surfaces
Barren Land
Croplands
Grasslands/Savanna
Flooded Forests (Permanent)
Flooded Forests (Seasonal)
Primary Forests
Secondary Forests







The GDSA Secretariat held a workshop in Libreville to meet with stakeholders and understand the in-country priorities for implementing the GDSA. The workshop consisted of several presentations by Conservation International, NASA, AGEOS and the GDSA Secretariat. Our visit to Gabon also included meetings with the Managing Director from the ANPN (National Agency for National Parks) - Professor Lee White and the Minister of Industry, Carmen Ndaot. We also visited AGEOS facilities and included a field component at Pongara National Park. Photos: Miroslav Honzak and Cello Sousa

Libreville, Gabon March 2019

BOTSWANA

Land cover classes

- Literature review.
- 8 initial land cover/ • land use classes:

2 classes were subdivided into 2 sub-classes based on density of cover and seasonal occurrence.

Grasslands \sim

> All areas dominated¹ by hearbaceous type of cover.



Open Shrublands

All areas covered² by vegetation including shrubs^a and grasses.



All areas dominated¹ by vegetation including shrubs^a and grasses.



BOTSWANA

Land cover classes

Open water (Permanent) Open water (Seasonal) Wetlands (Permanent) Wetlands (Seasonal) Salt Pans Artificial surfaces Croplands Closed woodlands Open woodlands Closed shrublands Open shrublands Grasslands





NASA and Conservation International Teams in Botswana. The proximity of Kwando Lagoon Camp todifferent types of vegetation and ecosystems allowed the teams to collect a vast amount of ground data. In Gaborone, all the members from NASA-CI teams presented on their role in the partnership.



Gaborone & The Okavango Delta, Botswana July 2019





One hour long low altitude flight from Maun to the airstrip serving the camp. The teams took advantage of this flight to collect aerial photographs along the flight line. Also, the team was able to take advantage of the game drives offered by the camp tovisit different vegetation types. Ground photographs as well as GPS points were collected in every location

Gaborone & The Okavango Delta, Botswana July 2019



GENERALIZED DISSIMILARITY MODEL



- GDM is a statistical technique for modelling compositional dissimilarity (beta diversity)
- It measures the proportion of species in a given biological group (e.g., reptiles) occurring at one location that do not occur at a second location – as a function of the environmental characteristics of these two locations.
- It is used to predict the compositional dissimilarity between any two locations within the region, regardless of whether biological data are available for these locations.







BIEN DATASET FOR LIBERIA

Input species data used (BIEN, V. 4.1):

- 57,452 observations
- 4,166 unique species

























	X29 -	-0.7	0.25	-0.23	0.02	-0
XI = Annual iviean Temperature	X28 -	-0.79	0.32	-0.28	0.06	-0
X2 = Mean Diurnal Range	X27 -	-0.03	-0.05	0.07	-0.07	-0
X3 = Isothermality	X26 -	-0.8	0.32	-0.29	0.06	-0
X4 = lemperature Seasonality	X25 -	-0.95	0.66	-0.56	0.28	-0
X5 = Max Temperature of Warmest Month	X30 -	0.44	-0.32	0.46	-0.34	-0
X6 = Min Temperature of Coldest Month	X24 -	-0.46	0.4	-0.5	0.32	0.
X7 = Temperature Annual Range	X23 -	-0.01	0.22	-0.34	0.3	0.3
X8 = Mean Temperature of Wettest Quarter	X22 -	0.71	-0.32	0.35	-0.14	0.3
X9 = Mean Temperature of Driest Quarter	X21 -	-0.25	0.13	-0.24	0.23	-0
X10 = Mean Temperature of Warmest Quarter	X20 -	0.61	-0.5	0.58	-0.4	-0
X11 = Mean Temperature of Coldest Quarter	X19 -	-0.09	-0.02	-0.27	0.25	0.
X12 = Annual Precipitation	X18 -	0.12	-0.59	0.79	-0.63	-0
X13 = Precipitation of Wettest Month	X17 -	0.25	-0.74	0.74	-0.55	-0
X14 = Precipitation of Driest Month	X16 -	0.03	-0.36	0.05	0.05	-0
X15 = Precipitation Seasonality	X15 -	-0.06	0.31	-0.6	0.6	0
X16 = Precipitation of Wettest Quarter	X14 -	0.26	-0.77	0.7	-0.56	-0
X17 = Precipitation of Driest Quarter	X13 -	0.07	-0.38	0.11	0.04	-0
X18 = Precipitation of Warmest Quarter	X12 -	0.07	-0.46	0.29	-0.11	-0
X19 = Precipitation of Coldest Quarter	X11 -	0.99	-0.54	0.47	-0.18	0.3
X20 = Soil bulk density	X10 -	0.94	-0.19	0.14	0.28	0.
X21 = Soil clay	X9 -	0.98	-0.55	0.45	-0.13	0.3
X22 = Soil depth	X8 -	0,96	-0.6	0.54	-0.23	0.3
X23 = Soil Ph	X7 -	-0.47	0.97	-0.8	0.77	0.
X24 = Soil silt content	X6 -	0.87	-0.82	0.68	-0.44	-0
X30 = Sand content	X5 -	0.44	0.57	-0.46	0.76	
X25 = Elevation	X4 -	-0.05	0.71	-0.64	1	0.
X26 = Roughness	Х3 -	0.39	-0.66	4	-0.64	-0
X27 = Topographic Position Index (TPI)	X2 -	-0.46	1	-0.66	0.71	0.3
X28 = Terrain Ruggedness Index (TRI)	X1 -	1	-0.46	0.39	-0.05	0,
X29 = Vector Ruggedness Measure (VRM)		1	12	13	1X	1

-	-0.7	0.25	-0.23	0.02	-0.37	-0.57	0.26	-0.66	-0.66	-0.67	-0.69	0.03	0.03	-0.11	0.05	0.06	-0.12	-0.01	0.11	-0.44	0.19	-0.64	-0.08	0.3	-0.31	0.64	0.9	0	0.9	1
-	-0.79	0.32	-0.28	0.06	-0.38	-0.67	0.33	-0.76	-0.77	-0.75	-0.79	0.02	0.02	-0.14	0.06	0.05	-0.14	-0.02	0.11	-0.5	0.23	-0.73	-0.05	0.38	-0.38	0.75	1	0.01	1	0.9
-	-0.03	-0.05	0.07	-0.07	-0.09	0.01	-0.06	-0.02	-0.03	-0.06	-0.02	0.04	0.03	0.03	-0.04	0.02	0.03	0.08	0	0.03	-0.05	-0.01	0.02	-0.02	0.04	0.02	0.01	1	0.01	0
-	-0.8	0.32	-0.29	0.06	-0.38	-0.67	0.34	-0.77	-0.77	-0.75	-0.79	0.01	0.02	-0.15	0.06	0.04	-0.15	-0.03	0.11	-0.51	0.23	-0.73	-0.03	0.39	-0.38	0.75	া	0.01	1	0.9
-	-0.95	0.66	-0.56	0.28	-0.18	-0.96	0.68	-0.97	-0.96	-0.82	-0.97	-0.22	-0.18	-0.44	0.17	-0.14	-0.44	-0.29	0.07	-0.68	0.28	-0.7	0.12	0.56	-0.51	1	0.75	0.02	0.75	0.64
-	0.44	-0.32	0.46	-0.34	-0.01	0.49	-0.4	0,51	0,45	0.31	0.47	-0.04	-0.11	0.31	-0.44	-0.16	0.31	0.26	-0.33	0.69	-0.82	0.44	-0.22	-0.79	1	-0.51	-0.38	0.04	-0.38	-0.31
-	-0.46	0.4	-0.5	0.32	0.04	-0.55	0.47	-0.54	-0.49	-0.33	-0.49	-0.1	-0.02	-0.4	0.4	0.02	-0.39	-0.32	0.25	-0.64	0.31	-0.45	0.4	1	-0.79	0.56	0.39	-0.02	0.38	0.3
-	-0.01	0.22	-0.34	0.3	0.26	-0.18	0.29	-0.09	-0.07	0.1	-0.03	-0.21	-0.13	-0.3	0.29	-0.1	-0.31	-0.33	0.06	-0.29	-0.02	-0.15	া	0.4	-0.22	0.12	-0.03	0.02	-0.05	-0.08
-	0.71	-0.32	0.35	-0.14	0.29	0.64	-0.36	0.71	0.71	0.64	0.71	0	-0.04	0.21	-0.2	-0.07	0.21	0.12	-0.17	0.54	-0.26	1	-0.15	-0.45	0.44	-0.7	-0.73	-0.01	-0.73	-0.64
	-0.25	0.13	-0.24	0.23	-0.02	-0.25	0.19	-0.29	-0.24	-0.16	-0.28	0.17	0.21	-0.12	0.32	0.24	-0.12	-0.11	0.3	-0.48	1	-0.26	-0.02	0.31	-0.82	0.28	0.23	-0.05	0.23	0.19
-	0.61	-0.5	0.58	-0.4	-0.03	0.69	-0.58	0.68	0.63	0.45	0.65	-0.01	-0.09	0.41	-0.46	-0.14	0.37	0.33	-0.33	1	-0.48	0.54	-0.29	-0.64	0.69	-0.68	-0.51	0.03	-0.5	-0.44
-	-0.09	-0.02	-0.27	0.25	0.04	-0.07	0.08	-0.23	-0.07	-0.01	-0.13	0.74	0.85	-0.3	0.76	0.88	-0.26	-0.37	1	-0.33	0.3	-0.17	0.06	0.25	-0.33	0.07	0.11	0	0.11	0.11
-	0.12	-0.59	0.79	-0.63	-0.59	0.44	-0.68	0.32	0.18	-0.11	0.2	0.26	0.05	0.85	-0.72	0	0.87	1	-0.37	0.33	-0.11	0.12	-0.33	-0.32	0.26	-0.29	-0.03	0.08	-0.02	-0.01
-	0.25	-0.74	0.74	-0.55	-0.55	0.58	-0.78	0.46	0.32	0.05	0.32	0.41	0.22	0.98	-0.61	0.18	1	0.87	-0.26	0.37	-0.12	0.21	-0.31	-0.39	0.31	-0.44	-0.15	0.03	-0.14	-0.12
-	0.03	-0.36	0.05	0.05	-0.19	0.2	-0.27	-0.01	0.1	0.04	0.02	0.94	0.99	0.14	0.53	1	0.18	0	0.88	-0.14	0.24	-0.07	-0.1	0.02	-0.16	-0.14	0.04	0.02	0.05	0.06
-	-0.06	0.31	-0.6	0.6	0.4	-0.26	0.43	-0.26	-0.09	0.14	-0.13	0.25	0.49	-0.61	া	0.53	-0.61	-0.72	0.76	-0.46	0.32	-0.2	0.29	0.4	-0.44	0.17	0.06	-0.04	0.06	0.05
-	0.26	-0.77	0.7	-0.56	-0.56	0.59	-0.79	0.47	0.33	0.05	0.33	0.34	0.18	1	-0.61	0.14	0,98	0.85	-0.3	0.41	-0.12	0.21	-0.3	-0.4	0.31	-0.44	-0.15	0.03	-0.14	-0.11
-	0.07	-0.38	0.11	0.04	-0.19	0.25	-0.31	0.03	0.13	0.06	0.06	0.95	1	0.18	0.49	0.99	0.22	0.05	0.85	-0.09	0.21	-0.04	-0.13	-0.02	-0.11	-0.18	0.02	0.03	0.02	0.03
-	0.07	-0.46	0.29	-0.11	-0.31	0.31	-0.42	0.08	0.15	0.02	0.08	1	0.95	0.34	0.25	0.94	0.41	0.26	0.74	-0.01	0.17	0	-0.21	-0.1	-0.04	-0.22	0.01	0.04	0.02	0.03
-	0.99	-0.54	0.47	-0.18	0.33	0.91	-0.56	0.98	0.98	0.89	1	0.08	0.06	0.33	-0.13	0.02	0.32	0.2	-0.13	0.65	-0.28	0.71	-0.03	-0.49	0.47	-0.97	-0.79	-0.02	-0.79	-0.69
-	0.94	-0.19	0.14	0.28	0.69	0.68	-0.18	0.85	0.9	1	0,89	0.02	0.06	0.05	0.14	0.04	0.05	-0.11	-0.01	0.45	-0.16	0.64	0.1	-0.33	0.31	-0.82	-0.75	-0.06	-0.75	-0.67
-	0.98	-0.55	0.45	-0.13	0.34	0.92	-0,56	0.96	1	0.9	0.98	0.15	0.13	0.33	-0.09	0.1	0.32	0.18	-0.07	0.63	-0.24	0.71	-0.07	-0.49	0,45	-0.96	-0.77	-0.03	-0.77	-0.66
-	0,96	-0.6	0.54	-0.23	0.24	0.93	-0.62	1	0.96	0.85	0.98	0.08	0.03	0.47	-0.26	-0.01	0.46	0.32	-0.23	0.68	-0.29	0.71	-0.09	-0.54	0.51	-0.97	-0.77	-0.02	-0.76	-0.66
-	-0.47	0.97	-0.8	0.77	0.59	-0.84	া	-0.62	-0.56	-0.18	-0.56	-0.42	-0.31	-0.79	0.43	-0.27	-0.78	-0.68	0.08	-0.58	0.19	-0.36	0.29	0.47	-0.4	0.68	0.34	-0.06	0.33	0.26
-	0.87	-0.82	0.68	-0.44	-0.05	1	-0.84	0.93	0.92	0.68	0.91	0.31	0.25	0.59	-0.26	0.2	0.58	0.44	-0.07	0.69	-0.25	0.64	-0.18	-0.55	0.49	-0.96	-0.67	0.01	-0.67	-0.57
-	0.44	0.57	-0.46	0.76	1	-0.05	0.59	0.24	0.34	0.69	0.33	-0.31	-0.19	-0.56	0.4	-0.19	-0.55	-0.59	0.04	-0.03	-0.02	0.29	0.26	0.04	-0.01	-0.18	-0.38	-0.09	-0.38	-0.37
-	-0.05	0.71	-0.64	1	0.76	-0.44	0.77	-0.23	-0,13	0.28	-0.18	-0.11	0.04	-0.56	0.6	0.05	-0.55	-0.63	0.25	-0,4	0.23	-0.14	0.3	0.32	-0.34	0.28	0.06	-0.07	0.06	0.02
-	0.39	-0.66	1	-0.64	-0.46	0.68	-0.8	0.54	0.45	0.14	0.47	0.29	0.11	0.7	-0.6	0.05	0.74	0.79	-0.27	0.58	-0.24	0.35	-0.34	-0.5	0.46	-0.56	-0.29	0.07	-0.28	-0.23
-	-0.46	1	-0.66	0.71	0.57	-0.82	0.97	-0.6	-0.55	-0.19	-0.54	-0.46	-0.38	-0.77	0.31	-0.36	-0.74	-0.59	-0.02	-0.5	0.13	-0.32	0.22	0.4	-0.32	0.66	0.32	-0.05	0.32	0.25
-	1	-0.46	0.39	-0.05	0.44	0.87	-0.47	0.96	0.98	0.94	0.99	0.07	0.07	0.26	-0.06	0.03	0.25	0.12	-0.09	0.61	-0.25	0.71	-0.01	-0.46	0.44	-0.95	-0.8	-0.03	-0.79	-0.7
2	+	12.	13	+X	40	10	4	18	10	0	~	2	3	NA.	10	6	2	18	2	20	n.	2	Ŷ.	24	30	25	20	2	1° .	2º
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RESULTS (RAW OUTPUT)

 False color composite of the first three principal components (PCA)





ASSIGNING LABELS

Premontane ecosystems dominated by one dry seasor

Lowland ecosystems dominated by one dry season

Lowland ecosystems dominated by two dry seasons



Montane ecosystems dominated by one dry season





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Inputs:

- Land cover map (13 classes)
- Map of potential distribution of ecosystems (4 classes)

Output:

Combined map (23 classes)

















COMBINED MAP (23 CLASSES)







SUMMARY

- The method developed in Liberia is a compromise between state of the art and easy-to-implement methodologies.
- We hope it will be applicable for other countries with minimal modifications; we plan to test it in Gabon and Botswana).
- Ground-truthing data and involvement of in-country experts is essential.







Input data (BIEN V 4.1):

- 109,722 observations
- 5,525 unique species



GABON – SNEAK PREVIEW





INITIAL GDM OUTPUT

 Unsupervised classification (n=15) of a GDM output based on spp. Records from public-access-BIEN, WorldClim bioclimatic variables, Africa Soils Atlas soil types map and NASA's SRTM terrain data







STATE OF THE ART



It took seven decades to refine it.





CONSERVATION INTERNATIONAL

