Scaling up Land Restoration Approaches to Reclaim the Hardpans of Niger for Agriculture Sentinel 2 Imagery

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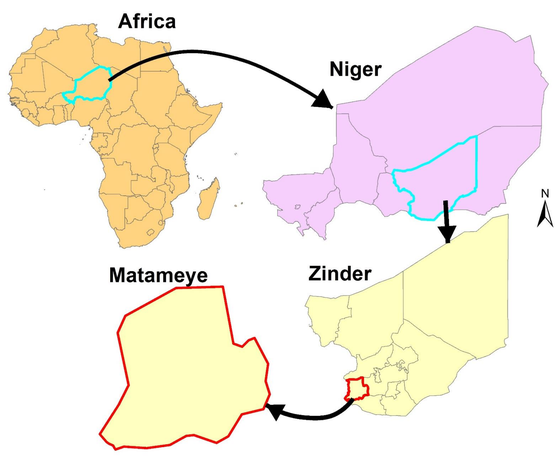
Introduction

Degraded lands, widespread across sub-Saharan Africa, are used mainly for grazing and firewood harvesting and have low agricultural production potential. Such areas have become degraded through overuse and removal of surface cover and associated erosion processes and are termed hardpans. Hardpans with high clay content, high cation exchange capacity (CEC) and water holding capacity have productive potential. ICRISAT has developed and scaled a gender sensitive approach Bio-reclamation of Degraded Land" (BDL) that combines water harvesting technologies (planting pits, half-moon and trenches), application of compost and plantation of high value fruit trees and annual drought tolerant indigenous vegetables. In partnership with CRS in Niger, BDL was scaled to over 3000 villages (2014-18) which led to many benefits in food security and income generation for the local population. To scale further multi-spectral remote sensing based imagery of high resolution (10 m) can identify and map hardpans and differentiate higher potential sites for the BDL approach. These maps will be used to quantify the area under hardpans and the potential area in which the interventions can be scaled up.

Study location

Matamye in Zinder region of Niger is a *département* extending from 8.315°N to 8.503°N and 13.196°E to 13.413°E. It extends over an area of 2149 km². It is in the Sahelian and Sahelo - Sudanian ecological zones of the west Africa. The normal annual rainfall is around 200-600 mm.



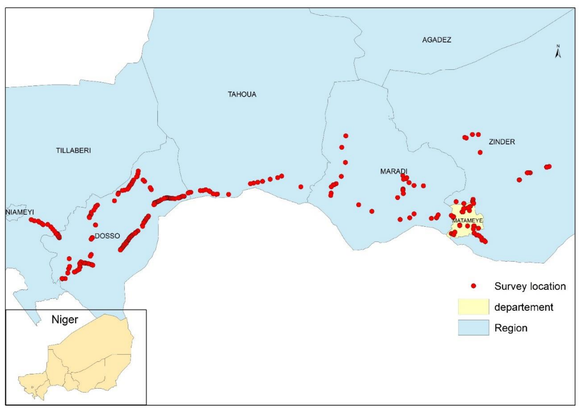
Data

Sentinel -2 MSI

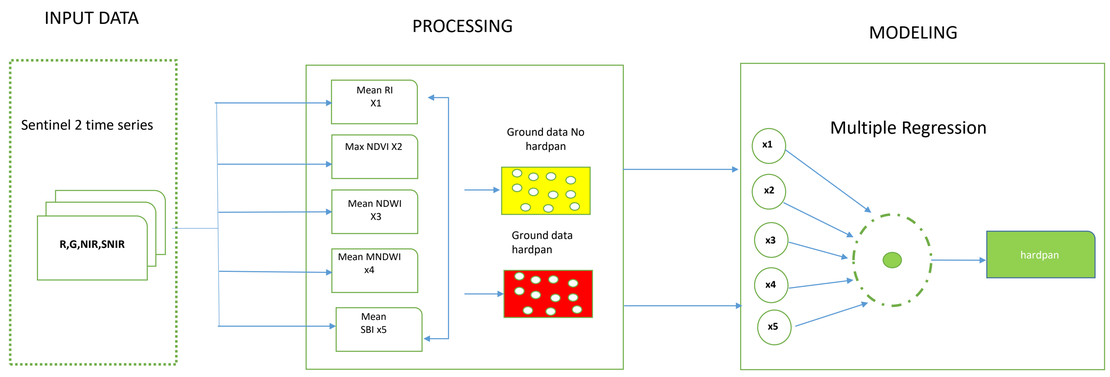
DATE 2016	BANDS	INDICES
Jan to Dec	NIR,SWIR	Mean NDBI
Jan to Dec	NIR , RED	Max NDVI
Jan to Dec	NIR, Green, SWIR	Mean NDWI
Jan to Dec	NIR, Green, SWIR	Mean MNDWI
Jan to Dec	Green , Red	Mean SBI

NDBI: Normalized difference built-up index, NDVI : Normalized difference vegetation index, NDWI : Normalized difference water index, MNDWI : modified difference water index, SBI : Soil Brightness index

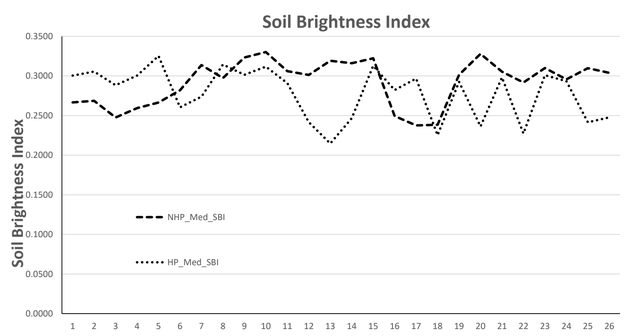
Ground data

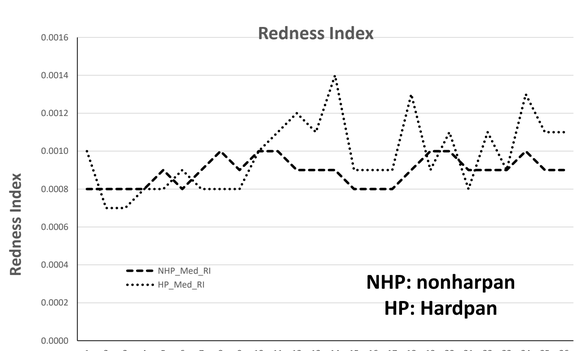


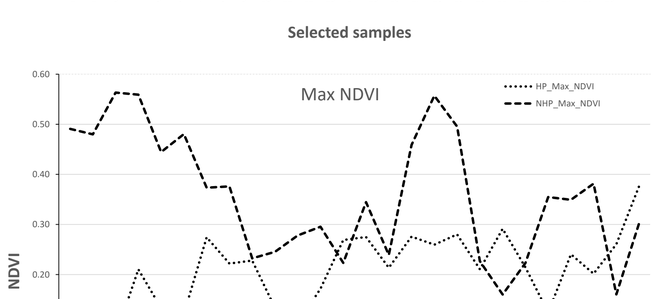
Methodology



Results





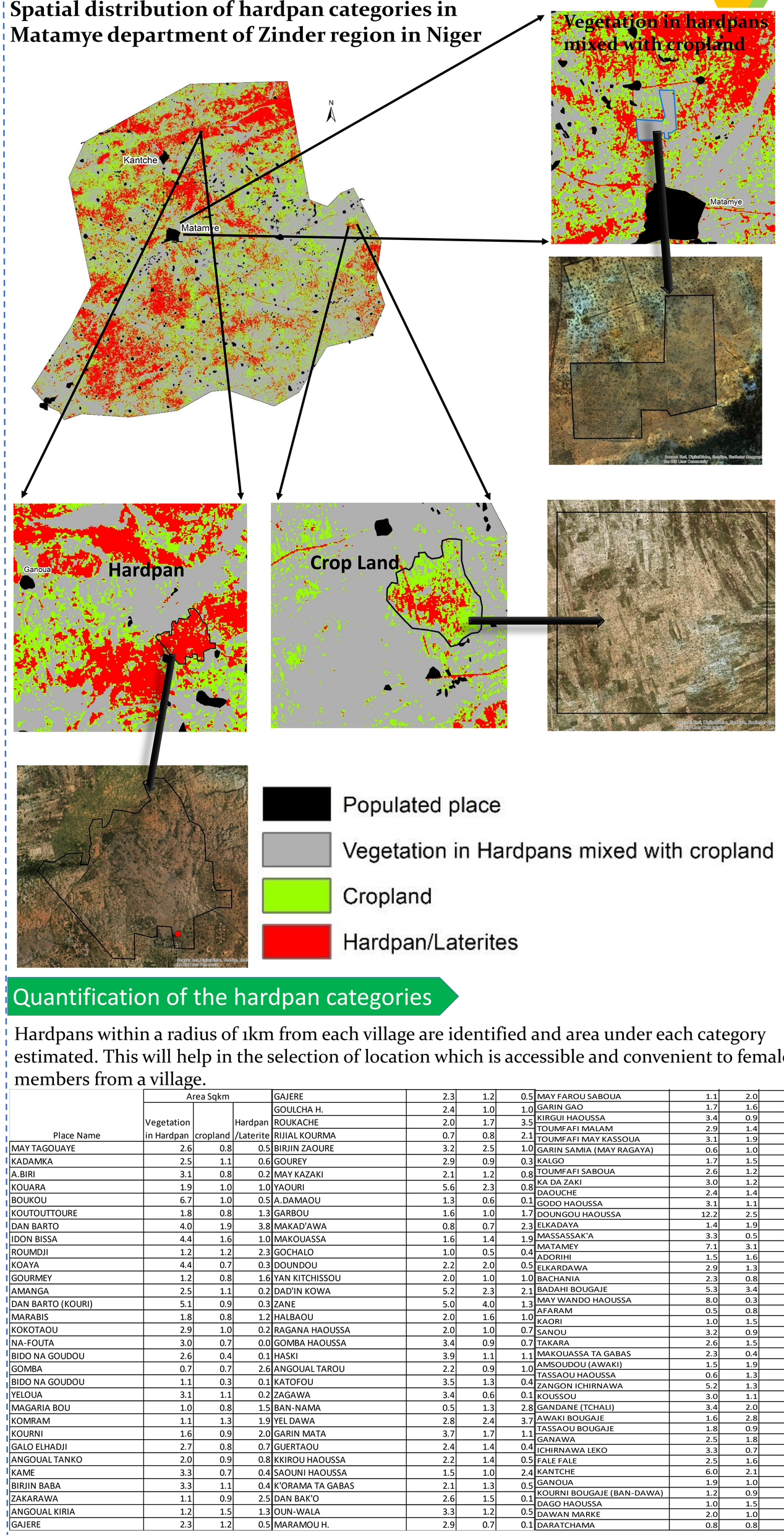


Variables	Estimate	Std. Error	t_value	Pr(>|t|)	
(Intercept)	2.1105	0.1967	10.731	< 2e-16	***
Median_SBI	-5.1496	0.4411	-11.673	< 2e-16	***
Median_RI_	937.3153	152.0764	6.163	9.59E-10	***
Median_NDWI	-1.1475	0.392	-2.927	0.00348	**
Median_MNDI	1.5197	0.6245	2.433	0.0151	*

Significant. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

R-squared: 0.3032, Adjusted R-squared: 0.3004

Spatial distribution of hardpan categories in Matamye department of Zinder region in Niger



Quantification of the hardpan categories

Hardpans within a radius of 1km from each village are identified and area under each category estimated. This will help in the selection of location which is accessible and convenient to female members from a village.

Place Name	Area Sqkm			GAJERE	2.3	1.2	0.5	MAY FAROU SABOUA	1.1	2.0	0.8
	Vegetation in Hardpan	cropland	Hardpan /Laterite	GOULCHA H.	2.4	1.0	1.0	GARIN GAO	1.7	1.6	0.6
				ROUKACHE	2.0	1.7	3.5	KIRGUI HAOUSSA	3.4	0.9	0.3
				RIJIAL KOURMA	0.7	0.8	2.1	TOUMFAFI MALAM	2.9	1.4	0.3
MAY TAGOUAYE	2.6	0.8	0.5	BIRJIN ZAOURE	3.2	2.5	1.0	TOUMFAFI MAY KASSOUA	3.1	1.9	0.4
KADAMKA	2.5	1.1	0.6	GOUREY	2.9	0.9	0.3	GARIN SAMIA (MAY RAGAYA)	0.6	1.0	1.8
A.BIRI	3.1	0.8	0.2	MAY KAZAKI	2.1	1.2	0.8	KALGO	1.7	1.5	0.6
KOUARA	1.9	1.0	1.0	YAOURI	5.6	2.3	0.8	TOUMFAFI SABOUA	2.6	1.2	0.6
BOUKOU	6.7	1.0	0.5	A.DAMAOU	1.3	0.6	0.1	KA DA ZAKI	3.0	1.2	0.3
KOUTOUTTOURE	1.8	0.8	1.3	GARBOU	1.6	1.0	1.7	DAOUCHE	2.4	1.4	0.5
DAN BARTO	4.0	1.9	3.8	MAKAD'AWA	0.8	0.7	2.3	GODO HAOUSSA	3.1	1.1	0.4
IDON BISSA	4.4	1.6	1.0	MAKOUASSA	1.6	1.4	1.9	DOUNGOU HAOUSSA	12.2	2.5	0.5
ROUMDJI	1.2	1.2	2.3	GOCHALO	1.0	0.5	0.4	ELKADAYA	1.4	1.9	1.2
KOAYA	4.4	0.7	0.3	DOUNDOU	2.2	2.0	0.5	MASSASSAK'A	3.3	0.5	0.1
GOURMEY	1.2	0.8	1.6	YAN KITCHISSOU	2.0	1.0	1.0	MATAMEY	7.1	3.1	1.9
AMANGA	2.5	1.1	0.2	DAD'IN KOWA	5.2	2.3	2.1	ADORIHI	1.5	1.6	1.4
DAN BARTO (KOURI)	5.1	0.9	0.3	ZANE	5.0	4.0	1.3	ELKARDAWA	2.9	1.3	0.7
MARABIS	1.8	0.8	1.2	HALBAOU	2.0	1.6	1.0	BACHANIA	2.3	0.8	0.3
KOKOTAOU	2.9	1.0	0.2	RAGANA HAOUSSA	2.0	1.0	0.7	BADAHI BOUGAJE	5.3	3.4	1.5
NA-FOUTA	3.0	0.7	0.0	GOMBA HAOUSSA	3.4	0.9	0.7	MAY WANDO HAOUSSA	8.0	0.3	0.0
BIDO NA GOUDOU	2.6	0.4	0.1	HASKI	3.9	1.1	1.1	AFARAM	0.5	0.8	1.0
GOMBA	0.7	0.7	2.6	ANGOUAL TAROU	2.2	0.9	1.0	KAORI	1.0	1.5	1.6
BIDO NA GOUDOU	1.1	0.3	0.1	KATOFOU	3.5	1.3	0.4	SANOU	3.2	0.9	0.2
YELOUA	3.1	1.1	0.2	ZAGAWA	3.4	0.6	0.1	TAKARA	2.6	1.5	0.6
MAGARIA BOU	1.0	0.8	1.5	BAN-NAMA	0.5	1.3	2.8	MAKOUASSA TA GABAS	2.3	0.4	0.0
KOMRAM	1.1	1.3	1.9	YEL DAWA	2.8	2.4	3.7	AMSOUDOU (AWAKI)	1.5	1.9	1.0
KOURNI	1.6	0.9	2.0	GARIN MATA	3.7	1.7	1.1	TASSAOU HAOUSSA	0.6	1.3	3.2
GALO ELHADJI	2.7	0.8	0.7	GUERTAOU	2.4	1.4	0.4	ZANGON ICHIRNAWA	5.2	1.3	0.3
ANGOUAL TANKO	2.0	0.9	0.8	KKIROU HAOUSSA	2.2	1.4	0.5	KOUSSOU	3.0	1.1	0.3
KAME	3.3	0.7	0.4	SAOUNI HAOUSSA	1.5	1.0	2.4	GANDANE (TCHALI)	3.4	2.0	0.2
BIRJIN BABA	3.3	1.1	0.4	K'ORAMA TA GABAS	2.1	1.3	0.5	AWAKI BOUGAJE	1.6	2.8	1.0
ZAKARAWA	1.1	0.9	2.5	DAN BAK'O	2.6	1.5	0.1	TASSAOU BOUGAJE	1.8	0.9	0.5
ANGOUAL KIRIA	1.2	1.5	1.3	OUN-WALA	3.3	1.2	0.5	GANAWA	2.5	1.8	0.5
GAJERE	2.3	1.2	0.5	MARAMOU H.	2.9	0.7	0.1	ICHIRNAWA LEKO	3.3	0.7	0.4
								FALE FALE	2.5	1.6	0.7
								KANTCHE	6.0	2.1	2.4
								GANOUA	1.9	1.0	1.3
								KOURNI BOUGAJE (BAN-DAWA)	1.2	0.9	1.1
								DAGO HAOUSSA	1.0	1.5	0.9
								DAWAN MARKE	2.0	1.0	1.0
								DARATCHAMA	0.8	0.8	3.0

Summary

- Hardpans were delineated using sentinel 2 multispectral imagery derived indices such as NDBI, NDWI, SBI and NDVI.
- The spectral characteristics of these indices and their usefulness for specific terrain conditions contributed to the separation of each category of land degradation especially hardpans in different land use settings.
- Multiple regression yielded a low r^2 of 0.3 and residual SE was 0.41 with a highly significant P value

Conclusion

This unique methodology is able to remotely detect hardpan areas which can be potentially reclaimed through land restoration initiatives by communities and encouraged by government and development agencies. By quantifying location, extent and potential for reclamation, such interventions can be better targeted and impacts measured.

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