Helping Nigerien farmers to manage their soil

FEED THE FUTURE
The U.S. Government's Global Hunger & Food Security Initiative

MICHIGAN STATE
UNIVERSITY

Introduction to our team

- **Overview & team introduction**

Vicki Morrone- Farming specialist & Extension educator

Michigan State University, USA

- **Insights on farmer practices from survey data**

Dr. Nicole Mason-Wardell & Christina Biedny

Agricultural economists

Michigan State University, USA

- **Challenges with Niger soils**

Dr. Vincent Bado-Agronomist

ICRISAT, Niger

- **LandPKS- An extension friendly tool**

Dr. Jeff Herrick-Soil scientist

USDA ARS, New Mexico, USA

- **Soils maps as a tool**

Ahmed Irshad Mohammad

GIS Manager-ICRISAT

Spatial distribution of hardpans in the Dosso region of Niger
A remote sensing approach

Program on **I**nnovation **S**ystems for **D**rylands (**ISD**)

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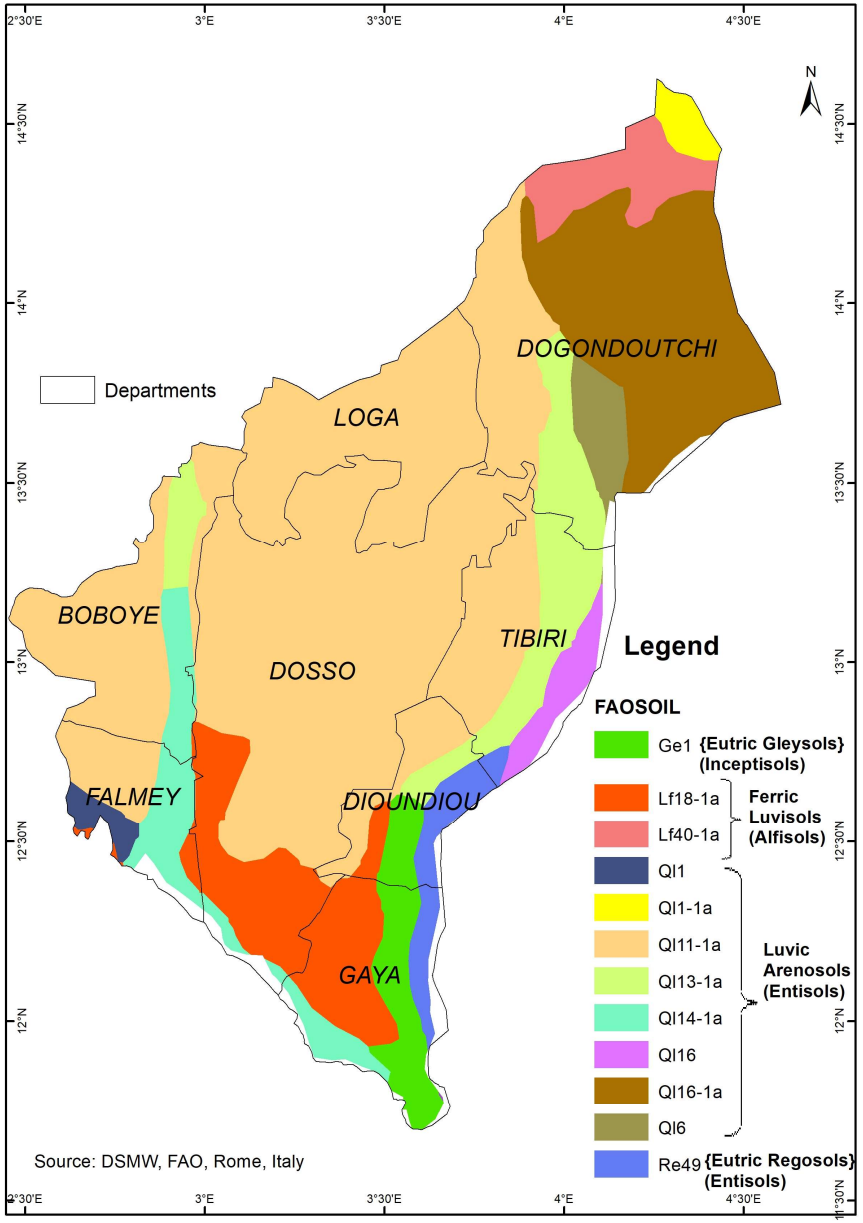
Soils in Dosso region, Niger

Total Geographical area = 31,002 sqkm			
FAO Soils	**USDA Order**	**Area (sqkm)**	**Area (%)**
Eutric Regosols, Luvic Arenosols	Entisols	26,325	85
Ferric Luvisols	Alfisols	3,643	12
Eutric Gleysols	Inceptisols	1,083	3

88% area under Entisols, Inceptisols

12% area under Alfisols

Image credits: Michigan State University Soil Profiles web page, R. Schaetzl, http://web2.geo.msu.edu/soilprofiles/



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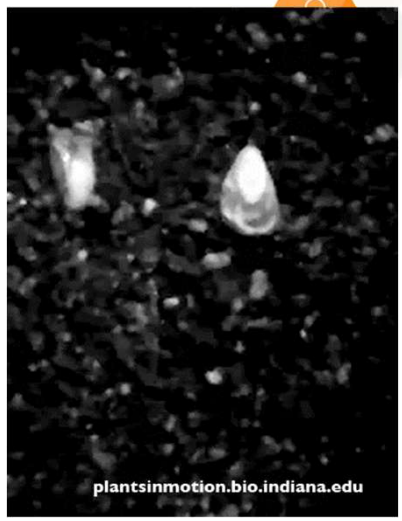
Problem soils or Crusted soils (Hardpans)

- Crusting of soil surface, Iron oxide concretions
- Their type and structure are influenced by (a) soil texture, (b)erosion and deposition effects by wind and water, and (c) vegetation cover
- Surface crusting not only impedes seedling emergence, restricts infiltration and favors rill and gully erosion



Hardpans or soil crusts – genetic nomenclature

- Structural or Physical — *In-situ*
  - Sieving crusts – pavement crusts
  - Packing crusts
- Erosional
- Depositional
- Biological

Hardpans or soil crusts – Explained (defined ?) - Functional

Hardpan A soil layer with physical characteristics that limit root penetration and restrict water movement.

Soil crust A transient soil-surface layer, ranging in thickness from a few millimeters to a few centimeters, that is either denser, structurally different or more cemented than the material immediately beneath it, resulting in greater soil strength when dry as measured by penetration resistance or other indices of soil strength.

(SSA, https://www.soils.org/publications/soils-glossary#)

Hardpan soil. A soil that has a layer whose physical characteristics limit root penetration and restrict water movement.
(Encyclopaedia of Agrophysics, 2011)

Hardpan A soil layer in which the particles have become cemented by secondary deposition of calcite, iron oxides, silica or other minerals. Addition of water does not cause slaking. Hardpans are commonly impervious and may cause a perched water table. In the WRB system, soils with hardpans within 100 cm of the surface are designated as Petric, and the horizon itself may be named in terms of the cementing agency e.g., Petrocalcic, Petrogypsic.
(FAO, 2001, Annex 2 and 3)

Hardpans or soil crusts

A physical crust is defined either as one formed by a combination of raindrop impact on the soil surface along with physiochemical dispersion of soil clay, or as one formed by the sedimentation of fine material as turbid water infiltrates following overland flow (Singer, 1991).

- Physical crusts can be found in areas that contain high amounts of coarse sandy soils, low organic matter and high sodium (Belnap et al., 1999).

- They are characterized by low soil stability and soil aggregates, which are easily broken down under the impact of water.

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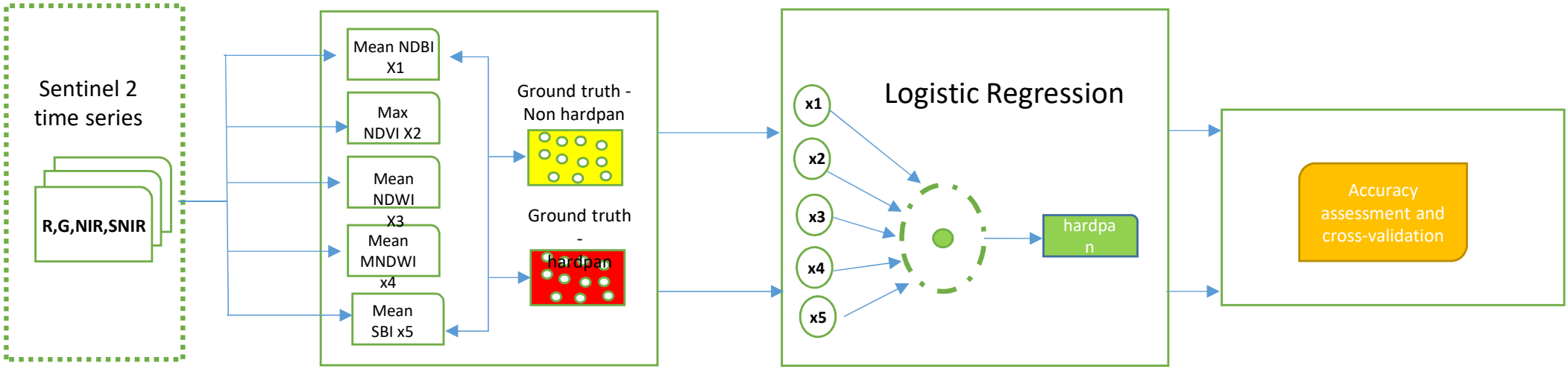


Mapping hardpans using Logistic Regression

Rationale behind using the different indices

1. Complex landscape with interplay of different natural and man-made excesses
2. Present land cover and soils are the result of different degradation processes
3. Soil are most affected and modified in the history of usage
4. Increasing population and occupation of agricultural land

Spectral Characteristics – Indices for mapping

Normalized Difference Built-up indicex

- Most confuse urban surfaces with bare soil and barren land covers.
- Concrete and asphalt both display spectral curves that generally increase from the visible through the Near IR and SW-IR regions.

NDBI = (SWIR – NIR)/(SWIR + NIR)

Normalized Difference vegetation index

- Indicates the health of vegetation

NDVI = (NIR-RED)/(NIR+RED)

Normalized Difference Water Index algorithm was developed by Gao (1996), being a measure of liquid water molecules in vegetation canopies that interacted with the incoming solar radiation.
NDWI is sensitive to changes in liquid water content of vegetation canopies. It is less sensitive to atmospheric effects than NDVI.

NDWI = (IR_factor * near_IR - mir_factor * middle_IR) / (IR_factor * near_IR + mir_factor * middle_IR)

Contd.

Modified Normalized Difference Water Index algorithm was developed by Xu, 2006 and can enhance open water features while efficiently suppressing and even removing built-up land noise as well as vegetation and soil noise.

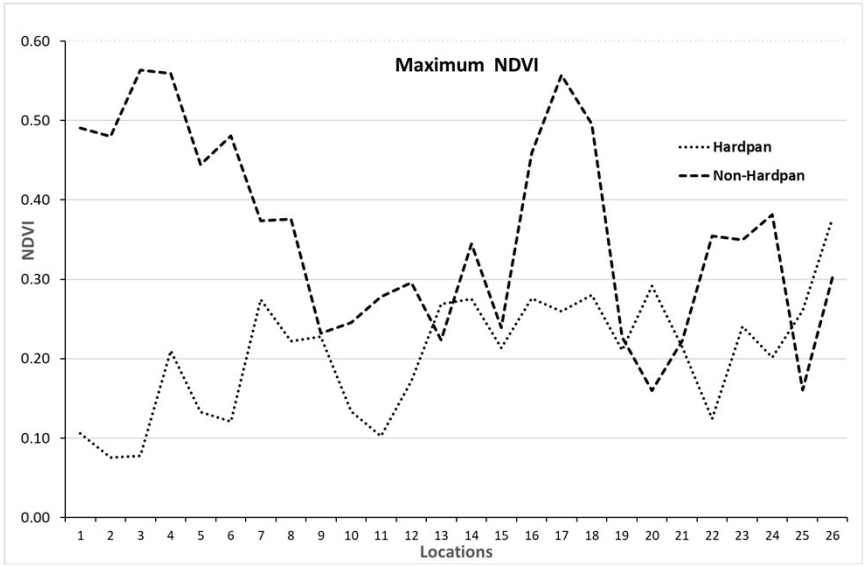
MNDWI = (green_factor * green - mir_factor * middle_IR) / (green_factor * green + mir_factor * middle_IR)

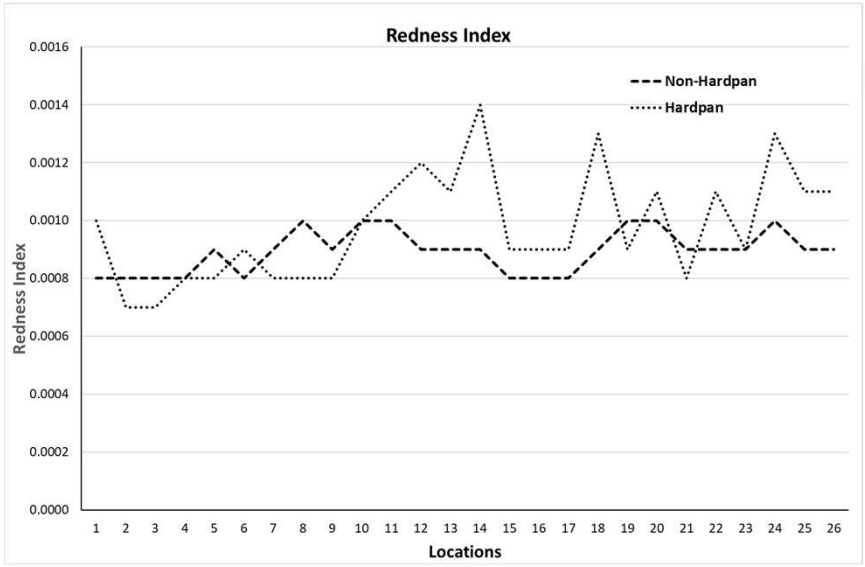
Soil Brightness Index

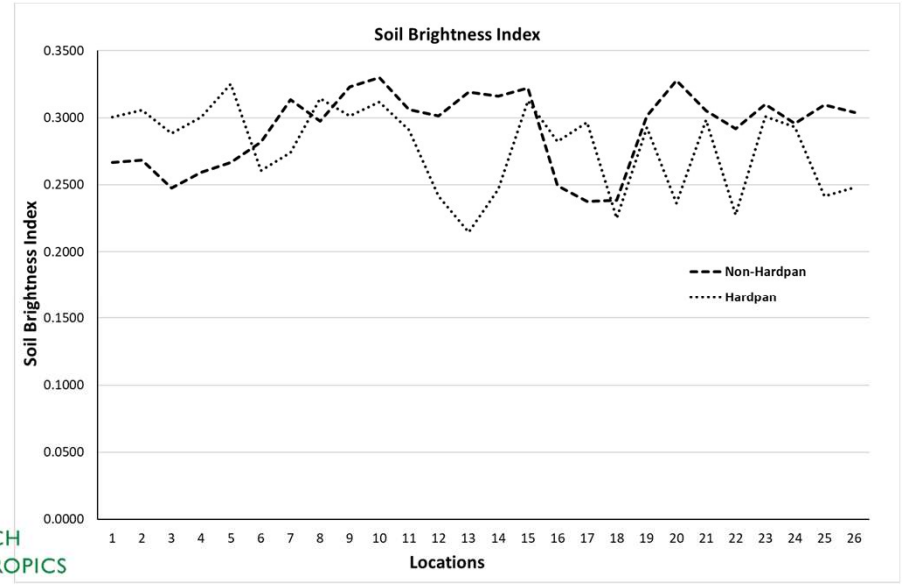
This index is sensitive to the brightness of soils which is highly correlated with the humidity and the presence of salts in surface (Escadafal, 1989).

BI = sqrt(((red_factor * red * red_factor * red) + (green_factor * green * green_factor * green)) / 2)

Contd.







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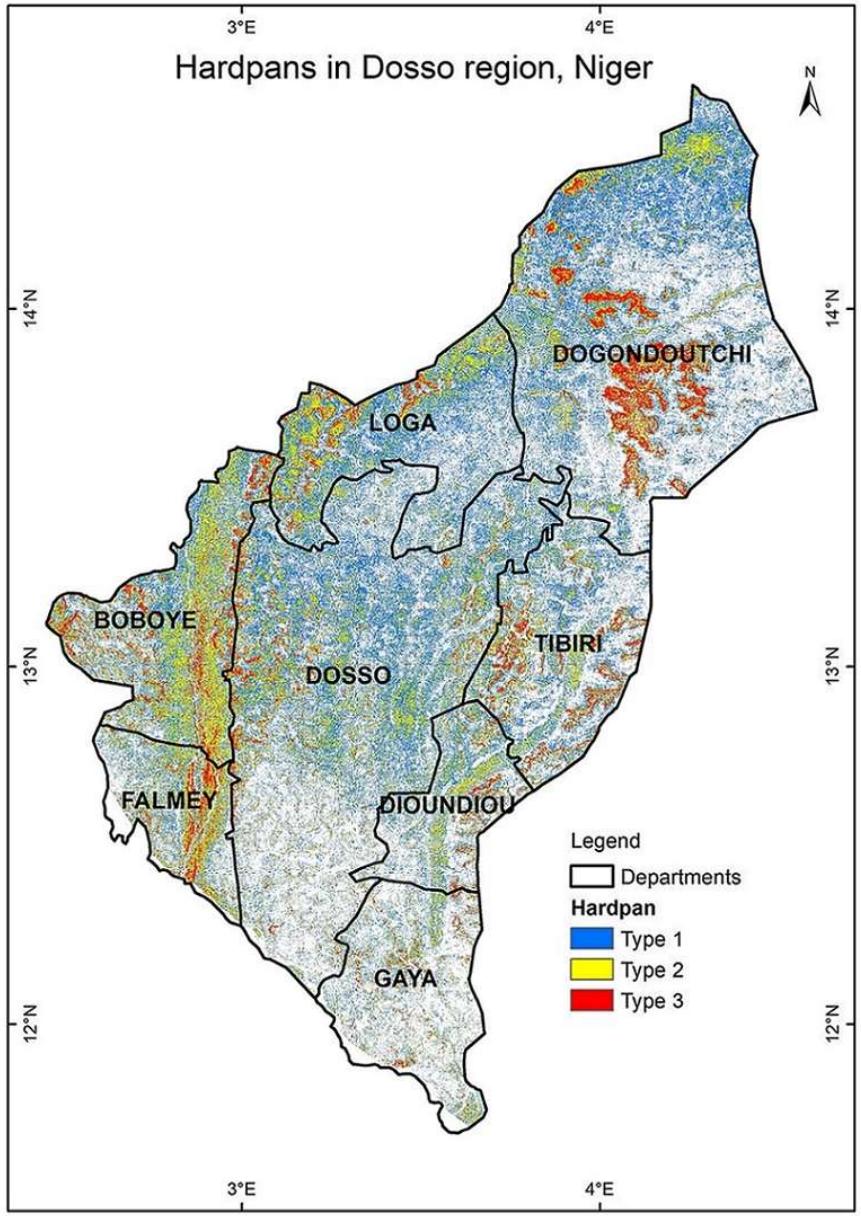
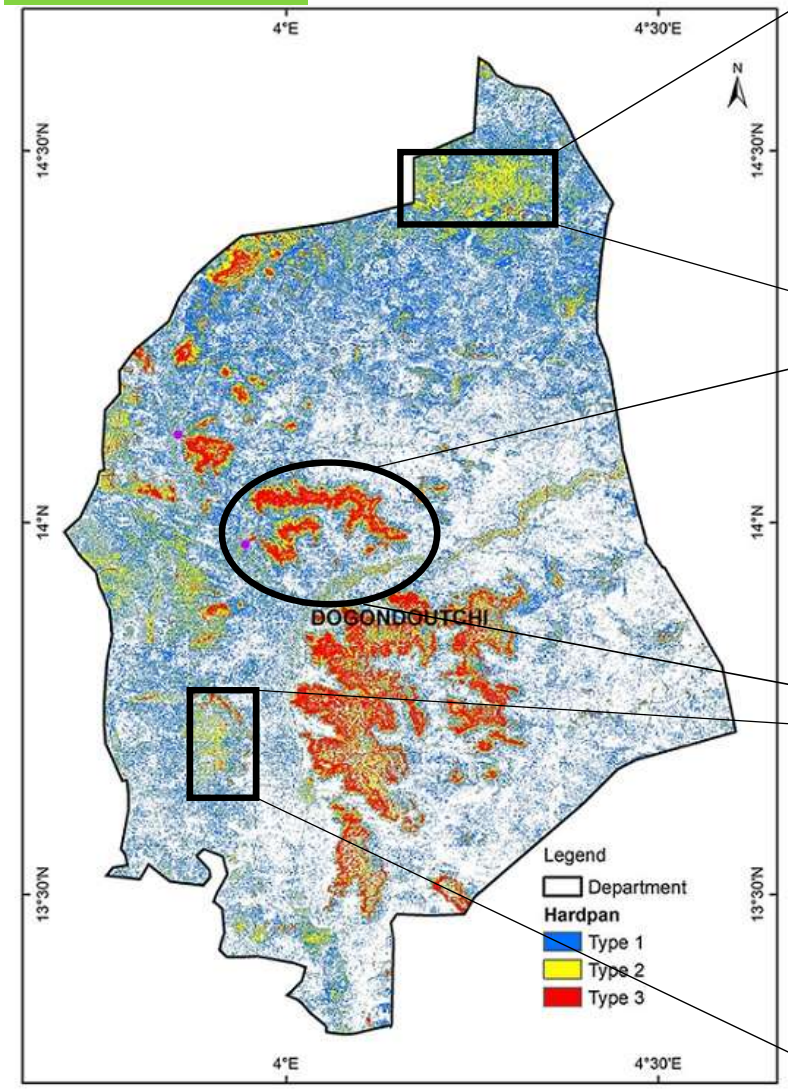
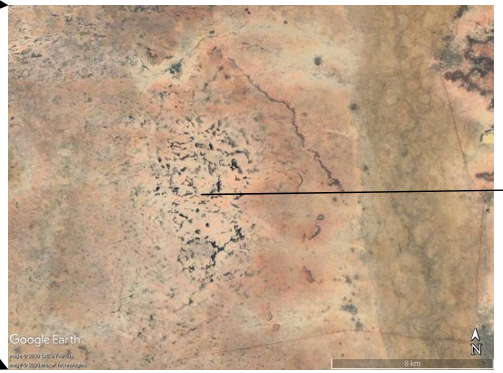


Dogondoutchi Hardpans



Non-agricultural hardpan

Lateritic hardpan



Eroded/depositional hardpan

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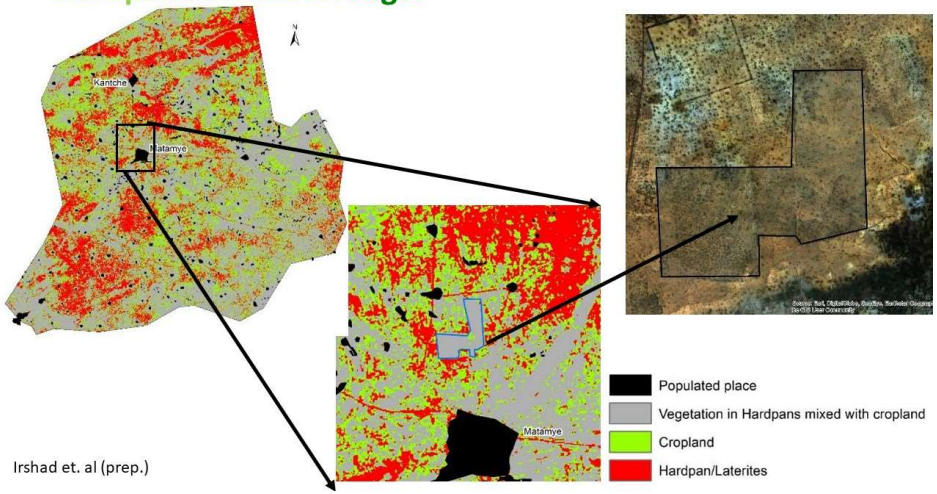
High resolution remote sensing (Sentinel 2) based identification of hardpan landscapes in Niger for upscaling intervention to scale

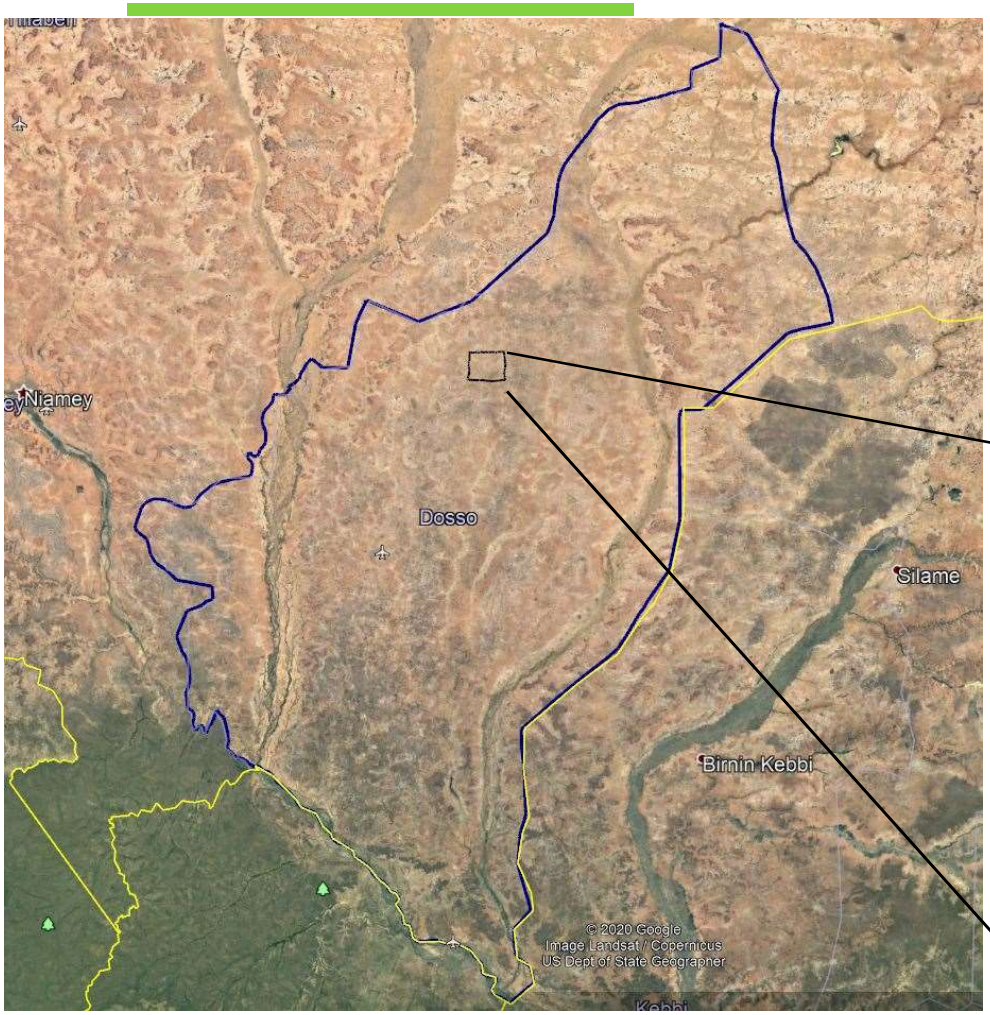
- Hardpans identified on the ground in Matamye
    1. Large patches within agricultural areas
    2. Larger patches of hardened iron oxide gravel
    3. Vegetated hardpans with natural shrubs and grasses

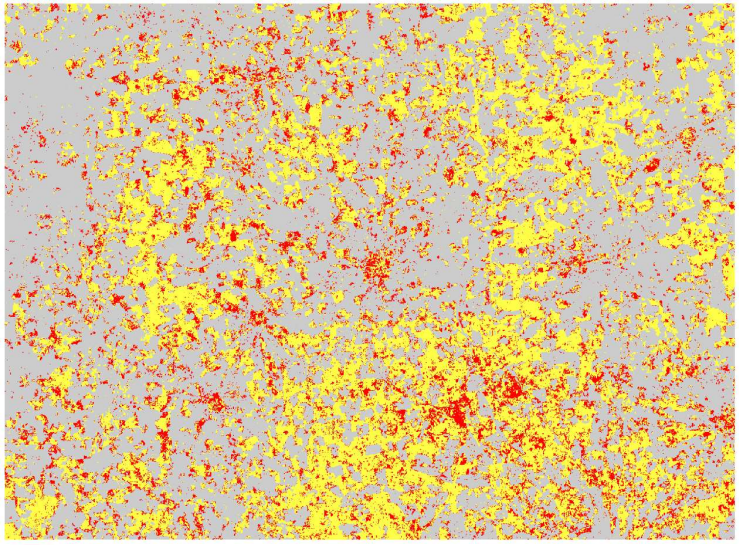
Bio-reclamation of degraded land along with Farmer managed natural regeneration in Niger

- Sentinel 2 multispectral imagery based indices relevant to soil surface characteristics were used in multi-linear regression
- Female farmers group was encouraged to own hardpan land near the village to adopt IMO's to improve the soil condition and penetrability along with economic incentive from the produce.



Spatial distribution of cropping pattern in Niger with high resolution sentinel 1 and 2 imagery to scale-up sustainable farming systems (Irshad et al. prep.)





Pearl millet
Pearl millet + Cowpea
Other land use

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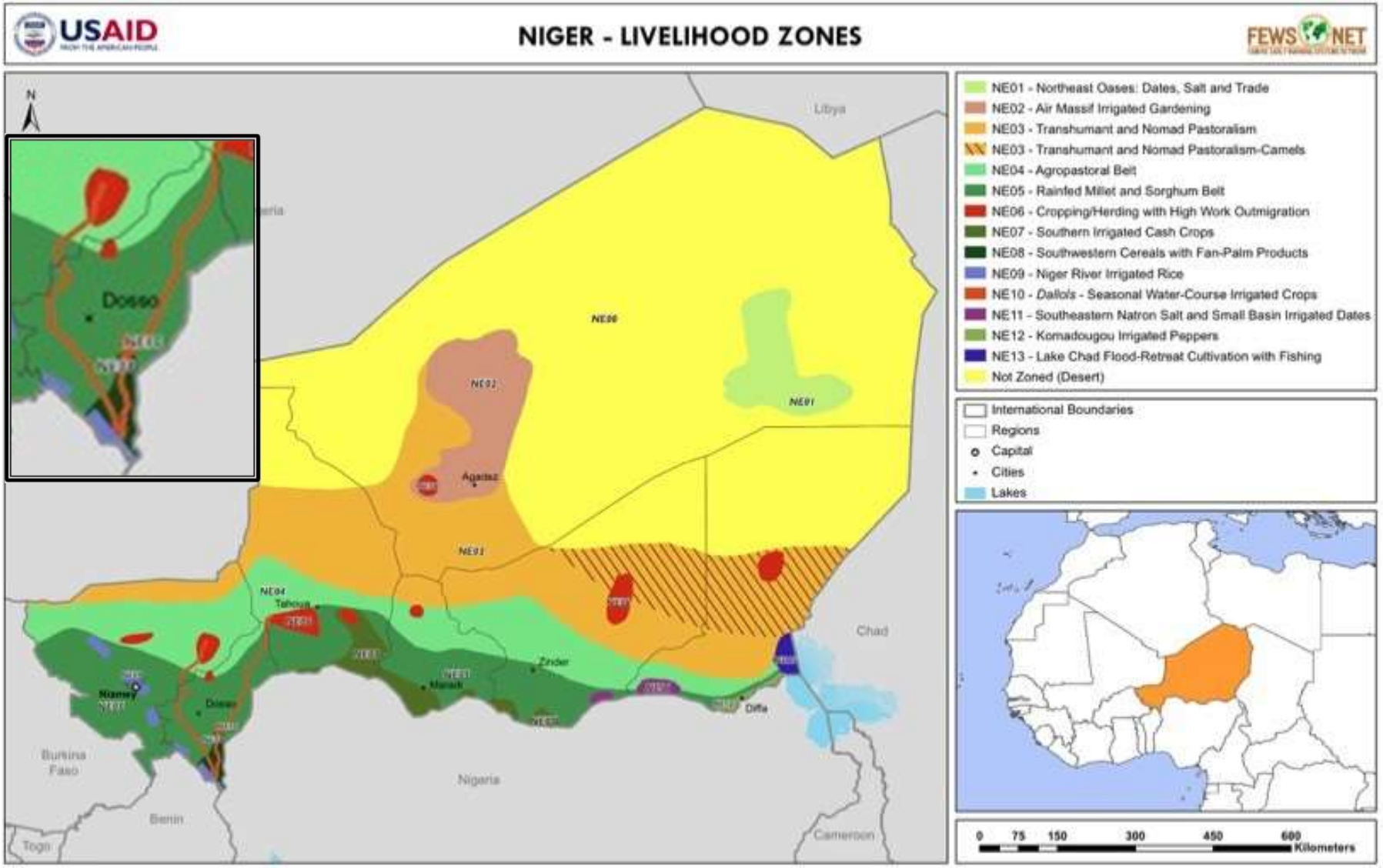

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Merci Beaucoup