



BeninCajù
Better cashew, Better lives

Land Mapping for Climate Smart Cashew Production

September 2020



Additional funding from:



Agenda

Context of Cashew in Benin

Introduction to Machine Learning/
Remote Sensing Initiative

Introduction to Chatbot and Quality App

Cashew is Benin's second largest export crop, farmed by an estimated ~200K farming families

Benin is 8th largest cashew producer in the world (4% market share) and 5th in Africa (6% share)

Cashew represents nearly **10%** of Benin's **national export earnings** and is farmed by ~200K farming families

Beninese cashew is **known for its high quality and white color**

Benin is actively developing policies to **sustainably increase cashew production and processing**



Benin's government has the ambitious goal of increasing cashew production 3x by 2027



300,000

tons of raw cashew nut **produced** annually



50%

(150,000 tons) of raw cashew nut
processed in-country annually

TechnoServe is testing innovative technologies to increase cashew production and processing

CURRENT SCALED INTERVENTIONS



Farmer training



Technical assistance on processing



New investments on policy and advocacy



Access to finance



Byproduct valorization (e.g., cashew apples & CNSL)

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Better cashew, Better lives

TECHNOLOGICAL INTERVENTIONS



CajùLab project (machine learning, remote sensing and ground data)

*FOCUS
OF
TODAY*



Cashew chatbot for extension workers



Massive open online course for processors/investors

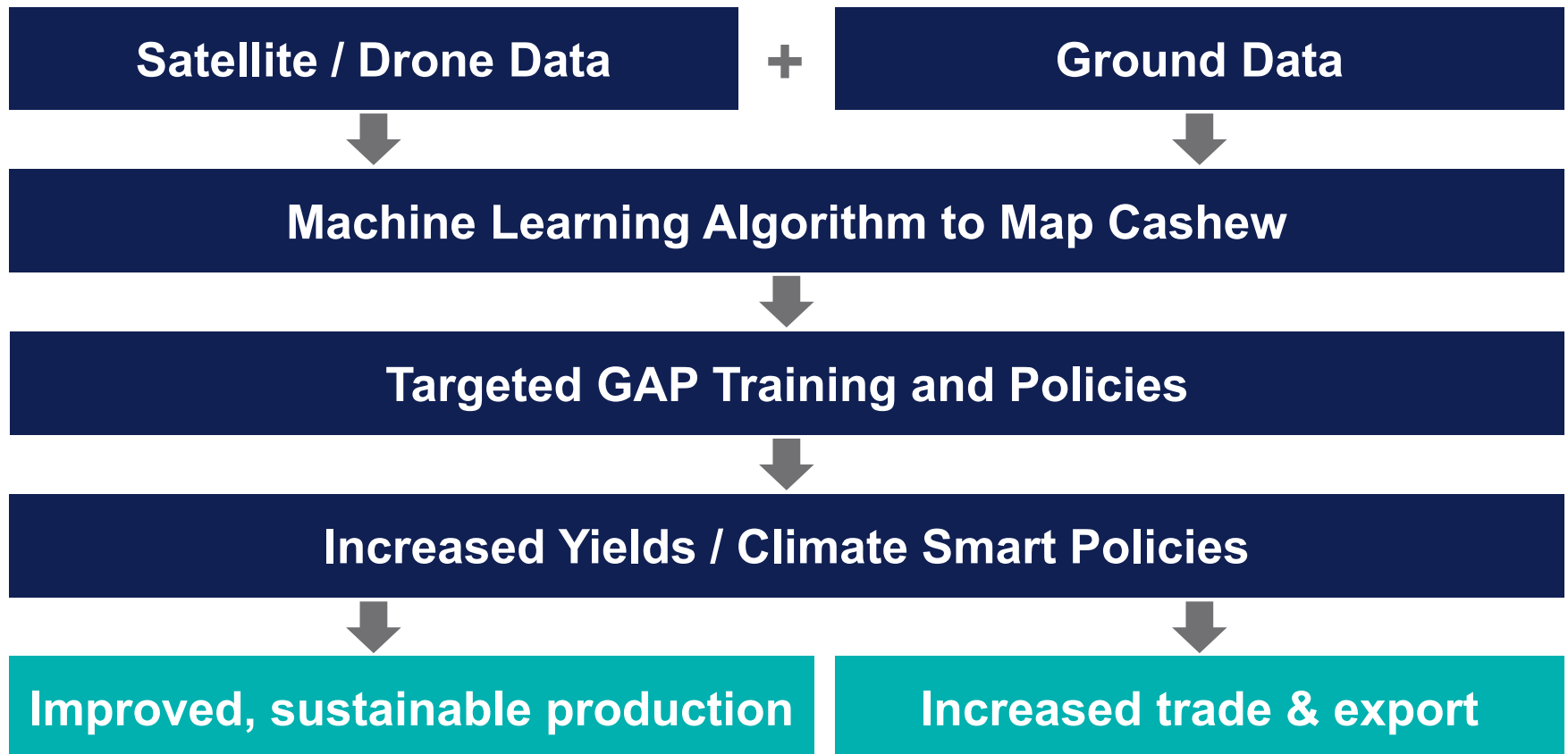


Android app to measure cashew quality



TechnoServe is using remote sensing and machine learning as tools to achieve sustainable increases in cashew production

THEORY OF CHANGE



Agenda

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Introduction to Chatbot and Quality App

TechnoServe is working in close collaboration with a University of Minnesota team to build the machine learning model to map cashew production



UNIVERSITY OF MINNESOTA

BeninCajù

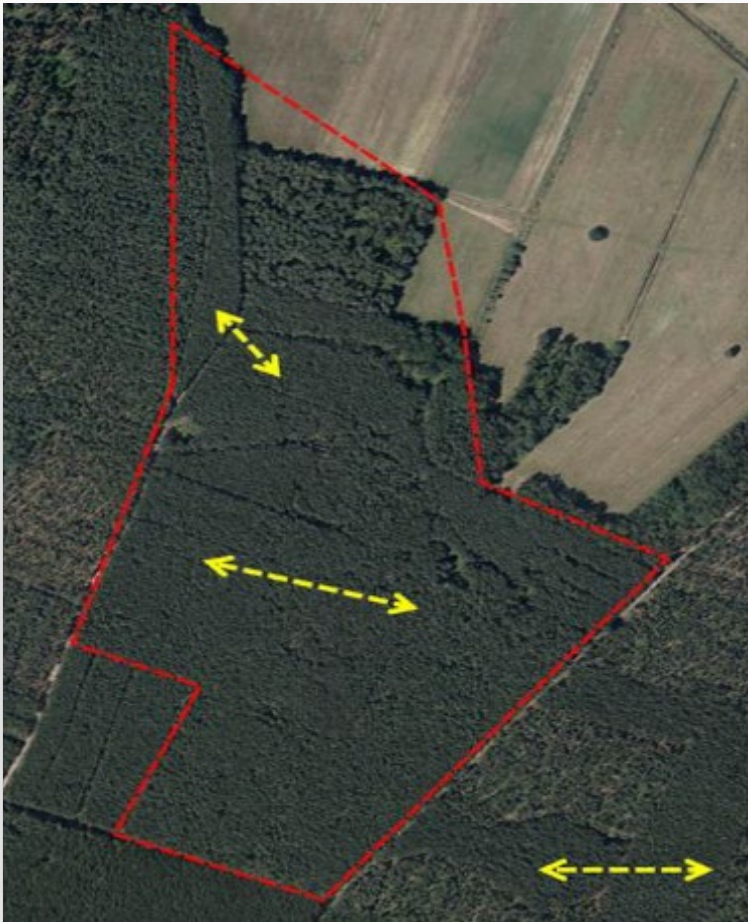
- **Built Python ML model** to map cashew production
- **Recommended improvements in data labelling** based on prelim ML model results.
- **Trained/tested model** on 100,000 ha zone in Benin
- **Planned rollout of model to 5.8 million ha cashew producing regions** in Benin

**MACHINE
LEARNING-
ENABLED
CASHEW
MAPPING**

- **Determined optimal mix of satellite and drone data**, working with Silicon Valley tech partners
- **Collected and labelled ground truth data** for farms and 100,000 ha training/test zone
- **Refined labelling protocols** to increase accuracy from 60% to >85%

Smallholder agriculture presents uniquely difficult challenges for computer vision, and there is a shortage of quality training data

Typical Plantation in Americas, EU



Typical Plantation in Benin



Challenges to accurately estimate area occupied by cashew, separate cashew from other trees

TechnoServe has used numerous technologies in partnership with various actors to gather remote sensing data



Multispectral satellite imagery

- Airbus Pléiades - 50cm resolution
- PlanetLabs – 3.5m resolution



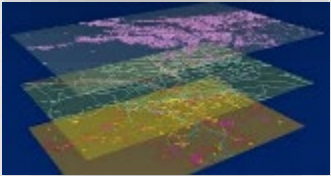
Aerial Imagery

- 50cm resolution



Drone Imagery

- 10cm resolution



Geospatial Information Systems (GIS)



Machine Learning



(current)



(under consideration)

Plus field data – ground truth!

Insights are made possible by combining ground truth data in the GIS to create a predictive machine learning model



Weather Data

- *Precipitation*
- *Temperature*
- *2010-2019 monthly/annual*



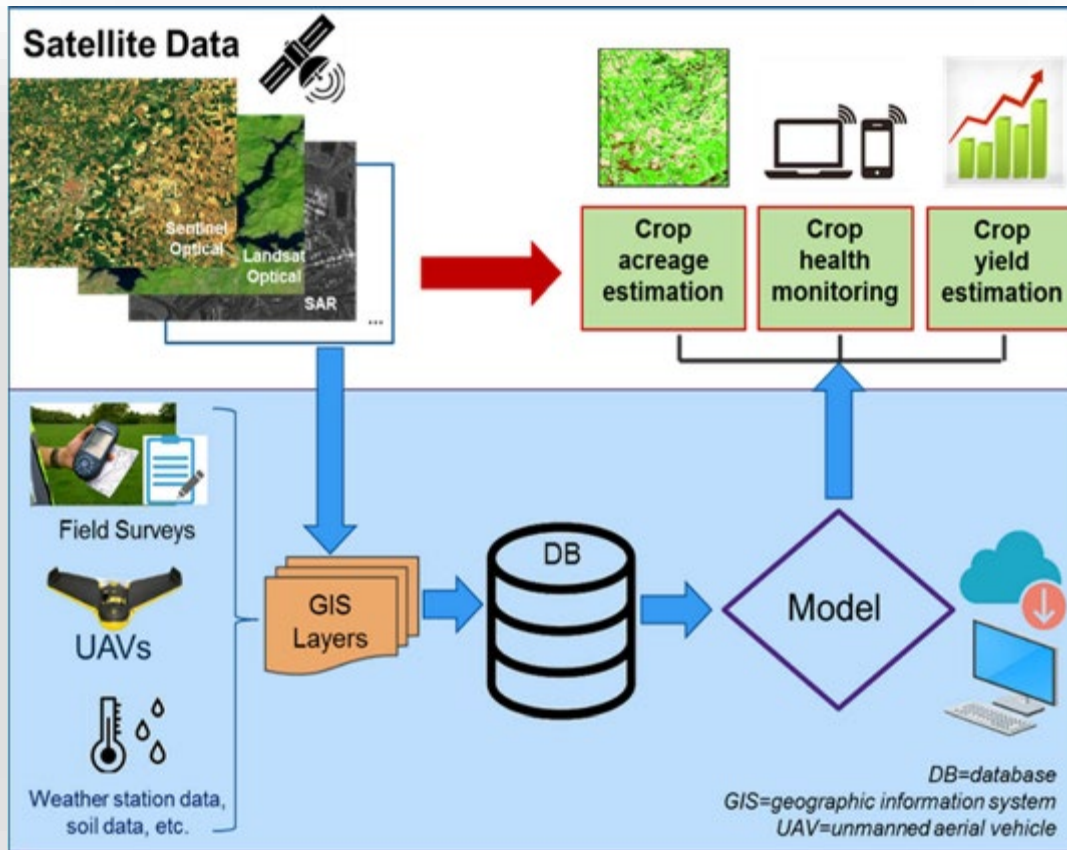
GIS Polygon Mapping of Cashew Farm Boundaries



Cashew Census Data and Yield Surveys

- *2017-2020*

The supervised machine learning model is based on GIS layers from remote sensing and ground data



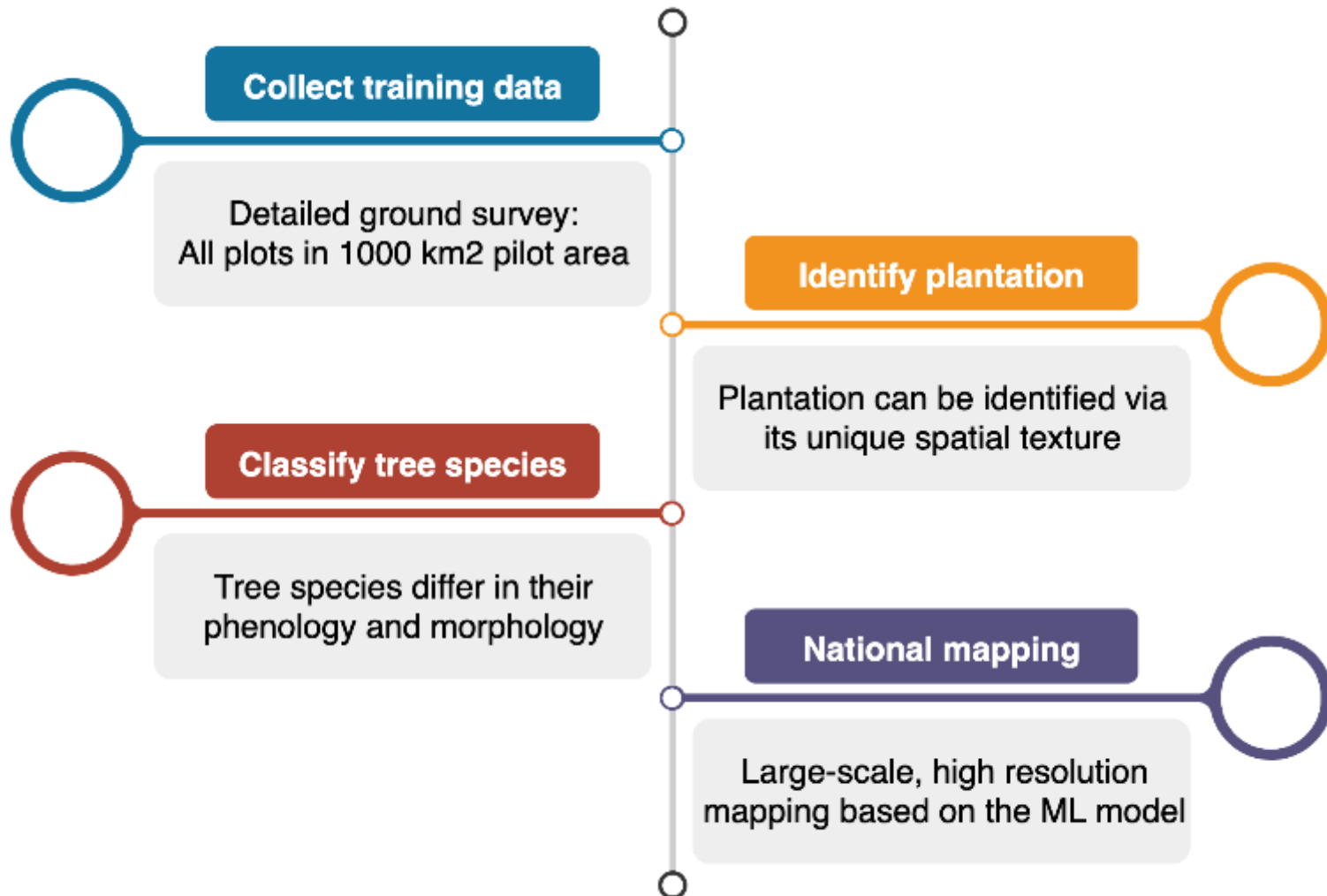
SATELLITE DATA

- **Airbus** 50cm resolution
- **PlanetScope** 3.5m multi-spectral temporal data

PLANE/DRONE/GROUND DATA

- **Institut Nationale de Geographie de Benin** (2015) Plane – 50cm resolution
- **Drone 10cm imagery**
1535 farms (2020)
- **Farm polygons**
1535 farms (2020)
- **Yield survey**
1533 farms (2020)
300 farms (2017-2020)
- **Weather data**
(2010-2020)
- **Detailed ground survey** – all plots in 1000 sq km ML training area

Remote sensing + AI roadmap



Creating labels for training ML model

Plantation



Forest



Background



Urban

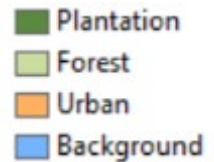
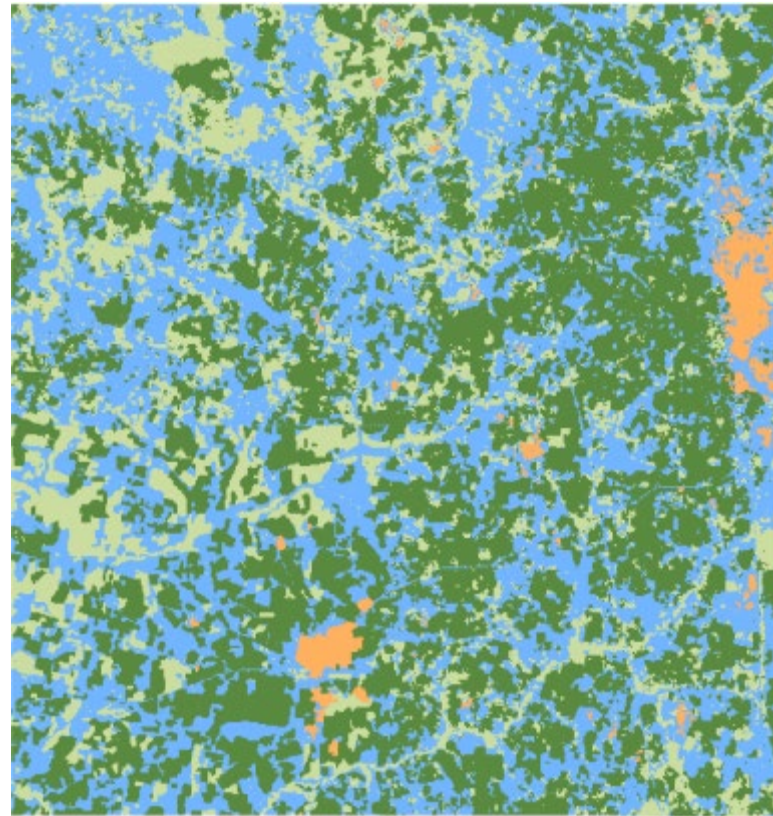


With satellite imagery, machine learning models can predict plantation (mostly cashew) with over 85% accuracy

Airbus imagery

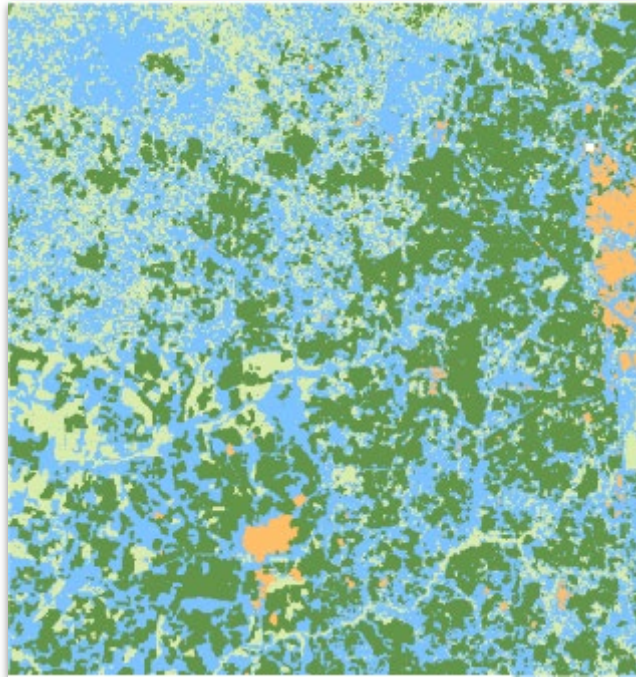


ML prediction



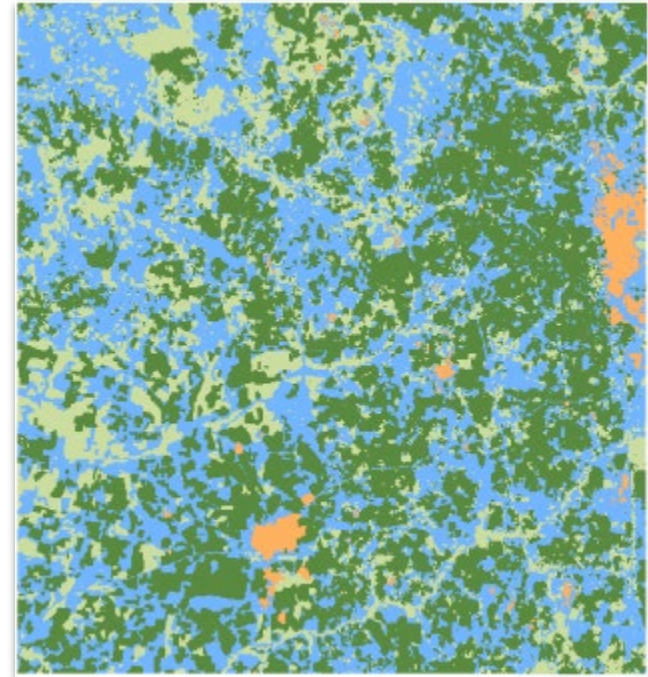
2015 prediction map vs 2019 prediction map

2015



Plantation: 37.14 km²
Forest: 24.11 km²

2020



Plantation: 48.87 km²
Forest: 23.72 km²

Nearly 30% expansion in Plantation

Examples of new development and deforestation

2015



2020



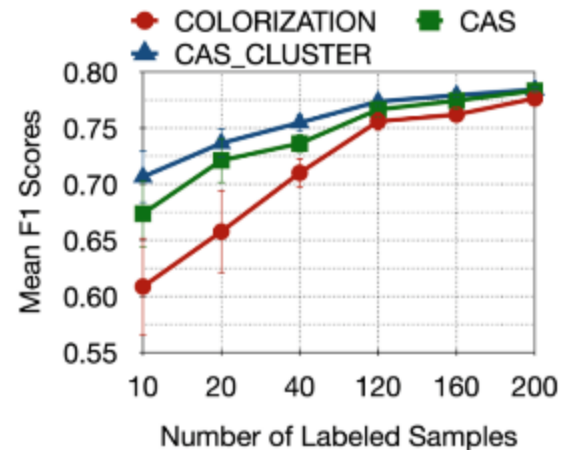
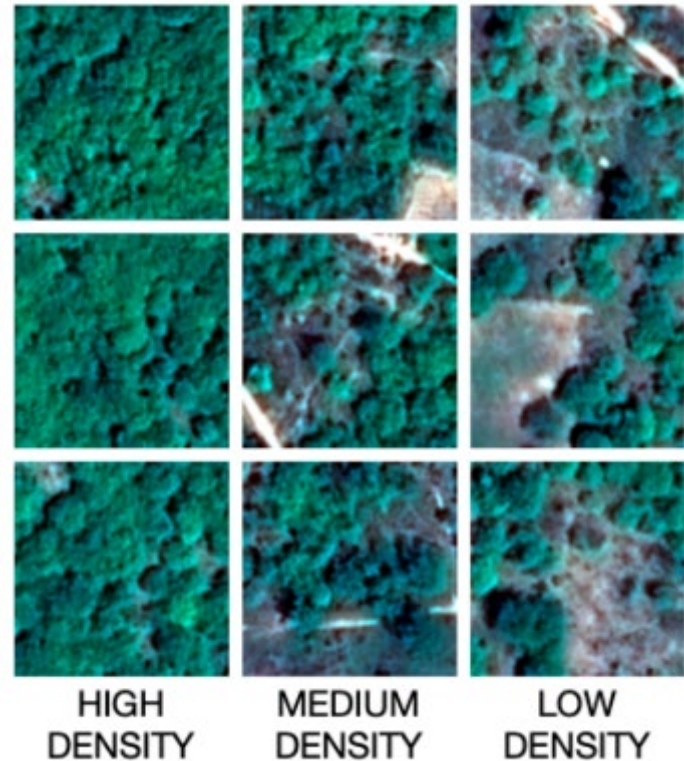
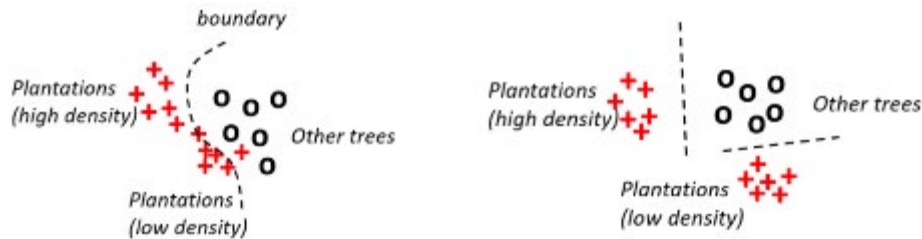
Self-Supervised Learning

The bottleneck to making accurate and timely predictions has shifted away from satellite imagery availability or data processing limits and toward a lack of ground truth labels.

Can we reduce the need for labels?



(a)



Vision for the future: Deepen impact for cashew in Benin and expand usage to other geographies and programs

EXPAND USE FOR CASHEW IN BENIN



Add quality data

to the model, with development of an open-source geo-tagged cashew quality (KOR) collection app

Creating targeted training programs

based on geospatial data

EXPAND TO OTHER GEOGRAPHIES AND CROPS



Expand project to
**other cashew-producing
West African countries
and Mozambique**

Expand efforts to
**other tree crops like
mango and shea**

ADAPT FOR OTHER TECHNOSERVE/ USDA FOCUS AREAS



**Adapt geospatial
machine for other
TechnoServe
focus areas,**

e.g., coffee (identifying trees that have been stumped)

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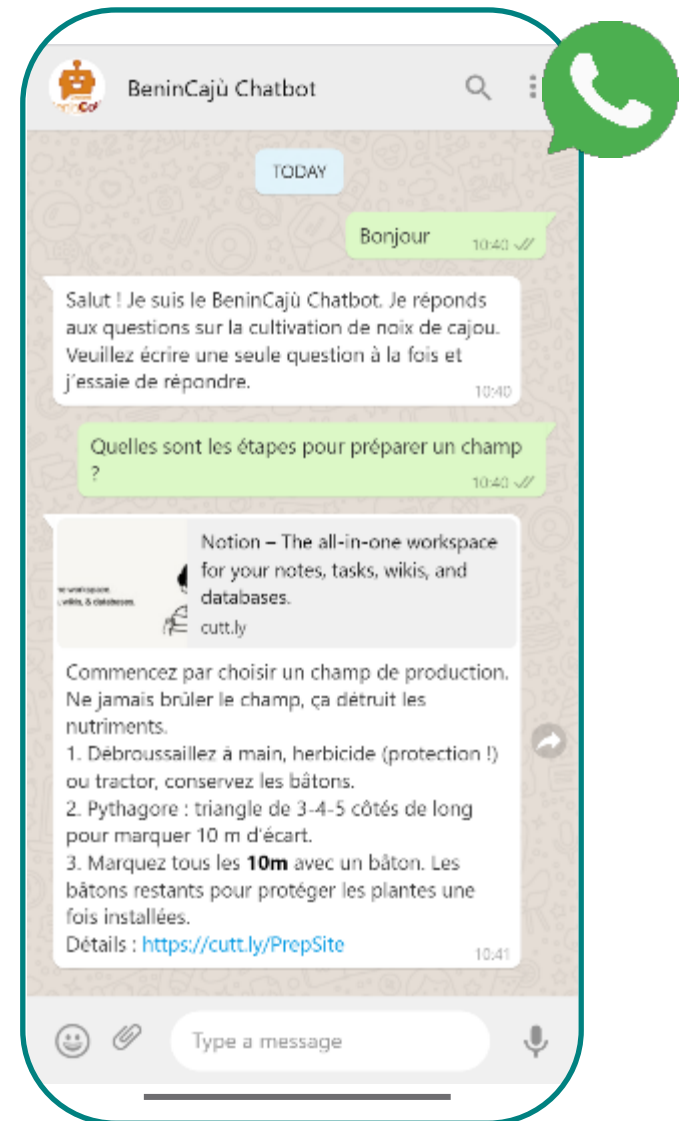
**Introduction to Chatbot and
Quality App**

The BeninCajù Chatbot is an easy to use digital resource to answer questions on best practices in cashew farming

What is a chatbot?

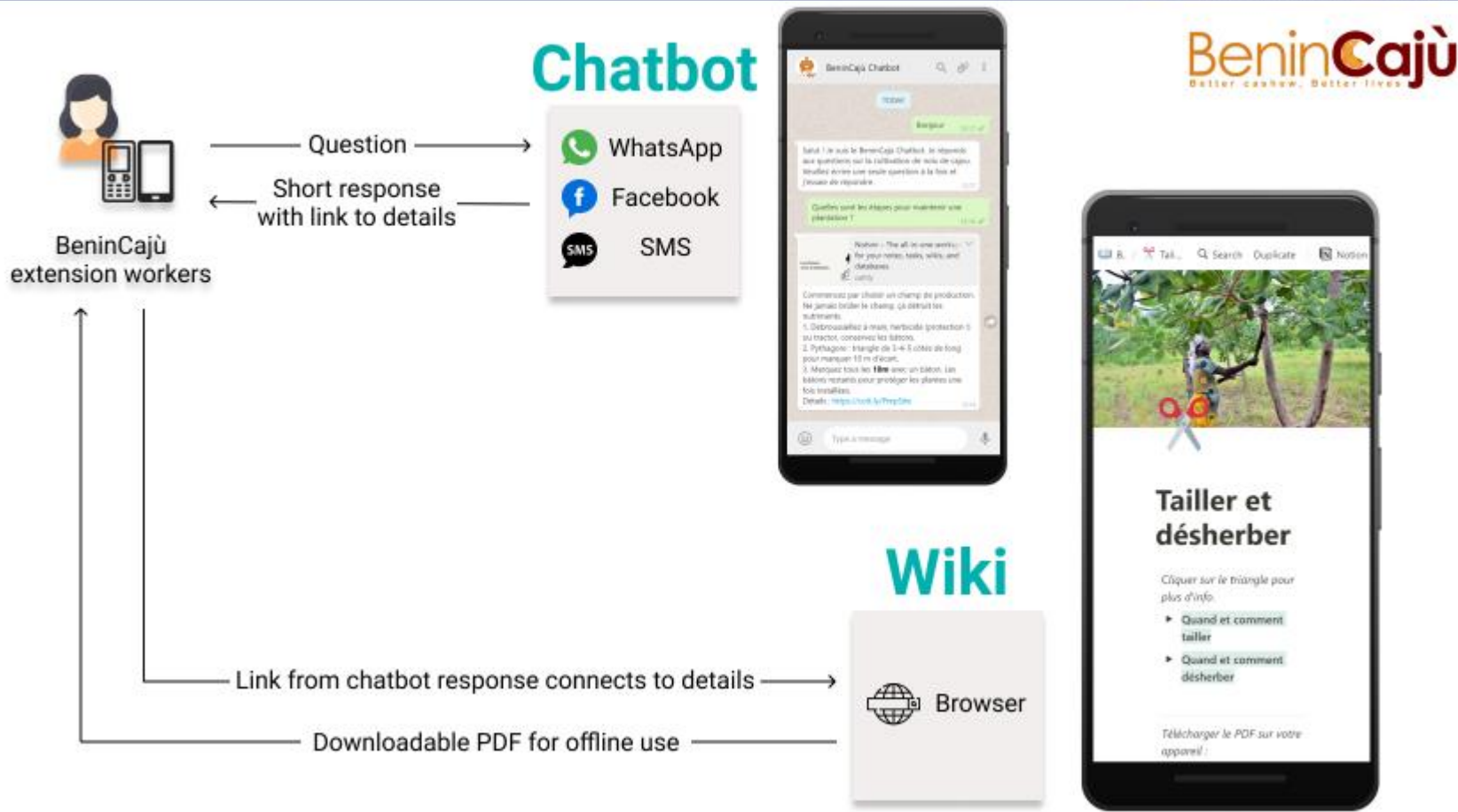


- A computer program that **simulates human conversation**
- A text- or voice-based interface that enables users to **get immediate answers to questions**
- Example channels:



The BeninCajù Chatbot is adaptive to user needs: telegraphic responses for use in the field + details on demand via hyperlink

Architecture: BeninCajù Chatbot



Sept 2020

The BeninCajù Chatbot will increase efficiency of extension worker training, thereby scaling farming training and overall production

- **Chatbot** as solution of choice, because information becomes:
 - immediately available – no time lag
 - easily accessible – familiar platform, hyperlink
 - consistent – no guess-work
 - up-to-date – content updates within a few clicks, immediate broadcasting
 - rapidly scalable – **has the potential to be the central platform for information on cashew cultivation for all stakeholders** (add features such as real-time pricing).
- **Needs training** – is in its infancy but has great potential



Business problem: There is a lack of consistency in measuring and recording cashew quality at the farm-gate

- **Quality affects marketability and price of cashew** at the farm-gate
- However, farm-gate buyers **lack a solid understanding of key quality metrics** and **tools to estimate them correctly and consistently**
 - Thus they're unable to demonstrate to farmers why they should be paid more or less for a particular stock, and why farmers should invest in best practices

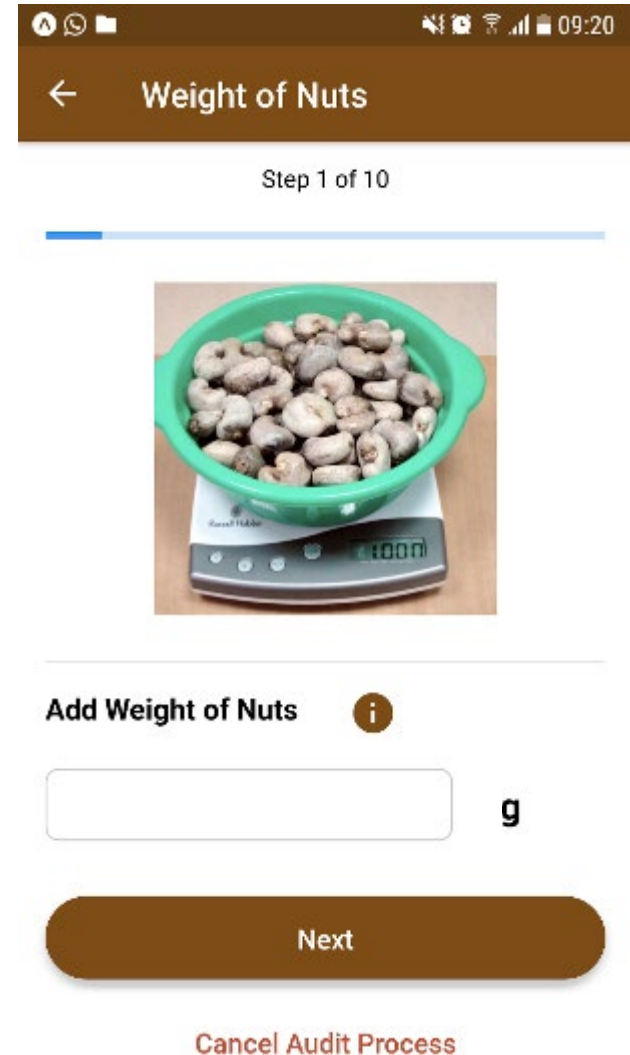


A simple, standard mechanism is needed to **capture and report quality data from farm-gate to buyers**



Proposed solution: A simple Android app will help measure and record key cashew quality metrics


- Android app with a step-by-step guide and instructions on **proper sampling and evaluation techniques**
- Co-op's or farm-gate buyers can use the app to ensure they are managing quality well and share results with buyers
- Data captured will include **location, time-stamped and geo-tagged photos, and key quality parameters** (outturn, nut count, moisture level, defective nut rate, etc.)
 - App will automatically calculate key parameters
- Quality results can then be **shared with the buyer via SMS, WhatsApp or email** from the app




The screenshot shows an Android app interface for 'Weight of Nuts'. At the top, there's a status bar with icons for notifications, signal, and battery, and the time 09:20. Below the status bar is a brown header bar with a back arrow and the title 'Weight of Nuts'. Under the header, it says 'Step 1 of 10'. A progress bar is shown below this. The main content area features a photo of a green bowl filled with cashew nuts, sitting on a digital scale. Below the photo, there's a text input field labeled 'Add Weight of Nuts' with an information icon. To the right of the input field is a 'g' unit indicator. At the bottom, there's a large brown 'Next' button and a red 'Cancel Audit Process' link.

Weight of Nuts

Step 1 of 10



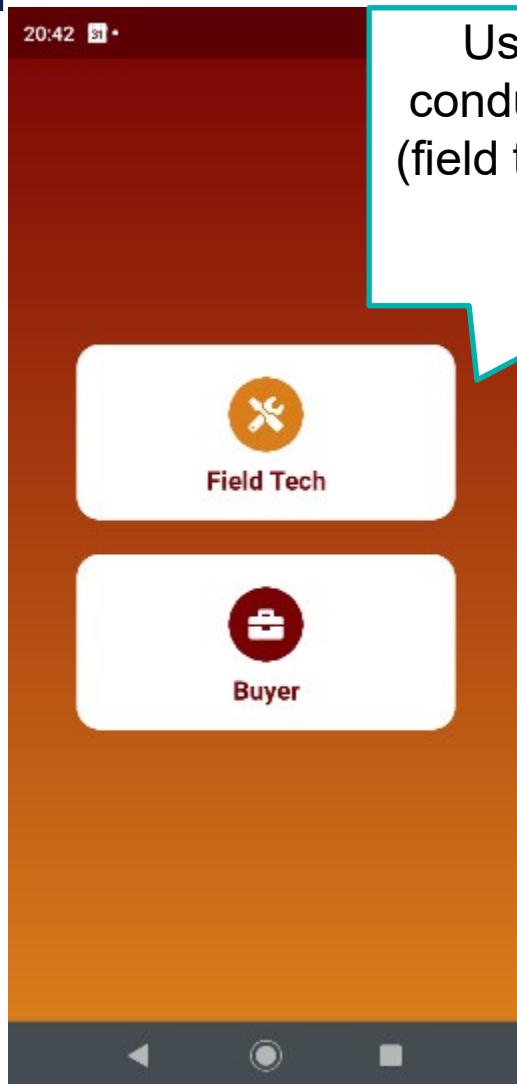
Add Weight of Nuts 

g

Next

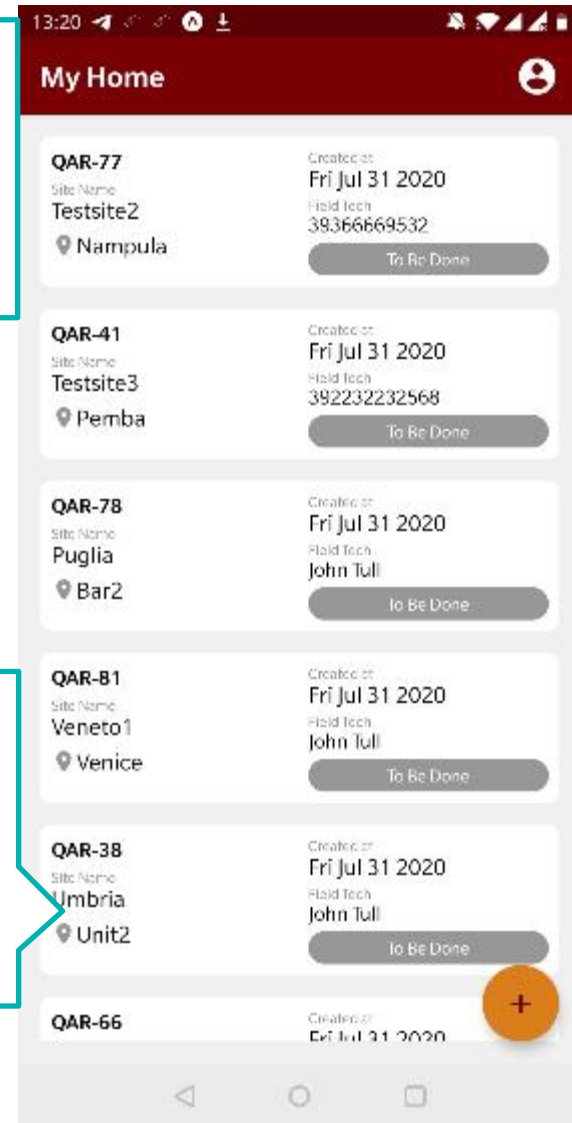
[Cancel Audit Process](#)

App can be used to request, conduct and share quality audits among buyers, field technicians and farmer co-operatives



User can sign up to conduct and send audits (field tech) or request and receive audit reports(buyer)

Buyer can request audits to be conducted, and see summary of requests



App walks through 10 key steps of quality audit assessment, and automatically calculates key quality

Photo required for proof that step weight of good kernel for outturn calculation was completed

Clicking the "i" icon opens up instructions on how to conduct the test

After 10-step process, app summarizes key metrics which can be sent to buyers

Result Summary	
Nut Count	200
Moisture Content	8%
Foreign Material	5%
KOR	48 lbs.
Defective Rate	10%

Buyer Information	
John Tull	
393276306853	
Veneto1	

Confirm

Data from mobile app will be aggregated into a web portal that TechnoServe/governments can use to manage and analyze data

App will capture geotagged data, which will be aggregated and analyzed on website



Dashboards will show heat map of average KOR by region

Dashboards will also show average KOR by each site



THANKS!