eKichabi v2

Designing and Scaling Digital Information Systems
in Rural Tanzania

Ananditha Raghunath

XunMei Liu

Yunwei Zhao

George Wang

Hans Easton

Alexander Metzger

Hosea Mpogole

Richard Anderson

Background

Scoping Fieldwork (May 2022).

- Tanzania is 65% rural
- Focused study in rural district of Kagera
- Recent widow with ill child
  - Could not travel
  - Relied on transporter
  - No leverage
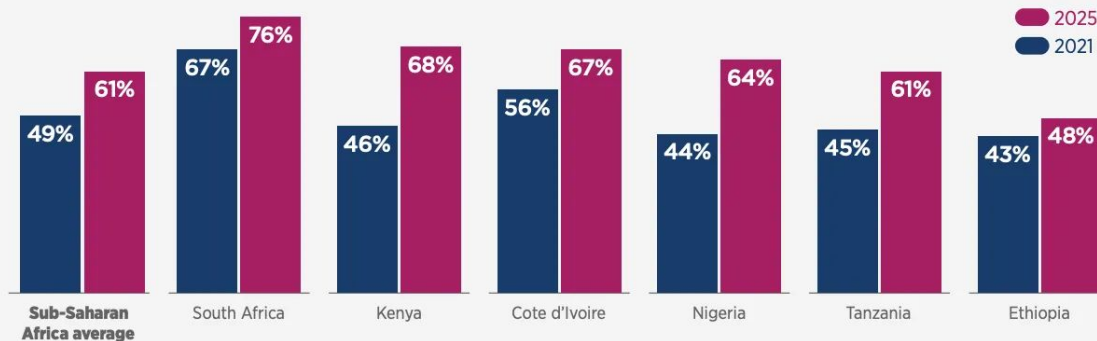- Solution? Digital Phone Directory?

Smartphone (Android Access)?

- Highest estimate: 49% of SSA inhabitants[2]

By 2025, smartphones will account for 61% of total connections, on average, in Sub-Saharan Africa
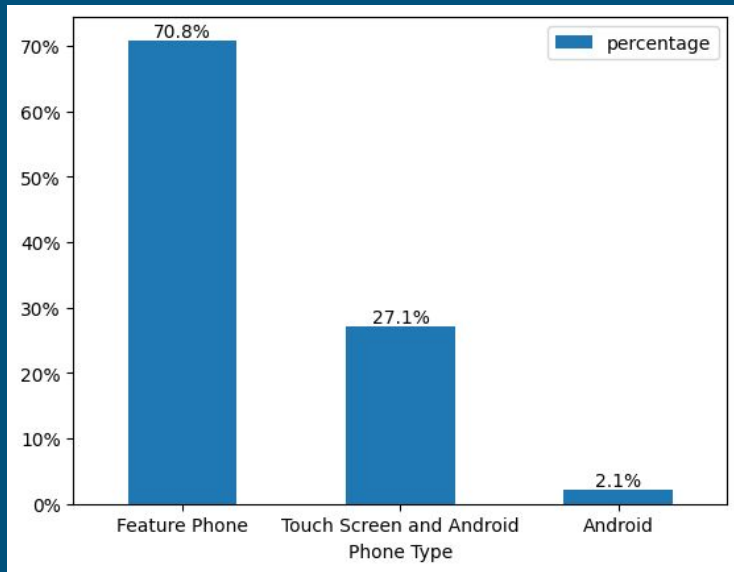
Smartphone adoption (percentage of total connections) in the top six markets in Sub-Saharan Africa

2025
2021

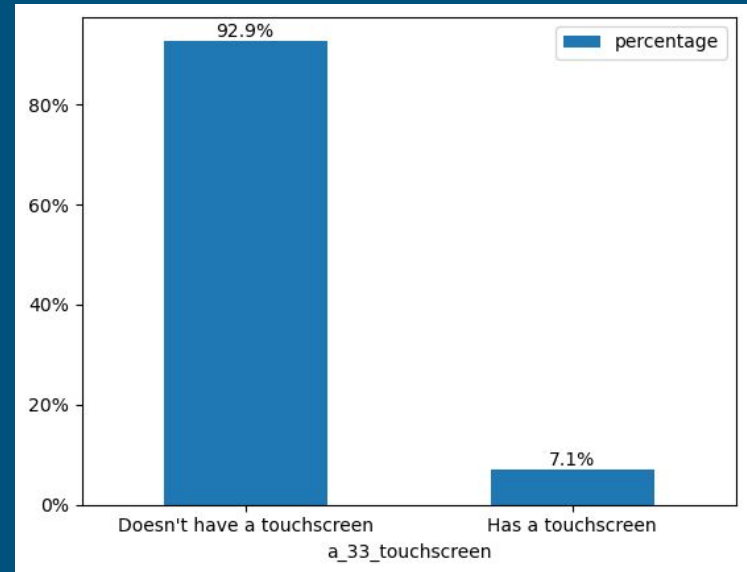|	2021	2025
Sub-Saharan Africa average	49%	61%
South Africa	67%	76%
Kenya	46%	68%
Cote d'Ivoire	56%	67%
Nigeria	44%	64%
Tanzania	45%	61%
Ethiopia	43%	48%

Source: GSMA Intelligence

Smartphone (Android Access)?

- Highest estimate: 49% of SSA inhabitants[2]

← Scoping

HH Census →

Internet Society - Tanzania Lacks Internet

Overall Resilience · Infrastructure · Performance · Security · Market Readiness

Region Sub-Region Country

0%	
10%	
20%	
30%	
40%	
50%	
60%	
70%	
80%	
> 90%	
N/A	

Tanzania, the United Republic of

● **Overall Resilience**	**38%**
● Infrastructure	25%
● Performance	30%
● Security	61%
● Market Readiness	35%
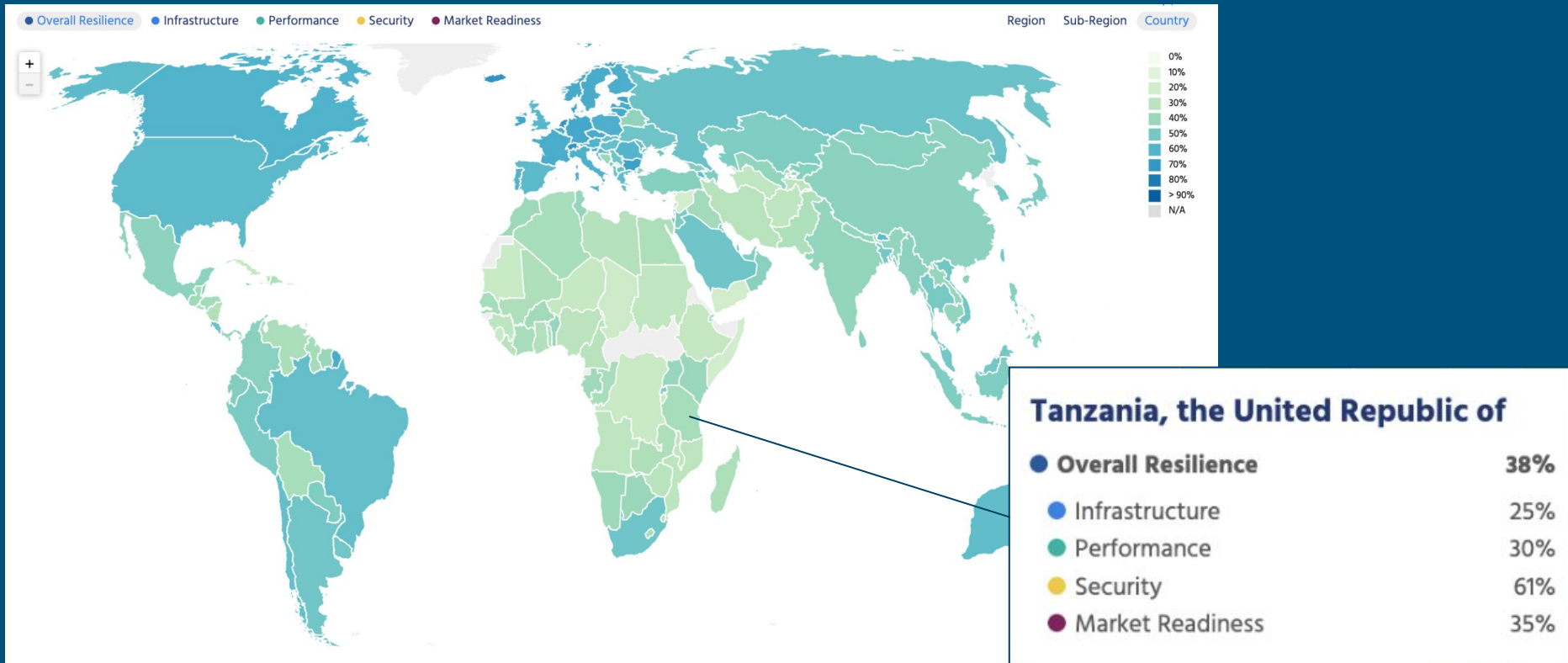
Internet Society

Infrastructure
The existence and availability of physical infrastructure that provides Internet connectivity.

Performance
The ability of the network to provide end-users with seamless and reliable access to Internet services.
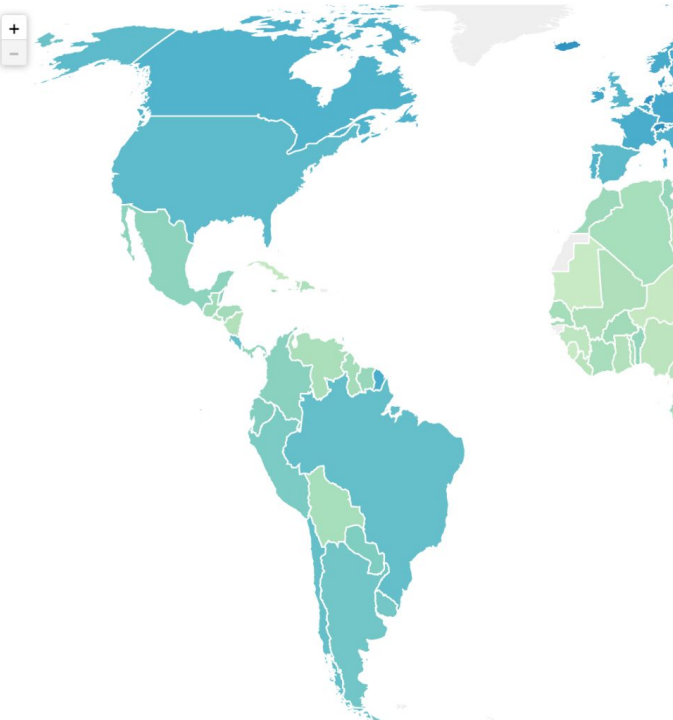
Security
The ability of the network to resist intentional or unintentional disruptions through the adoption of security technologies and best practices.

Market Readiness
The ability of the market to self-regulate and provide affordable prices to end-users by maintaining a diverse and competitive market.
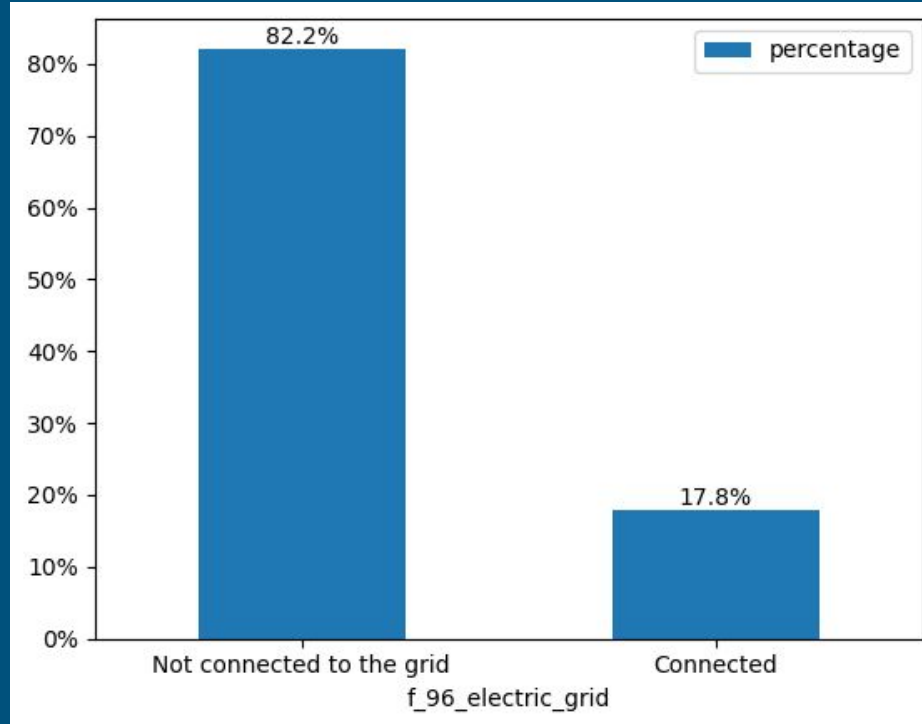
● Overall Resilience   ● Infrastructure   ● Performance   ● Security   ● Market Readiness

70%
80%
> 90%
N/A

Tanzania, the United Republic of

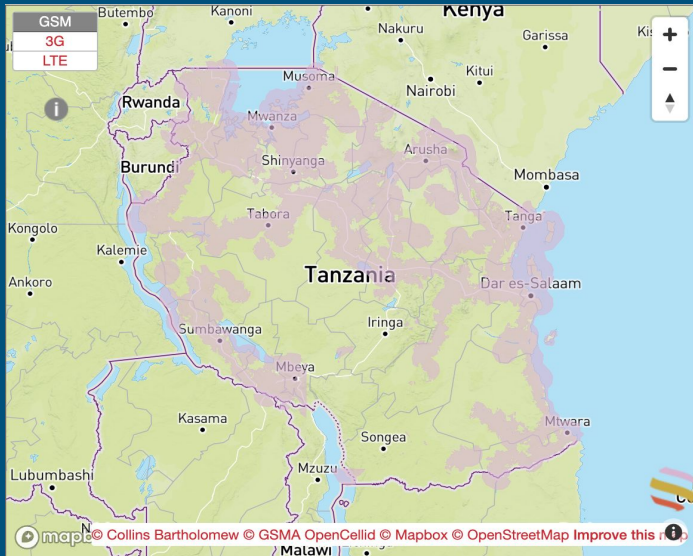|	
● **Overall Resilience**	**38%**
● Infrastructure	25%
● Performance	30%
● Security	61%
● Market Readiness	35%

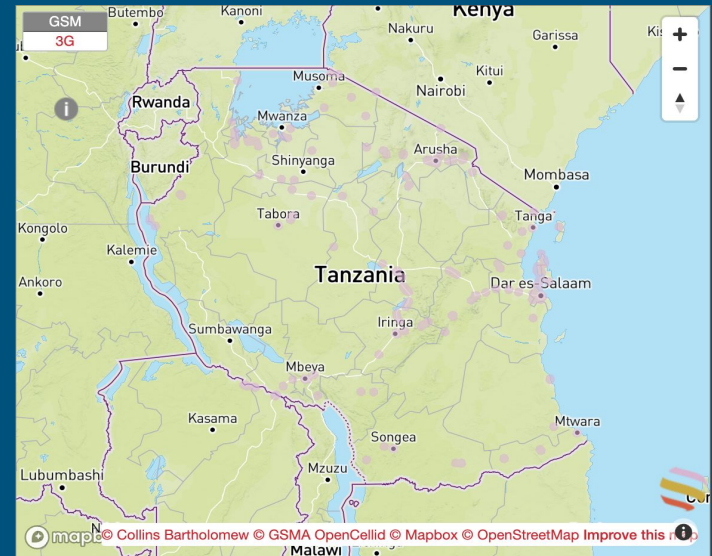# HH Census - 80% not connected to electrical grid

Mobile Network Coverage

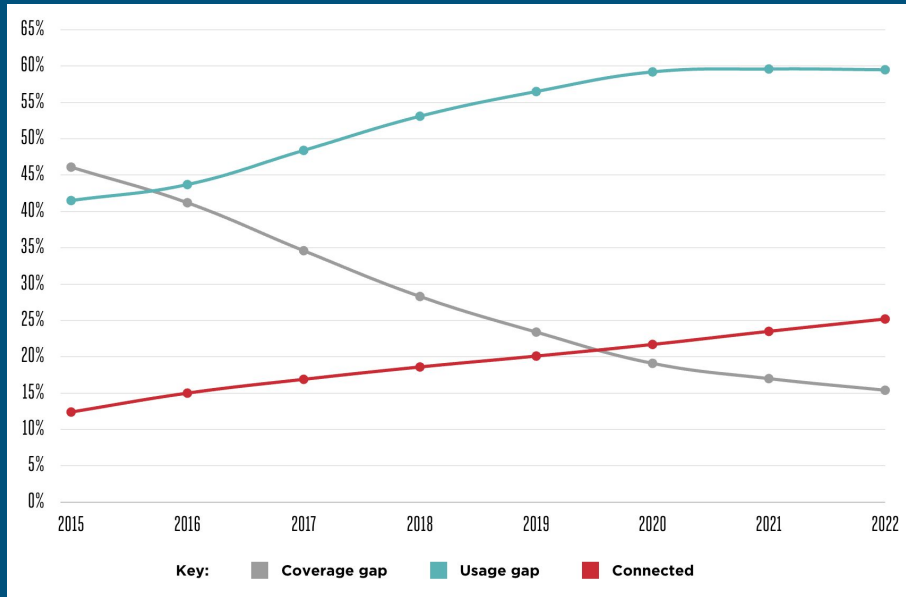- Penetration rate of 88% in 2019 to 101% in 2023[1]
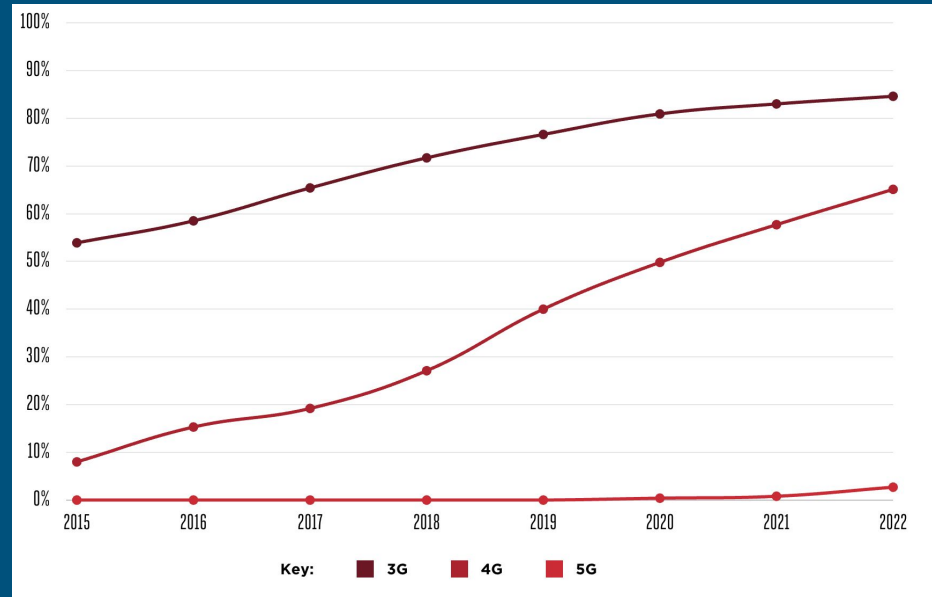
Vodacom

Halotel

GSMA - Internet vs Mobile Network Over Time

SSA Internet Coverage

Key: ■ Coverage gap ■ Usage gap ■ Connected

SSA Mobile Coverage

Key: ■ 3G ■ 4G ■ 5G

USSD

What is it?

- Unstructured Supplementary Service Data
- Used by 1+ billion every day[3]
- Powers 94% of all digital financial transactions across Africa, offline payments for almost every bank in India, and Togo's emergency cash transfers during the Covid-19 pandemic[3]

Local testing of Niafikra USSD service

How does it work?

User

*149*26#

Mobile
Network
Operator

OSMO COM

Africa's Talking

niafikra

Gateway

REST

Our Server

Advantages

- Stateful session based interactions → Security + UX
- Widely available, does not require internet
- People in SSA are familiar
- User doesn't pay
- Identify users based on MSISDN
- Less error prone, costly, subject to delays than SMS
- Works on both Feature and Smartphones
- Cheaper than custom hardware like SIM apps
- Easier to develop and translate than IVR

HH Census - Self Perceived Comfort w/ USSD

A. Very Comfortable–I can use USSD without help from anyone
B. Somewhat comfortable–I may ask for help sometimes
C. Not very comfortable–I need help over 50% of the time
D. Uncomfortable–I always ask someone else to navigate the menus on my behalf
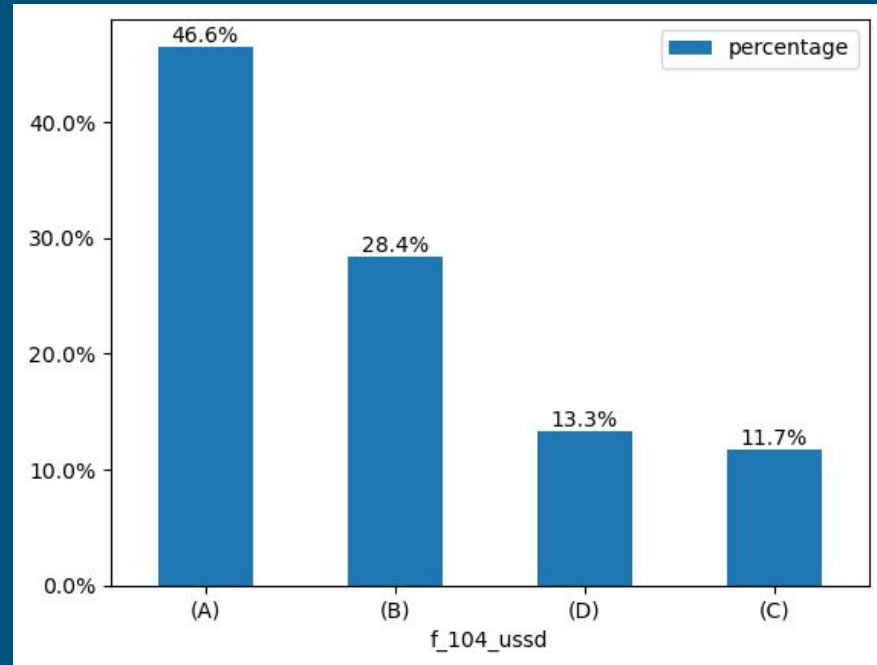
Disadvantages

- Text based UI less intuitive than GUI
  - Carrier dependent character limits
  - Session timeouts
  - Eyesight
  - Confusion about back button
- Harder to test
- More later
  - Maybe not as reliable as we think?

Prior Work

eKichabi v1

- Demonstrated the feasibility of USSD for information access applications
- The Stats
  - 17 focus groups (57 participants)
  - 4 villages with 107 registered participants
  - 1883 USSD session, 500+ businesses, 30 day study
  - 65 follow up interviews

Select an option:	Select District
1.Browse by Location	1.Babati Mjini
2.Browse by Sector	2.Chamwino
3.Search	3.Chemba
4.Help	4.Dodoma Urban
	5.Kiteto
	0.Next
	99.Back

A) User input : 1   B) User input : 5

Select Village	1.All Businesses (24)
1.Busi	or Select Subvillage
2.Keikei	2.Kiteo – Marumba
3.Kinyasi	3.Kiteo – Matinga
4.Kiteo	4.Kiteo – Muya
5.Kwadelo	5.Kiteo – Nkundusi
0.Next	
99.Back	99.Back

C) User input : 4   D) User input : 1

Select Business	Ally Kiosk
1.Ally Kiosk	-----------------
2.Amiri Shop	Location:
3.Chavai Kiosk	Kiteo – Matinga
4.Fundi Baiskeli	Phone: T653965711
5.Genge la Mama Mtaa	
0.Next	
99.Back	

E) User input : 1   F) Business found

Figure 3. An example eKichabi session. Screens A-F show browse by location to find Ally Kiosk. Text translated to English for publication.

Motivation: Scale and emerging trends in LMICs

Pros and cons of Smartphone Apps

Pros:

- Can work offline after initial install
- Better UI + UX
- Browsing large amounts of data makes more sense
- Image capture/display capabilities
- Internet access
- Accessibility
- Video streaming
- GPS
- Larger, more adaptable touch screens
- Use is growing

Cons:

- Requires a lot of data for initial install
- Takes up storage space
- Can't easily acquire phone number for ID
- Access is far from ubiquitous
- Smartphone users preferred USSD

A Dual Platform Intervention - At a Glance

- Survey of 1014 HH
  - Low smartphone ownership in this rural area (49% → 7%)
  - A large minority of USSD non-users (30%)
  - Diverse tech comfort
  - Sustained use of Wakalas as tech intermediaries
- Scale
  - 500 → 9833 businesses
  - 1883 → 121,771 sessions
  - 30 → 337 days (and running)
  - 4 → 100 villages
  - Running into the limits of USSD

- Offline Android Application
  - Log analysis to compare usage across demographics
  - Reluctance to download Android Apps
  - Smartphone users end up using USSD
  - Android has higher retention and more complex use
- Trust and Intermediation
  - Wakala pilot shows interest and capability to engage community members and further trust

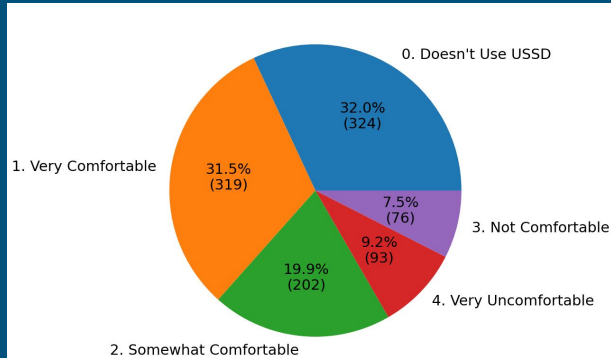# Demographics

Number of Household Responses per District
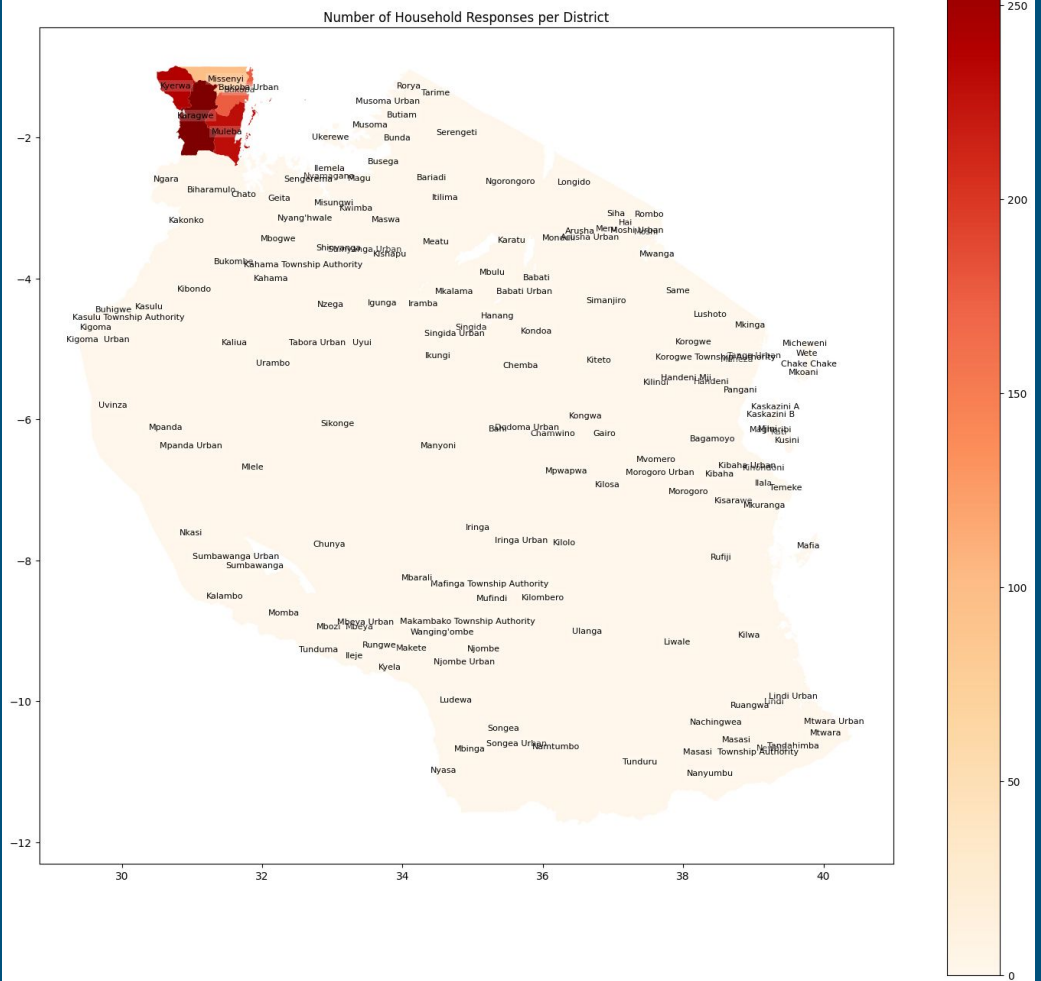
Demographics
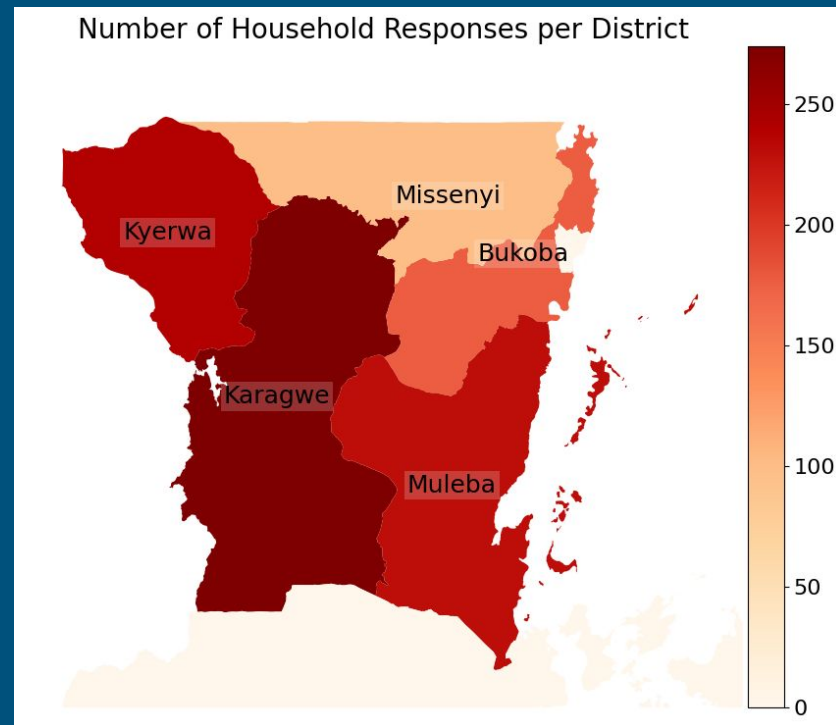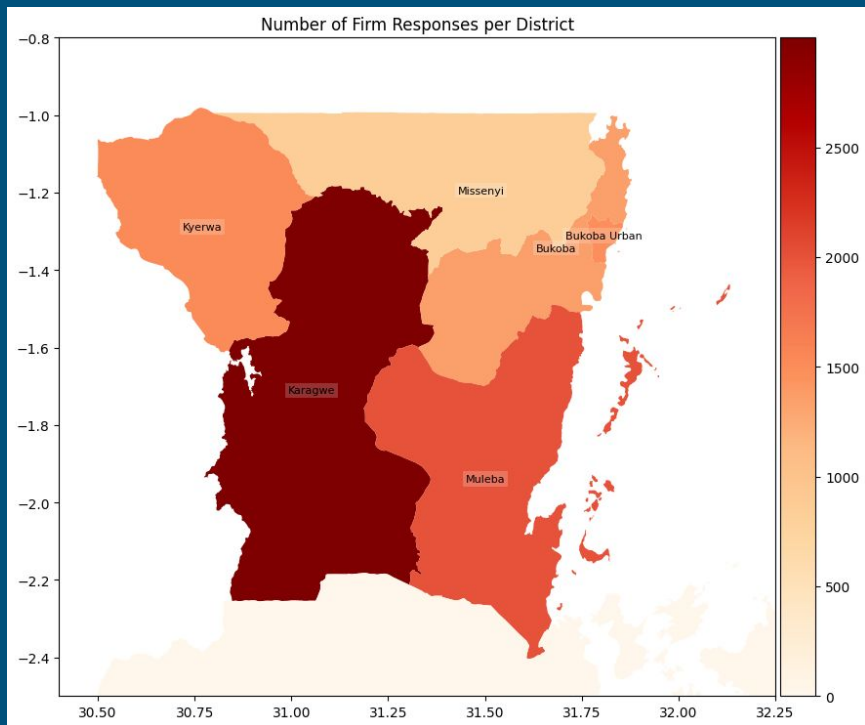
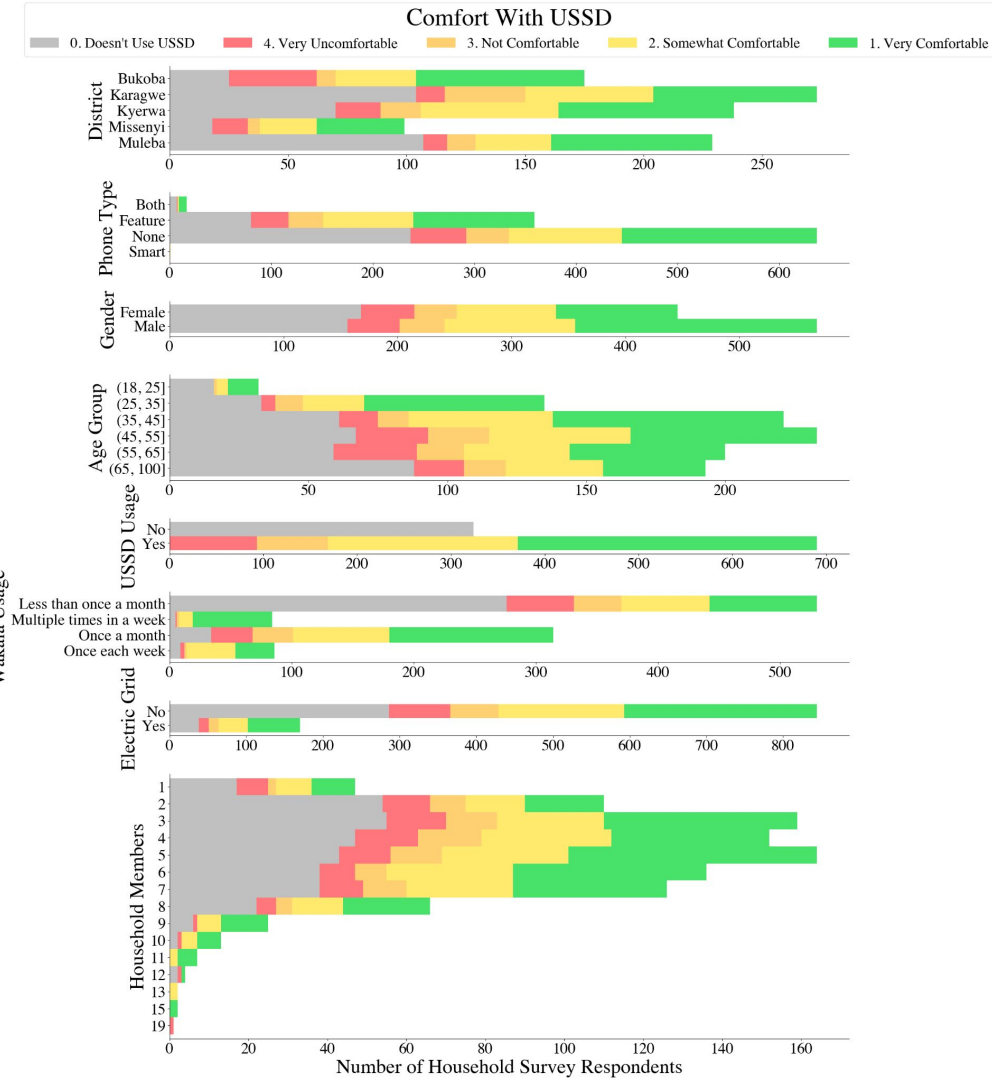# Demographics

- Comfort differed significantly with age and gender (p << 0.001)
  - Gender difference less significant for < 40 ⇒ bridging the gender gap
- District/village was not associated with comfort (p = 0.073)
  - Perhaps no peri-urban/rural split
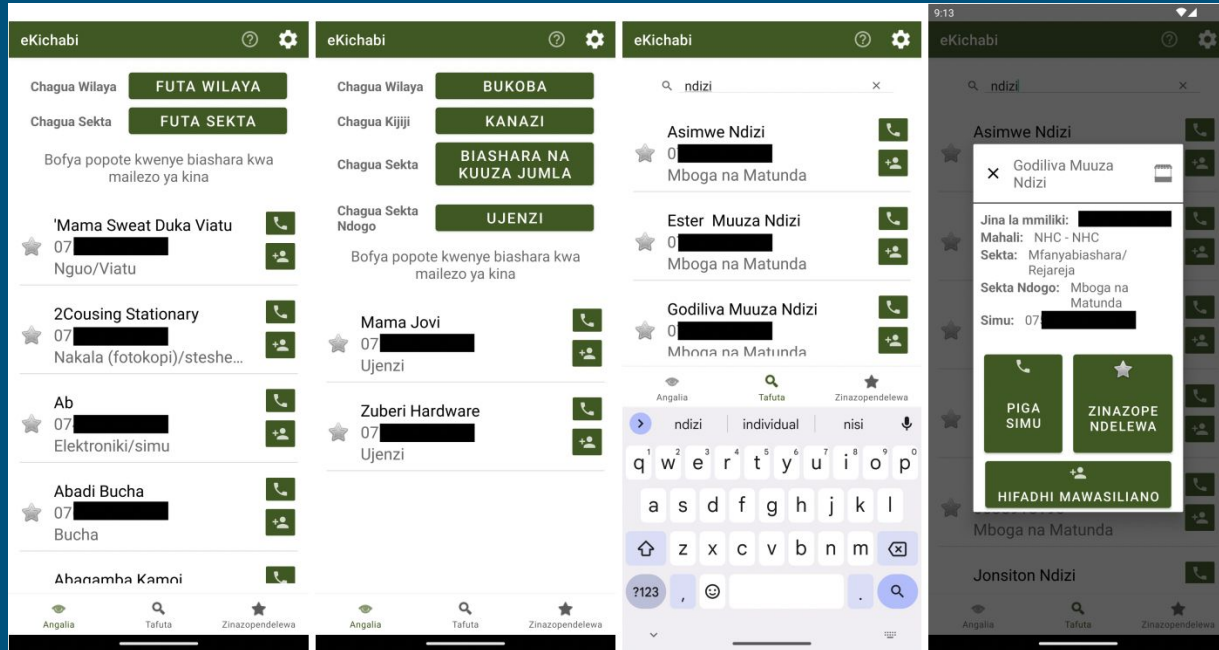
Android

(a) Initial Screen | (b) Filtering by Menu | (c) Filtering by Text Search | (d) Business Detail Screen

Android Usage

- 42 active devices.
- 40 unique users
- Favoriting was used by 12.5% of Android users
- 40 favorite/unfavorite actions
- 51 call actions from within the app
- 15 businesses were added to phone contacts

USSD Improvements over eKichabi v1

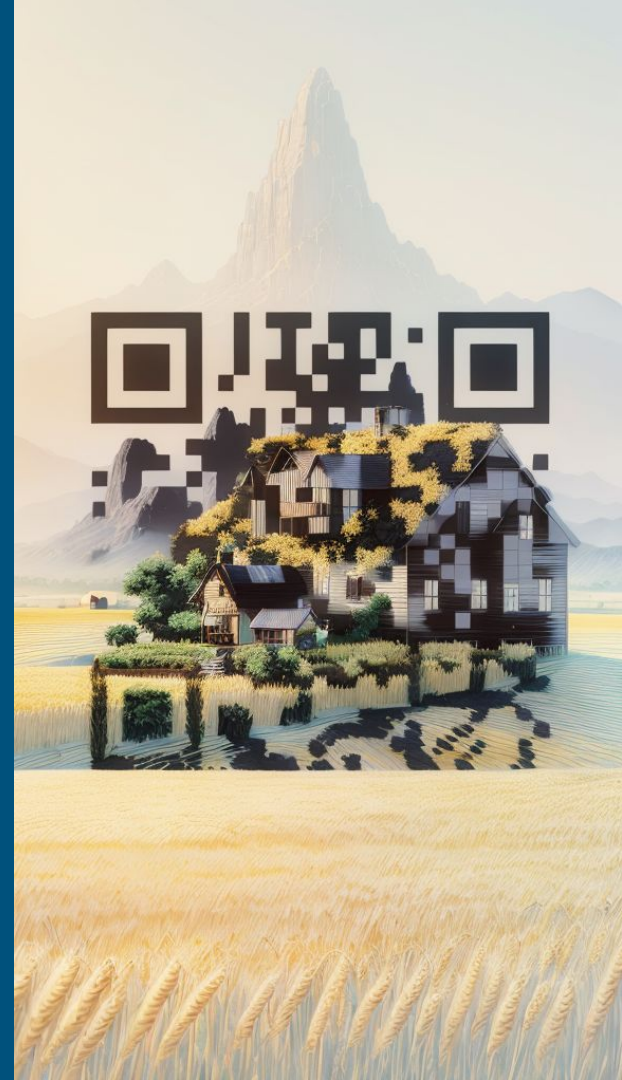- Performance
  - Improved serialization
  - Caching and lazy loading search results
  - Fuzzy-search indexing
  - SQLite → MySQL
  - Took search from 5+ min to 100-800ms
  - Overall 7000x average speedup across a randomized session
- Reorganized Text Search
  - More subcategories to enable narrowing down results for display on smaller screens
  - Filter results by keyword (also helps spelling issues) and location
- Trust
  - A/B test owner name
  - Improved training
  - More!

Trust

- Text message/USSD scams are becoming commonplace in SSA[50]
- One user tester asked "What if I find a transporter through this directory and he kills me"?
- Designers should make clear how businesses' information was gathered to increase trustworthiness
- It is unclear whether the directory guarantees transactions; trust in a business partner is usually made by meeting face-to-face rather than through an online directory.
- Designers should verify people's national ID when adding them to the directory to ensure that they are telling the truth, or add only the businesses named by and registered with the Tanzania Revenue Authority
- Trust would be better facilitated if the directory designers made their motivations more clear in disseminating such a technology.

USSD Usage

- 121,771 Sessions (~3000 from HHs)
- Average session: 1 minute and 40 seconds
- 782 business screens visited
- Usage statistics—session duration, number of sessions, retention, use of back buttons, and text search—were highly correlated with number of businesses visited ($p \ll 0.001$)
- Gender did not predict usage (P = 0.086)
- Despite age predicting usage (P = 0.006) and males being younger (mode 35-45) than females (mode 65-100) in the sample
- Usage did not differ across districts (P = 0.937) $\Rightarrow$ no peri-urban/rural split
- Usage differed significantly across whitelist dates (P = 0.012) $\Rightarrow$ seasonal farming practices important

Plotting session length 0 secs to 1 hour - histogram
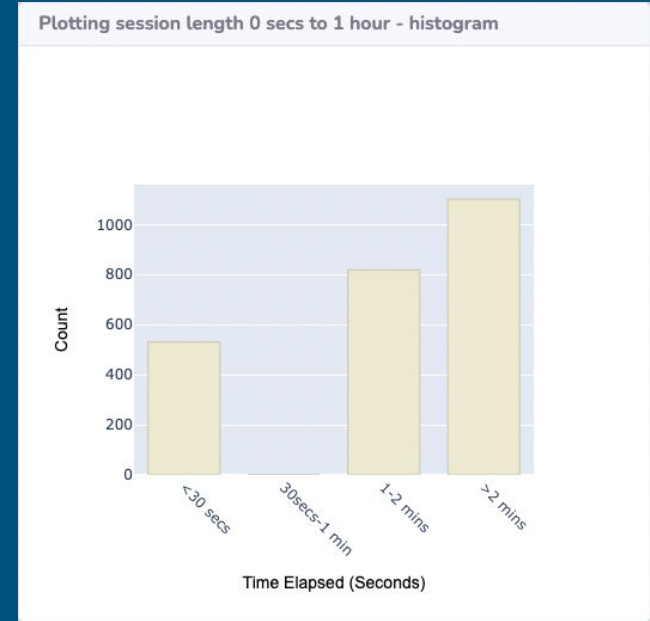
USSD Temporal Use

Total USSD Sessions grouped by Day of the Week

USSD Sessions per Month

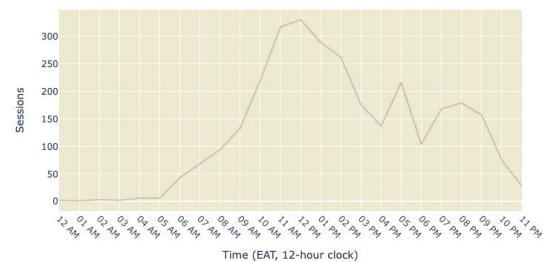Harvest | Rest | Plant | Pesticide/Fertilizer, etc. | Harvest
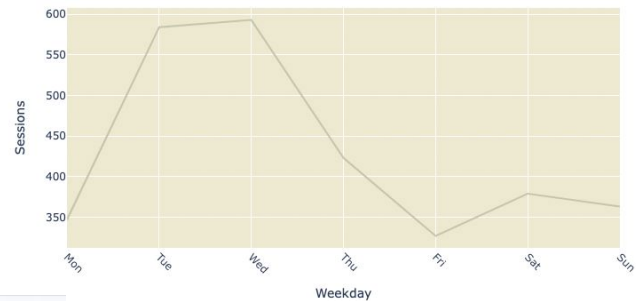
Total USSD Sessions grouped by Hour of the Day

Android vs USSD

- **Android use was more complex with higher retention**
- 22 actions per Android user (874 total)
  - 42 inputs per active USSD user (25K)
- 5 business detail views/Android (193)
  - 3 business views/USSD (1785)
- 12 filter actions/Android (462)
  - 0.2 browse/USSD (126 total)
- 2 text search/Android (85)
  - 0.5 text search/USSD (288)
- Android users returned on average 2.65 different dates
  - 1.72 for USSD

Theme	USSD App	Android App
Navigation	Users navigate through USSD screens with numerical input corresponding to selections. To go to the previous screen they enter 99, and to go to the next screen they enter 0.	The Android app leverages the smartphone touchscreen to move back. 'Next' is not a necessary function since all relevant businesses can be scrolled through at once.
Visibility of Businesses	Users must navigate a minimum of 6 screens before businesses become visible and open business details screens individually to see more than the business name.	The Android app displays the list of unsorted businesses as soon as the user opens the app (see 3a), with business name, owner phone number, and economic sector/product type available without clicking on the business details screen.
Search	Screen size and character limits limits put a ceiling on the number of business names displayable on a single screen, i.e., typically 5 to 6 businesses. This means there can be tens of pages of responses for some queries that the user must traverse sequentially.	Android search is dynamic and the list of businesses updates as the search is being narrowed. As many businesses as are applicable appear as the search occurs.
Additional functions	Users must physically write down contact numbers from final business screen as feature phones do not allow copying and pasting of text. The use of the help screen requires returning to the first page of the app.	Android users can favorite businesses (which then appear on a separate tab), save phone numbers to contacts, and call businesses through the app. The help button can be toggled from any screen.
Costs	No costs are incurred when users dial the USSD app.	Android users exhibit reluctance to download the app, citing data costs.
Authentication	The USSD app automatically authenticates users with their phone number since it has access to that information from MNOs.	Operating system version challenges on popular smartphones cause users to self authenticate as opposed to using a hardware-based guarantee from sims.
User Experience	USSD has strict character limits of 160, and on feature phones, it is often necessary to scroll down to display a single screen. This makes USSD more laborious to navigate. Further, feature phones have no way to increase screen brightness or increase text size.	The Android app displays more data while remaining readable and having a more intuitive user interface. Further, smartphones can increase screen brightness and text size to suit users and the environment.
Potential Interruptions	If the telecommunications network is going in and out, the USSD connection fails, and the user has to resume from the beginning when the connection returns.	Once the app is downloaded, there is no connection necessary unless the directory changes and new businesses must be downloaded (even this can be done whenever WIFI becomes available, and the app remains usable in the interim).
Trust	Trust building comes in the form of a disclaimer and the addition of business owner names to the directory. There is no easy way to corroborate the validity of information given the amount of steps needed to find a business	Trust is perceived to be greater: although there is a similar disclaimer presented, owner names are visible with the list of businesses just as the app is opened and familiar businesses can be located with ease.

Table 2. Differences between the USSD and Android apps.

Contributing Percentage	from Comfort Group A	from Comfort Group B
eKichabi USSD users	21%	12%
eKichabi Android users	0.3%	0.0%
Total Sessions	488	205
Average sessions per user	7	5

Table 3. Differences in use by comfort level.

Challenges

Android - Where's my free Wiffy?

- Users had WiFi in their village center but not in their homes
- Could not have Android app fall back to USSD when internet was poor
  - Android operating system support was limited
  - USSD Gateway could not accept initial payloads
  - Not reliable
- Solution
  - Offline copy of db compressed to 1.8 Mb
  - Efficient updates from server when connected
  - Custom binary format for logs (to be uploaded when connected) - 20K actions in 100 KB
  - Total size of 6.73 Mb (~67 TSh or $0.02 USD in Tanzania in 2023)

Android User Identification

- For allowlisting we needed to identify users by phone number
- For log analysis we needed to identify users
- Dual SIM, operating system specific irregularities, etc. make this unreliable to get from the device
- Considered doing a USSD handshake
  - Introduces another point of failure
  - Not supported by gateway
- Other methods, e.g. OTP, would pose as a tech barrier for target audience
- Solution
  - User enters phone number
  - Common endpoint that standardizes phone number format
  - Inspection of logs showed that sharing of phone numbers was not a problem

Questionable Firm Census

- To get the right answers, you need to ask the right questions
- A few days before deployment, we discovered that we mistranslated seed to pesticide and that there were not a lot of results for agricultural products
- Turns out some agricultural questions were only asked to 40 businesses
- Solution
  - Delay deployment
  - Turn USSD app into a temporary questionnaire
  - Provide 3 days to complete the survey, with one reminder text sent on day 2
  - Use lottery to incentivize responses
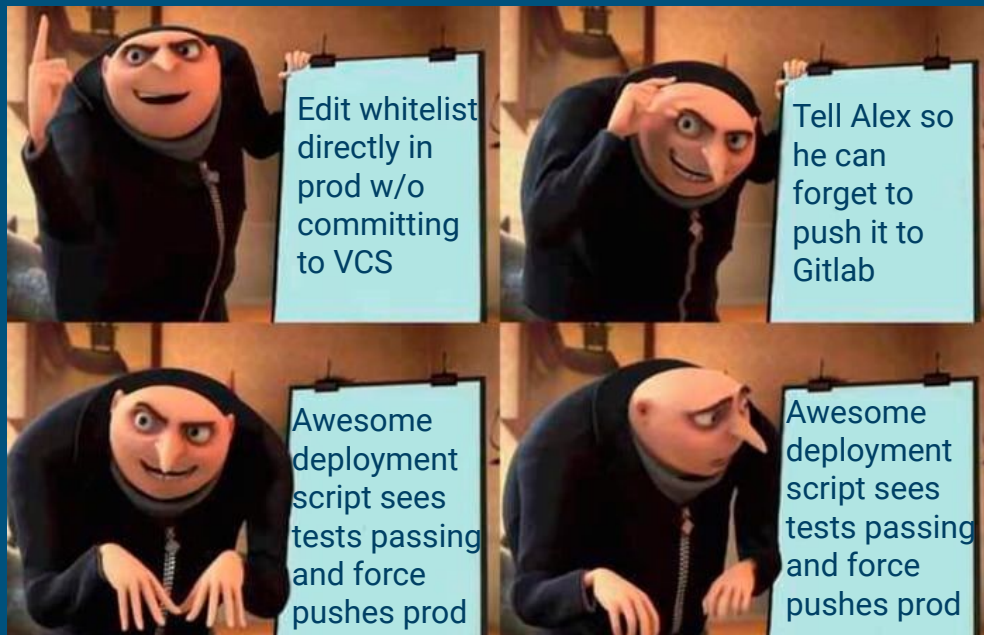
The Lottery Scam

- 100K TSH = 40 USD (awarded to 3 respondents)
- SMS had to be short for cost reasons (4K affected businesses)
- Our enumerators reported: "people think we are scammers"
- Only got around ~400 respondents
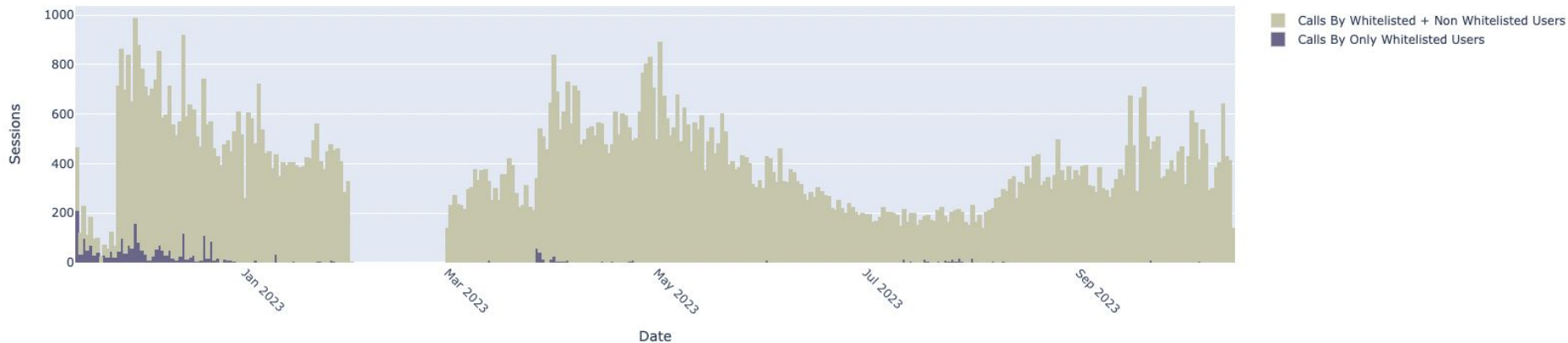- Aker et al. notes that data integrity is vital for trust and adoption

To Allowlist or Not

What happened to February?

USSD Sessions per Day

Calls By Whitelisted + Non Whitelisted Users
Calls By Only Whitelisted Users

What happened to February?

USSD Sessions per Day
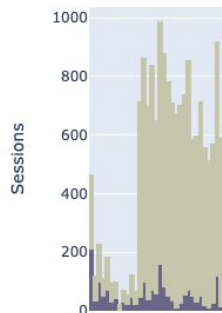
Network failure rates, top 5 services in KE

Calls By Whitelisted + Non Whitelisted Users
Calls By Only Whitelisted Users
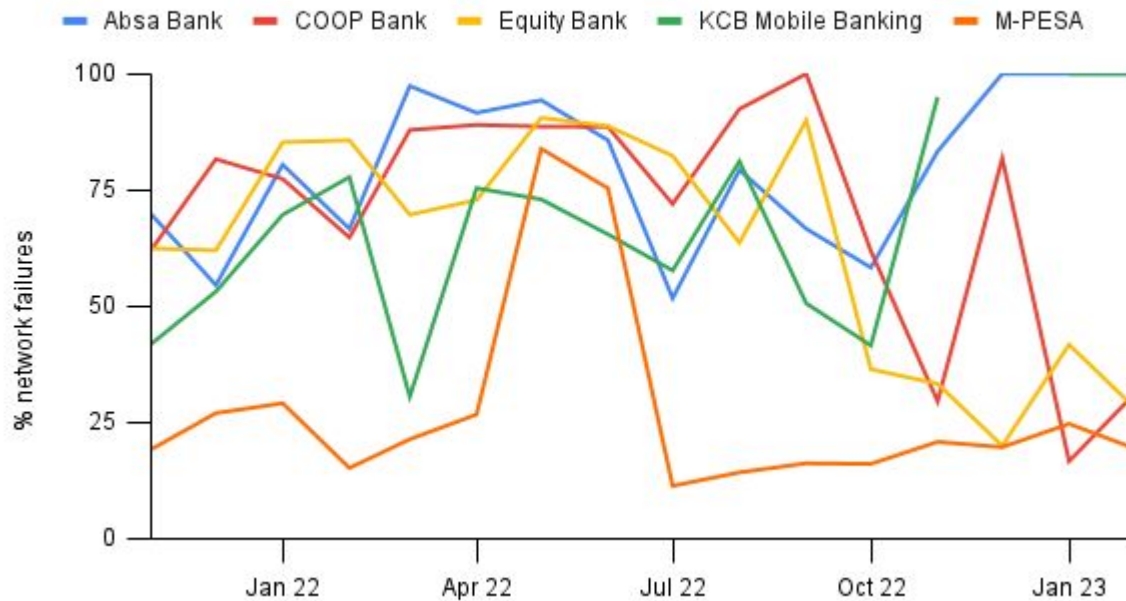
Recommendations

Unexpected Phenomena

- A lot of non-whitelisted interest
  - Wakalas confirmed talking to people not enrolled who were interested in learning how to access the app and how it could help their farming
- Very limited smartphone penetration in rural areas in Tanzania (~7%)
- 50% of smartphone users exclusively used USSD
  - Mirrors financial service findings that smartphone users prefer USSD[13, 55]
  - Need to incentivize downloading the app
  - There is still significant room for dual interventions as the technology landscape continues to grow in SSA
- 30% of respondents were non-users of USSD and 53% need help at least on occasion
  - Familiarity is not a given, intermediation, good tutorial/help material, and training is still vital

Technology

- Performance matters
  - Original app caused MNO-implemented session timeouts
  - User testing indicated being able to quickly retry searches was important
- Opt for a well documented gateway
  - Africa's Talking or better yet Twilio (if your region is supported)
  - Niafikra request headers were non-standard and non-documented and missing features
- Use VCS and CI/CD well
  - Even in small teams (helps catch mistakes)
- Connection issues mean authentication via Android is hard
  - Study and application needs to be designed around offline use

Design

- When asked whether having multiple screens in a shortcode application deters their use, 46.4% of users in our testing groups agreed
- 76.9% of SPOs in these groups preferred Android over the USSD app. Due to data costs (USSD is understood to be free), there was an overall preference for USSD by both smartphone and feature phone users
- Designing short (< 160 chars) yet informative screens is hard when dealing with 1000s of businesses
    - Make sure it is easy to filter results down to a manageable size quickly
    - USSD at scale is more easily adapted to mobile money transaction than information access

Organization

- Keep surveys shorter
- Contact subjects close to their allowlist date
- Avoid giving people access and then remove it (most firms never returned)
- Lotteries make for questionable motivation

Questions

Thank you for listening!

References

1. TCRA [n. d.].
   https://www.tcra.go.tz/uploads/text-editor/files/1st%20Quarter%20Statisctics%20Report%20for%202022-REVISED%20FINAL%201.11.2022_1667386626.pdf
2. 2021. GSMA (2021).
   https://www.gsma.com/mobileeconomy/wp-content/uploads/2021/09/GSMA_ME_SSA_2021_English_Web_Singles.pdf
3. https://medium.com/use-hover/more-than-a-billion-people-depend-on-ussd-based-services-that-fail-at-an-alarming-rate-63a992ba1a92
4. https://www.gsma.com/r/somic/
5. https://pulse.internetsociety.org/
6. eKichabi papers

Appendix

Wakala Intermediation Pilot

- 10 Wakalas and 31 HHs in Comfort Group B were sampled
- 90% Wakalas sent initial text offering help
- 50% sent the reminder text
- 27% of HHs met wakala in person, 18% called, 9.1% texted. The rest said they did not need help
- 70% of questions were about how to use the app or about its trustworthiness
- Most extended trust in Wakala to trust in the app but one Wakala reported "people think we are thieves"

Wakala HH Usage

- More complex and sustained use
- 12% of registered HHs with Comfort Level B accessed the app
  - 33% of Wakala HHs accessed the app
- More sessions than users
  - Not true for other HHs with Comfort B
- Average session length 175 seconds
  - 30 seconds
- 20% of Comfort B sessions viewed 2+ firms
  - Wakala HHs accessed 2+ in 60% of sessions