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Using web and mobile phone technologies to collect food market prices in Africa

Approaching real-time data and use of crowdsourcing, 2013 - 2016

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Abstract

Large agricultural commodity price swings observed in recent years have made the importance of accessible, timely, accurate and frequently updated price data more obvious. This study investigates the potential of innovative web and mobile phone technologies and alternative data collection methods such as crowdsourcing in order to collect food price data in Africa. The report summarises these experiences through the lessons learned and provides a detailed overview and assessment of different aspects of the collected data that can be of help for the success of future food price collection exercises.

1 Introduction

This report summarises the activities carried out at the European Commission's Joint Research Centre (JRC) within the context of food price data collection at rural and urban markets in Africa between 2013 and 2015. This research aimed to explore methods and systems for collecting and disseminating accurate, relevant, timely and high-frequency food price data in Africa. The motivation is to use the findings for the improvement and sustainability of data collection systems in Africa in order to support the availability, accessibility and use of market price data at national and sub-national levels. This motivation is in line with the need for high-quality and timely data, which has become pressing after the large agricultural commodity price swings in 2007/2008 and in 2011 and mid-2012. To achieve the overall objective, new technologies (i.e. mobile phones and web technologies) are tested together with innovative data collection methods using hired on contract (professional or amateur) collectors and some steps towards crowdsourcing (based on voluntary contributions).

The motivation for the research arose from the difficulties related to the availability and accessibility of high-frequency price data for econometric analysis of food price volatility (see Donmez and Magrini, 2013). In more general terms, timely and high-frequency (daily or weekly) food price data are useful for various purposes, including early warning systems related to the assessment of food security, improvement of market efficiency by reducing information asymmetries, and ex ante and ex post economic analysis to support evidence-based decision making. Especially in Africa, where the population mainly depends on agriculture for its livelihood and where poor households allocate more than 60% of their budgets to food (Lozano-Gracia and Young, 2014), the information on food prices is vital to help policy makers to make sound decisions. Although data from throughout Africa are already available, existing time series are often characterised by a lack of continuity (missing observations and data gaps), heterogeneity in geographical coverage, delays in or absence of dissemination, and lack of metadata.

Although the degree of transition towards smartphones and social networks is not uniform throughout the continent (between countries, and between urban and rural areas within countries), the potential for improvement through the use of new technologies and innovative methods in Africa cannot be ignored. This report questions the efficiency of such technologies and methods while testing crowdsourcing as a tool for making use of the 'wisdom of the crowd' (Surowiecki, 2004) and eventually reducing the cost of data collection. The experience with crowdsourcing reflects some challenging areas of work, such as data processing and quality, the incentives for and communication with data collectors (the 'crowd'), and the dissemination of data.

Food price data collection activities at the JRC were initiated by the launching of a pilot project in 2013 in three countries (Ethiopia, Kenya and Zambia). In 2014, the number of countries was extended to 20 through co-funding by the European Commission's Directorate-General for International Cooperation and Development (DG DEVCO), aiming to collect data for at least one urban and one rural market in each country for the duration of 1 year. A similar approach was implemented in an additional 33 African countries by the African Development Bank (AfDB). From mid-2015 the AfDB expanded and continued its price collection activity in 54 countries and about 150 markets until the end of 2016.

The outputs of this initiative have been publicly available from the very beginning on a user-friendly website (http://africafoodprices.io), where raw data (output dataset) as well as lists of markets and food items and infographics on country profiles and rankings are depicted.

The report is organised as follows. Section 2 describes the project background and methodology. Section 3 introduces the metadata (i.e. commodities and market locations) used throughout the price collection study. Section 4 describes the implementation of the data collection, the network of collectors, the validation processes and the dissemination tool. Section 5 first combines the data quality framework from the

European Statistical System (ESS) with the results of measuring several aspects of data quality on the collected prices. Then it evaluates the price collection according to several success criteria of innovative solutions (Robinson and Obrecht, 2016) and provides an overall assessment. Section 6 describes steps taken towards crowdsourced data collection based on contributions from multiple individuals ('crowd') per point with no contractual relationship. We conclude with directions for future research and outline the necessary conditions for collection methods using new information and communication technologies (ICTs), i.e. mobile phones, and the participation of citizens to promote complementary systems for improving food price information and the picture of related food security in Africa in terms of data frequency and spatial coverage.

2 Background and methodological approach

In 2013, the JRC initiated the pilot Africa Food Price Volatility (AFPV) project to investigate methods of timely and high frequency food price data collection for running volatility analysis on market prices across African countries. The aim was to collect weekly market price data on selected staple agricultural commodities in three countries: Ethiopia, Kenya and Zambia. In each country, the largest urban commodity market place and one typical rural commodity market were selected. The data collection in the capital cities was from the largest market or one of the largest markets in each city. The JRC contracted the private company Knoema to collect the food price data and create the platform to both collect and disseminate them.

The AFPV project ran its continuous data collection for 6 months. The time dedicated to the project was certainly not long enough to test the overall data collection activity, but it was long enough to build and test the web-based tool created for data entry and dissemination.

Following the AFPV project, the JRC and the AfDB's Statistics Department, in partnership with Knoema, enlarged the geographical scope of this initiative. The new project, called the Africa Food Prices Collection (AFPC), began in mid-2014 and aimed to collect weekly price data for various agricultural products and non-agricultural items at both rural and urban markets in 53 African countries, using modern technologies and methodologies as well as testing crowdsourcing techniques. In addition to the expansion in the geographical scope, the methodology and the tools utilised were improved. Rather than using only personal computers, as the AFPV had, mobile phones as an important daily tool were considered the most appropriate vehicle to get access to information. In fact, the majority of internet users in Africa are mobile-based smartphone and feature phone users (ITU, 2015). The data collector network consisted of citizens (professionals or amateurs) who were recruited and hired for the project. The collectors were trained and monitored by assigned experts. The data collected during the AFPV and AFPC projects was compiled into a comprehensive and up-to-date market price database which can be accessed online and free of charge.

These data collection exercises did not seek to capture detailed individual and household characteristics or any institutional or higher level economic, social, demographic, geographical (including climatic and environmental), political and other such factors. Instead, it was focused mainly on the collection of high-frequency (weekly) food market price data. Key protein, mineral and vitamin sources were selected in particular, covering staple food items such as cereals, meat, fish, vegetables, oils, fruits and dairy products listed on the International Comparison Program (ICP) product list. Note that not all ICP products were involved; only prices of some products from the ICP product list were collected. The prices of some non-agricultural items (petrol, diesel and cooking gas) were also collected to cover factors which potentially have an impact on food market prices.

Starting in 2015 and for 3 months, the AFPC project also hosted a pilot of crowdsourcing in which the tasks were performed through collective intelligence and outsourced to individuals who are motivated and capable of providing a set of required information without being officially hired in a traditional business model (Surowiecki, 2004; Howe, 2006; Brabham, 2008, 2010 and 2012). The form of business is not traditional, since in crowdsourcing the 'crowd' is created through an open call to an undefined and generally large group of people with a promise of a reward for successful completion of a task. There is already a vast variety of tasks associated with crowdsourcing, including creation of content as well as prioritising it (e.g. Wikipedia and Dell IdeaStorm); collection of ideas for a new product or output as well as collection of feedback about an already existing one for any potential improvement (e.g. Amazon Mechanical Turk, InnoCentive, LEGO Design byME, the European Space Agency's AstroDrone, Google Translate); gathering physical observations (e.g. OpenStreetMap, Google Traffic, UNOSAT GeoTag-X, NASA Image Detective, Planet Hunters, The Milky Way Project); and gathering

opinions related to real events (e.g. avaaz, change.org, Twitter). Overall, compiling information is the core activity to produce an output for most of those crowdsourcing tasks but, as a task itself, data collection is just one type and this paper focuses on that.

In addition to the characterisation of tasks, the definition of the 'crowd' itself requires special attention. Estellés-Arolas and González-Ladrón-de-Guevara (2012) summarise various definitions existing in the crowdsourcing literature around the following characteristics of the crowd:

> (i) It is a group of individuals with varying level of individual knowledge, group heterogeneity and number. These characteristics will be determined by the requirements of the crowdsourcing initiative.
> (ii) The crowd participates through contributing the members' work, money, knowledge and/or experience.
> (iii) Crowdsourcing always entails mutual benefit whereby the crowd receives a reward and the crowdsourcer/job creator receives a specific desired output.
> (iv) The participation of the crowd is online.
> (v) The job is publicised through an open call.

At different stages of the AFPC project, various techniques were tested in order to satisfy the conditions listed in (i)-(v) but they were not fully achieved at the end. To create the requirement related to open calls in (v), Facebook and the project website were extensively used. However, not enough people responded to the calls, which resulted in the failure of (i) and (ii). The mutual benefit model was experimented with by giving different forms of rewards to the crowd: satisfaction of given types of need, which were mainly economic (including free minutes or text messages for mobile phones), social recognition, self-esteem and development of individual skills (Estellés-Arolas and González-Ladrón-de-Guevara, 2012). For the job creator, on the other hand, the benefit was to receive large quantities of high-quality data in a sustainable manner. However, soliciting the contributions of the crowd requires careful analysis to reach appropriate levels of data quality. Unlike paper survey studies, which have been tested numerous times, this new method using applications on modern technological instruments (tablets, personal digital assistants, mobile phones) has only recently started to be utilised. Hence, the quality of the outcome of crowdsourcing is still being questioned (see Kleeman et al., 2008; Ipeirotis and Horton, 2011). The AFPC experience with crowdsourcing also raised similar questions, and finding definite answers still requires additional work.

To conclude, starting with the AFPV project and continuing with the AFPC project, the JRC in cooperation with the AfDB and Knoema investigated the use of new technologies and innovative collection methods through citizens' contributions to collect and disseminate timely and high-frequency data about food prices. Different aspects of the definition of crowdsourcing were tested but the implementation of the full concept was not achieved and this raised further methodological questions.

3 Description of metadata

3.1 Commodities

3.1.1 List of commodities

The selection of the food commodities was based on the ICP product list and included items such as staple grains and other staple foods, as well as various fuels. The ICP uses product list uses structured product description (SPD) forms. Each SPD usually contains the header, product name and type of business, quantity and packaging, origin, availability, product characteristics, brand, other item features and observations.

The product list (**Table 1**) for the AFPC project was prepared using the product list of the ICP-Africa (AfDB, 2014). This ensured that products were comparable and representative of patterns of national expenditure, and it accounted for the characteristics that affect prices, such as outlet type, unit of measure, quality, etc. Drawing up the list for the project started with the 332 food products of the 2011 ICP-Africa product list and the 27 basic headings (BHs). For each product the number of countries that indicated that the product was important (representative) was established and within each country the BH weights (%) were computed according to the food expenditure weight. Within each BH the products were then selected according to representativeness (number of countries which considered the product important) (AfDB, 2014).

The most recent version of the product list is always available at http://africafoodprices.io/product-list.

The selected products comply with the representativeness and comparability requirements of the ICP, but, because the number of products to be selected was small (25), BHs with small weights in household consumption were not included in the list. The AfDB stressed that, as the computation of purchasing power parity (PPP) requires having at least three products per BH, it would be necessary to increase the number of products to be collected. This would create better synergies with the Consumer Price Index (CPI) and would allow all BHs to be represented. Also cross-country and cross-regional comparisons are hampered by the fact that not enough products from the ICP list were included in the data collection.

3.1.2 Units of measurement

Data collectors could submit the commodity prices either in local currency or in US dollars. The default is set to local currency, but the collector can change it to dollars. In addition, a set of common units of measurement was defined for each commodity. For instance, three different units of measurement were defined for white rice: 500 g, 1 kg and 2 kg. The data collection platform automatically converted the information provided to a recommended base unit (highlighted in bold) for comparability purposes. The automated conversion minimises possible human error in calculations and, at the same time, allows users to easily compare and review food prices collected across different regions in a country or across multiple countries.

Table 1 shows the list of commodities and units covered by the AFPC project.

Table 1 List of commodities and units (recommended base unit in bold)

Commodity	Units
Legume and cereal products (7)	
Loaf of white bread	*100 g, 200 g, **450 g**, 700 g*
White rice, 25% broken	*500 g, **1 kg**, 2 kg*
Wheat flour	***1 kg**, 2.5 kg*
White maize flour	***1 kg**, 10 kg, 25 kg*
Maize grain	***1 kg***
Millet whole grain	***1 kg***
Sorghum white whole grain	500 g, **1 kg**
Animal products (7)	
Beef with bones	**1 kg**
Goat meat	**1 kg**
Whole chicken frozen	**1 kg**
Large chicken eggs	**Dozen**, 1.5 dozen
Pasteurised unskimmed milk	**500 ml**, 1 litre
Bream fish	**1 kg**
Nile perch	**1 kg**
Oils and fats (1)	
Vegetable oil	750 ml, **1 litre**
Fruits and vegetables (5)	
Onion	**1 kg**
Round tomato	**1 kg**
Green cabbage	**1 kg**
Sweet potatoes	**1 kg**
Spotted beans	**1 kg**
Key minerals/flavourings (2)	
White sugar	**1 kg**
Cooking salt	**1 kg**
Non-agricultural (3)	
Gas (regular, unleaded)	**1 litre**, 1 US gallon
Diesel	**1 litre**, 1 US gallon
Cooking gas (LPG cylinder)	**1 kg**, 1.25 kg, 2 kg, 5 kg, 6 kg, 9 kg, 12 kg, 12.5 kg, 19 kg, 25 kg, 48 kg

Source: http://africafoodprices.io/

3.2 Countries and market locations

Initially, in the scope of the JRC project, price data for key food commodities were collected for multiple market locations in 20 African countries. Table 2 lists the countries, and the numbers of data collectors, locations and markets in each country. Location is defined as the place (city/town/village) where the data collection took place. Within each location, prices were collected from various markets/stores depending upon the availability. For example, fuel prices were collected from the petrol pumps and cereal/vegetable prices were collected from the store/market within the same location.

During the course of the project, the geographical coverage was extended; the total number of countries covered increased to 53 through the cooperation with the AfDB (Figure 1). The number of data collection points was also increased in many countries to cover more markets. After the end of the JRC project in mid-2015, the AfDB expanded the collection to 54 countries with the inclusion of the Republic of the Congo.

Figure 1 Africa Food Price Collection website showing the most recent country coverage

Source: http://africafoodprices.io/
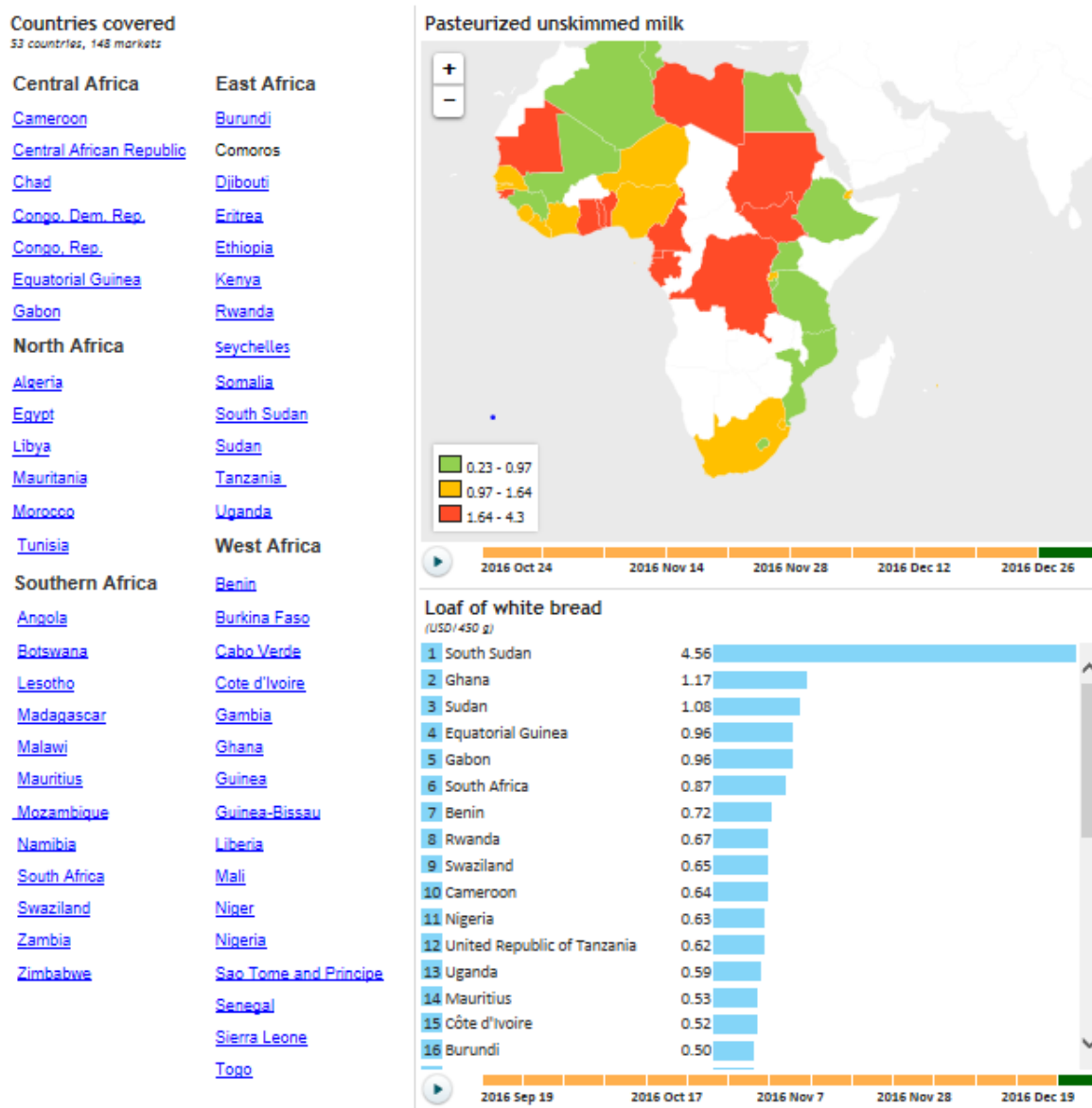
Table 2 Summary of locations, markets and data collectors in 20 countries under the scope of the AFPC project

No.	Country	Data collectors	Locations	Markets
1	Benin	1	2	4
2	Burkina Faso	2	6	19
3	Cape Verde	1	2	4
4	Côte d'Ivoire	1	2	4
5	Ethiopia	2	4	4
6	The Gambia	4	8	8
7	Ghana	1	10	4
8	Guinea (from Sep.	1	1	4

No.	Country	Data collectors	Locations	Markets
	2014)			
9	Guinea Bissau	1	2	4
10	Kenya	2	2	4
11	Liberia	2	4	4
12	Mali	1	2	2
13	Mauritania	2	4	6
14	Niger	1	2	4
15	Nigeria	1	2	9
16	Rwanda	1	2	7
17	Senegal	1	2	4
18	Sierra Leone	2	4	9
19	Togo	1	6	4
20	Zambia	5	3	8

In Annex 1, Table 15 provides a project market list with details on the markets and types of markets, including geo-location, by market location and country, while the most recent version of the market list is always available at http://africafoodprices.io/jsrpqg/market-list.

Finally, Figure 2 provides a complete overview of countries (53) and markets together with their distribution on the map.

Figure 2 Markets with data collection

Source: http://africafoodprices.io/
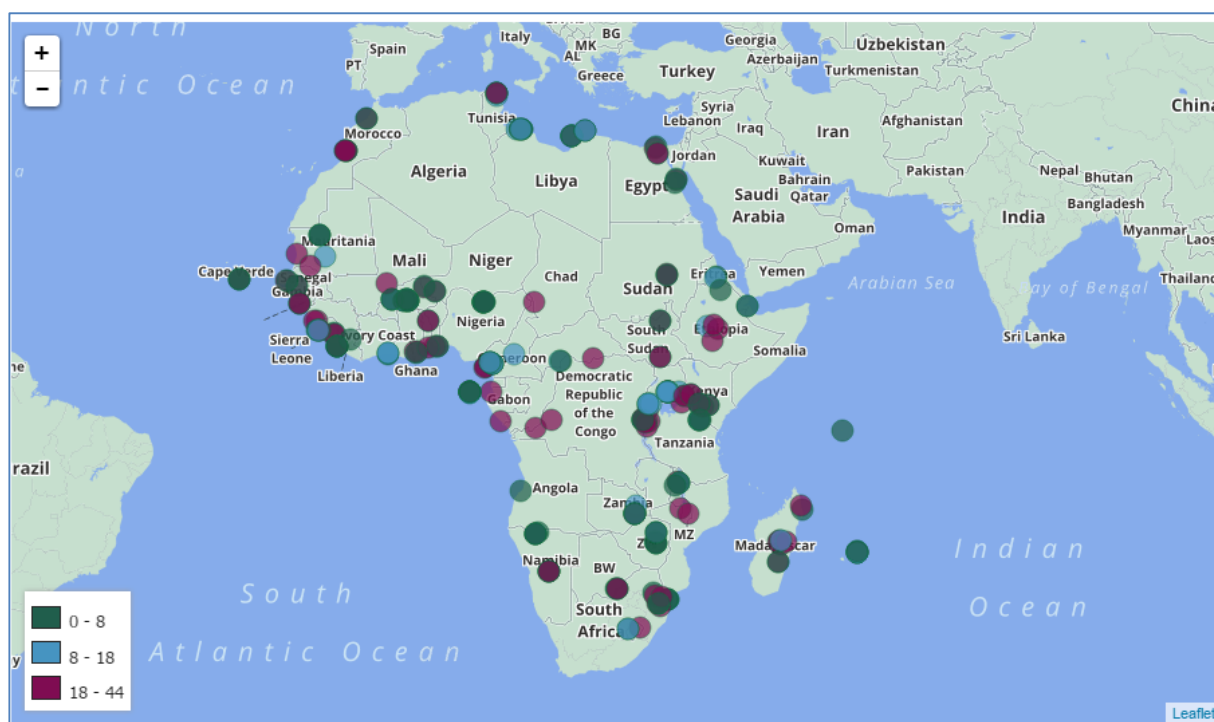
3.3 Type of price

All prices collected in this project are at market/consumer level. **Table 3** shows the distribution of the type of data collection point, i.e. type of markets by store or outlet type. These details were requested from the data collectors in order to have more details on the factors which can have an impact on reported prices. Below **Table 4** briefly explains each market type.

Table 3 Market classification by country

Country	Bakery	Butcher's shop	Fish market	Fuel station	Market	Mini market	Neighbourhood shop	Open market	Specialised store	Street vendors	Supermarket
Benin				2	2						
Burkina Faso	3	1	3	4	4	2	2				
Cape Verde				1	2				1		
Côte d'Ivoire				2	4						1
Ethiopia	2	2		2	5		2	1		1	1
The Gambia		1		2	5						
Ghana				2	2						
Guinea				2	2						
Guinea Bissau				2	2						
Kenya		3	3	20	5	1	1	2			20
Liberia			1	7	6						1
Mali				2	3						
Mauritania				2	4		1		1		
Niger				2	2						
Nigeria	1			2	1		1	1	1		2
Rwanda		1		2	2	1					1
Senegal				2	2						
Sierra Leone				22	11			6			6
Togo				1	2						1
Zambia		1		3	1				2		4

Table 4 Description of each market type

Market Type	Brief Description
Bakery	place/store that sells primarily bread, biscuits, etc.
Butcher shop	place/store that sells meats exclusively
Fish Market	place/store that sells only fishes
Fuel/Gas Station	Petrol Pumps/Gas station where fuels are getting sold
Market	Common market place where many retail sellers sells directly to consumers on their daily needs
Mini Market	Markets that are local to specific area within a city/ town
Neighborhood Shop	Next door small shop that sells few of daily needs
Open Market	set of shops established on road side
Specialized store	place/store that sells only specific items like; only grains,
Street Vendors	Individual sells on the street side
Supermarket	organized, branded stores that sells almost everything from grains to vegetables, meat, etc.
Wholesaler	small size wholesale seller, sells directly to retail customers as well

3.4 Time coverage and frequency

The AFPV project collected prices during 6 months in 2013. Subsequently, within the scope of the AFPC project, prices were collected between June 2014 and August 2015. From then, prices continued to be collected until December 2016 using the developed methodology in collaboration with the data company Knoema, with funding from the AfDB. Initially the price data were collected weekly on a fixed day of the week in each country; then flexibility to collect data at any time during the week was provided in order to address infrastructure challenges encountered (e.g. lack of access to internet or electrical power). Prices were disseminated within less than 1 week after the data collector's submission.

4 Implementing citizens' data collection, management and dissemination of contributions

This section describes the implementation of the data collection and validation/verification processes through a network of hired data collectors. First, it covers the establishment, training and moderation of the collector network. Second, it covers several issues related to quality maintenance. Challenges faced during the whole process are described, as well as the improvements implemented where possible. Finally the mobile-based application developed during the project and the dissemination tool are presented.

4.1 Building a network of data collectors

4.1.1 Establishing credibility and expanding data collector network

The data collectors were recruited and hired following different approaches. As detailed in the methodological section (Section 2), the AFPC initiative deviates from the concept of crowdsourcing in the strict sense, since the latter is based on an open call whereby the unknown 'crowd' participants are not hired but participate on a voluntary basis by bringing their work for mutual benefit in which the crowd receives a reward (monetary or not) and the crowdsourcer/job creator receives a specific desired output (Estellés-Arolas and González-Ladrón-de-Guevara, 2012). In the particular case of this project: (i) the hired participants were the local people and they worked as freelancer with Knoema for the project, and (ii) the participants were asked to choose a market and every week prices were collected from the same market/store.

The initial challenges faced by the project were about establishing a relationship and building confidence with data collectors. Many of the data collectors were worried about the project duration, payment mode, background of the company running the project, etc., before they decided to join the project. Most of the data collectors were looking for a longer duration/ongoing project to gain regular income.

The issue was addressed by keeping in touch with data collectors individually by email, telephone, social media or Skype to build confidence in the project and by sharing the project nature, scope, duration and portfolio of the team behind the project. Data collectors gained confidence in the project and the team when they started receiving their remuneration for the work done.

The initial network of data collectors was limited to a very few cities in Africa. The next challenge was to expand our data collector networks across all African countries, as planned in the complementary efforts of the JRC and AfDB projects. More challenges were encountered in building a data collector network in non-English-speaking countries and countries that are facing political or social conflicts or uncertainties.

Multiple alternatives were tried and some solutions worked really well to expand the data collector network across all African countries. We began with establishing contact by email with international non-profit organisations such as Global Integrity, which has local teams of researchers and journalists in each country, particularly in African countries. They were included in our data collector network and engaged on our project. Subsequently, data collectors were asked to refer their friends, colleagues or network of people living in other African countries and offered a referral bonus or incentive scheme to bring them on board. One such referral bonus scheme consisted in the referrer being paid USD 50 per data collector when a person referred by them joined the project and submitted data regularly for at least 4 weeks. There was no specific limit to the number of referees. It was open to get at least one collector per location and in three specific cities (Freetown, Kampala and Nairobi), there were more than 10 collectors. Furthermore, the project was advertised on the Knoema platform, in the expectation that people visiting the Knoema website would join our data collector networks; however, this did not work well because the number of visitors to the Knoema website

from African countries is low. Then we started tapping social media such as Facebook, Google+, LinkedIn, etc. and advertised the project. An example of the visual advertisement can be seen in **Figure 3**.

In addition, some people in our data collector networks are members of non-profit organisations such as the International Governance Institute, the Policy Analysis and Research Institute of Lesotho, Youth Advocacy Network Sierra Leone and Liberation Chocolates. Through those organisations we expanded our network of data collectors into other countries. For non-English-speaking countries, we hired some French-speaking people in Africa and also established a native-language communication channel to expand the network.

Figure 3 Example of Facebook advert

With these various approaches described above (solutions), we were able to create and expand data collector networks to further countries in the scope of the project. See Table 2 for more details.

Table 5 provides a summary of information of the data collector network by country.

Table 5 Africa data collector network summary

No.	Indicator	Number of countries	List of countries
1	No data collectors	1	Republic of Congo
2	Data collectors engaged for less than a month	1	Comoros
3	Data collectors engaged for less than a quarter	1	Somalia
4	Data collectors engaged for less than a year	23	Angola, Cape Verde, Chad, Equatorial Guinea, Guinea, São Tomé and Príncipe, South Sudan, etc.
5	Data collectors engaged for more than a year	26	Kenya, Zambia, Ethiopia, Tunisia, Senegal, etc.

No.	Indicator	Number of countries	List of countries
6	Largest data collector networks (more than 10 people)	6	Kenya, Uganda, Sierra Leone, Liberia, Mali, Mauritania
7	Data collectors with intermittent submissions/difficult to expand	5	Zimbabwe, The Gambia, Somalia, Cape Verde, Angola See section 4.1.3 Intermittent Submissions for details

4.1.2 Training data collectors

After data collectors were identified, they had to be trained to use our data collection and submission software. Training data collectors was a challenge, especially when they needed to be trained remotely.

We followed the approach of creating a test collection project in the tool and allowing collectors to make several trial submissions until they became familiar with the tool and the submission process. A data collector user manual with all details about the project and a step-by-step guide on how to use the software for data submission were prepared. Two moderators based in Bangalore, India, verified the test submissions and guided collectors by email, chat, Skype, etc. Once both moderator and data collector became comfortable with the submission process, collectors were enrolled in the actual (live) project for real data submission.

Some of the common mistakes made by data collectors during the training process are as follows:

- At the beginning, most collectors tend to submit data under the name of their country without the local market location available in the software. One example is that data collected from the city of Kampala are submitted against the country Uganda. The moderator strictly verifies the location in the submission received and trains the collectors to choose the relevant location. In addition, the data collection tool was enhanced to show the location by default to avoid this error.

- Data collectors tend to skip several items while submitting data. The moderator strictly verifies whether or not the collector entered the price of all possible items and, if not, trains the collectors to do so. In addition, the moderator collects the list of unavailable items in advance from the collector, to compare against the data submission. This is to verify that data are received for all available items. The data collection tool was also enhanced to alert the data collector before he or she made the submission.

- Data collectors enter the price as '0' if they do not find the item in their local market. The moderator verifies the prices that are submitted '0' and trains data collectors to leave the price blank if items are not available in their local market.

4.1.3 Challenges of building a network

Several **infrastructure challenges** such as lack of internet availability or electrical power interruption hindered timely data submission. Many of the data collectors were collecting the data any time between Friday and Sunday and, if any internet or power interruption happened, it caused a delay in reporting data. Data collectors tended to skip or forget to make their submission.

Although the infrastructure issues could not be resolved, flexibility to collect data any time during the week was provided. Furthermore, a new feature has been introduced in the system to record collection date in addition to submission date. Submission date signifies the date of reporting and collection date signifies the actual date of collection.

In some countries, **intermittent data submissions** were due to the nature of data collectors' jobs, infrastructure challenges, unrest, etc. Some collectors travel a lot both within and outside the country because of their jobs, and in such periods intermittent submissions were common (**Table 6**).

In those countries (e.g. Cape Verde), we tried to use two collectors for the same location; but we continue to face difficulties in establishing collector networks in some places. In most cases, if a collector failed to submit data for more than two consecutive weeks, we looked for other collectors and dropped data collectors who were not consistent in submitting their data regularly.

Table 6 Examples of intermittent submissions/dropouts

Country	Reason for intermittent submissions/dropouts
Zimbabwe	Data collector is a software developer and makes his living from a full-time job. Hence, he did not collect data regularly.
The Gambia	Data collector faced several problems in receiving remittances in his bank account and could not get them resolved. Finally he gave up.
Cape Verde	Data collector is an entrepreneur and often travels to other parts of the country. Hence, she was not consistent in submitting data. After 8 months, she decided to withdraw herself.
Somalia	Data collector stopped responding after he got his first remuneration. Later, he declared that he was busy in other project work and did not want to continue with the project.
Angola	Data collector claimed that she lives far away from the store/market and she cannot go every week to collect prices.

About half of the 53 African countries are not English speaking, and data collectors had difficulty in understanding the product names in English and also in communicating with the moderator, who could not speak other languages.

The issue was addressed by implementing **multi-lingual support** to the system. Now, the data network supports nine languages, including French, Portuguese and Arabic.

Several African countries continue to face **various political or social uncertainties** and it has been challenging to establish data collector networks there. Among these countries are Libya, Eritrea and Somalia. Recently, the unrest in Burundi has affected data collection. The Ebola situation in Sierra Leone also hampered data collection for some time.

There was no other solution to these challenges than waiting for the situation to return to normal.

4.1.4 Paying the contributors

Making payments to the data collectors presented multiple challenges, including the following:

- No single payment solution is available or works across Africa.

- Collectors wanted to get paid by different payment modes such as Western Union, MoneyGram, PayPal, cash or bank transfer.
- PayPal was not available in most African countries.
- Data collectors did not often have their own bank account.

As there is no single payment solution that works for the whole of Africa, and payment by specific transfer agencies has its own challenges for both the data collectors and Knoema, most of the data collectors were paid by bank transfer, also known as wire transfer, even though the cost of wire transfer is higher than other payment modes. For collectors who did not have their own bank account, money was transferred to the account of a friend or family member, according to their choice. After the wire transfer was made, details were sent to collectors for their reference.

Besides the cost of wire transfers, many of the African banks often change their intermediaries, which leads to many wire transfer failures. We continued to look for a better universal payment option that may ease payment processing without failure across Africa. Such options as mobile money transfer by Vodafone M-Pesa, MTN Mobile Money, Airtel-Money, etc. could be explored further and may help to resolve the issue.

Some collectors wanted to be compensated for the **cost of transport** that they would incur while visiting the market or store if they are far away. Similar concerns were raised when we asked people to collect data from rural locations.

The concerns were addressed by allowing data collectors to choose a market or store close to their residence or office so that they did not need to spend any additional cost on transport and it also helped to obtain a consistent series of data every week. For the rural locations, we identified data collectors belonging to rural communities. In some rural locations, we could not recruit any data collector. In such cases, we advised our data collector located in an urban area to collect the prices over the phone using their friends or network of people residing in the rural location and submit them to the system.

The **compensation method** that we adopted is that collectors are paid according to the number of submissions that they make in a month. The amount paid for each submission varied by country/collector and it ranged between USD 15 – USD 30 per submission. We introduced manual tracking of price submission and payment made, using an Excel workbook, which in some cases led to confusion and required efforts to clarify with data collectors.

Later, the complete manual process of tracking compensation was replaced by an automated online balance tracking and payment-recording system. With the help of this system, data collectors see their compensation and payment details online. **Figure 4** is a screenshot of the online billing system.

Figure 4 Screenshot of billing system

Source: http://knoema.com/billing
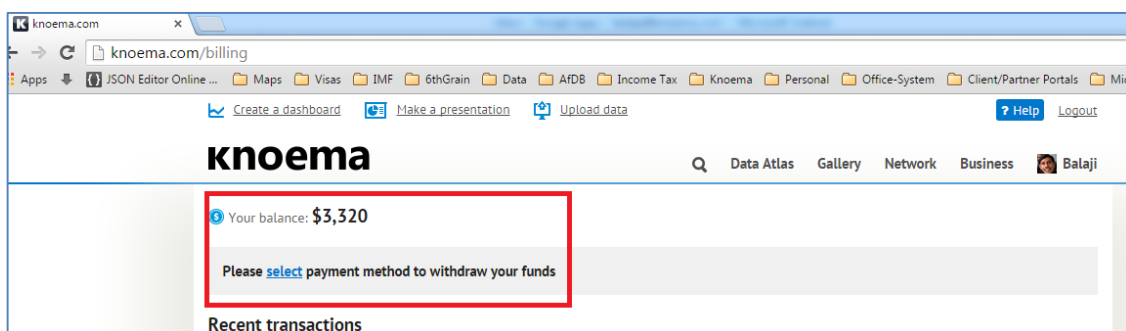
4.2 Maintaining data quality

4.2.1 Definitions of food items

The list of food items initially provided to data collectors was defined broadly. For example, the list contained an item called 'round tomatoes'. There are many different varieties, types, sizes and qualities of round tomatoes available in the markets across Africa and even in each single market. Prices for the same product may therefore differ significantly and there were no clear instructions provided to data collectors about what price to pick and submit to the system.

This issue was discussed extensively during an expert meeting in Tunis (August 2014) and it was agreed that the ICP team within the AfDB, together with the JRC, would come up with more precise definitions of food items for the data collection. Those definitions should be based on the ICP product list and include descriptions of commodities as well as sample images which data collectors should use to identify specific varieties of food items. Such a catalog could not be implemented in the scope of the present project.

Also, a quick survey was conducted with data collectors to better understand the availability of commodities at their local market. The results can be analysed further to adjust the commodity list. The survey form is in Annex 2 and data collectors can fill it in online   at https://docs.google.com/a/knoema.com/forms/d/1E2Ya8ppnm6v7PkXedyuYm5pDP9iSig MNFrO01x64uNI/viewform.

4.2.2 Price variations and fluctuations within a single market/location

It is very common for the price for a specific food item to vary even within a single market or location, depending on its quality, its freshness, the location of the stand in the market, the seller, the type of market, etc. There are no clear instructions provided to data collectors how to handle such situations and therefore on how to decide on the final price to submit to the system on their own.

This issue was discussed in follow-up conversations after live data collection sessions; however, so far it has not been possible to come to a conclusion on how to handle it. Several possible options were proposed. Ideally, data collectors would submit not only the prices for the given commodities, but all the price points noticed during each data collection session. Having all this information in the system, we can decide how to aggregate it to come up with a single market price or, alternatively, to provide price ranges, instead of time series of weekly aggregated prices, in the output dataset. It was agreed that data collectors would at this stage enter their best estimate of the average price for each commodity in each location or market, knowing that this might have strong data quality implications.

Furthermore, the data collection software was improved to monitor the price fluctuation over time and provide a visual alert to both data collector and moderator if the price fluctuates more than 30% above or below the previous week's (Figure 5). In addition, it forces the data collector to provide in writing one or more reasons for the price variation. Collectors can submit data only after providing reasons for all such price fluctuations. Moderators can also raise or exchange queries with collectors in such cases and can decide whether to accept or reject the data. Below screenshot (**Figure 5**) depicts one such incident.

Figure 5 Submissions with large price fluctuations

4.2.3 Flat prices

It was noticed that some data collectors kept submitting the same price for some food items for a relatively long period. On the one hand, it could be a valid price submitted simply because the price for the commodity is stable or regulated by authorities. On the other hand, it may be because the data collector is not really going to the market and is submitting a fake price.

Based on our experience, it is very uncommon for prices to remain stable for longer than 6 weeks. Therefore, it was decided to put additional checks (**Figure 6**) on data collectors submitting stable prices for 6 weeks or longer and get valid reasons for such observations. The additional checks are as follows:

- The moderator verifies the current week's price against the previous average price shown in the tool. If the current week's price and previous average price are exactly the same, the moderator asks the collector for clarification.

- Data collectors are specifically instructed not to ignore decimal places in the price. Typically, they tend to ignore the decimals and submit only the whole number.

- The moderator does spot checks on the price trend by using the Food Price Variation Monitor dashboard available on the Knoema website (http://knoema.com/vmdgged/food-price-variation-monitor).

Figure 6 Data submission review screen
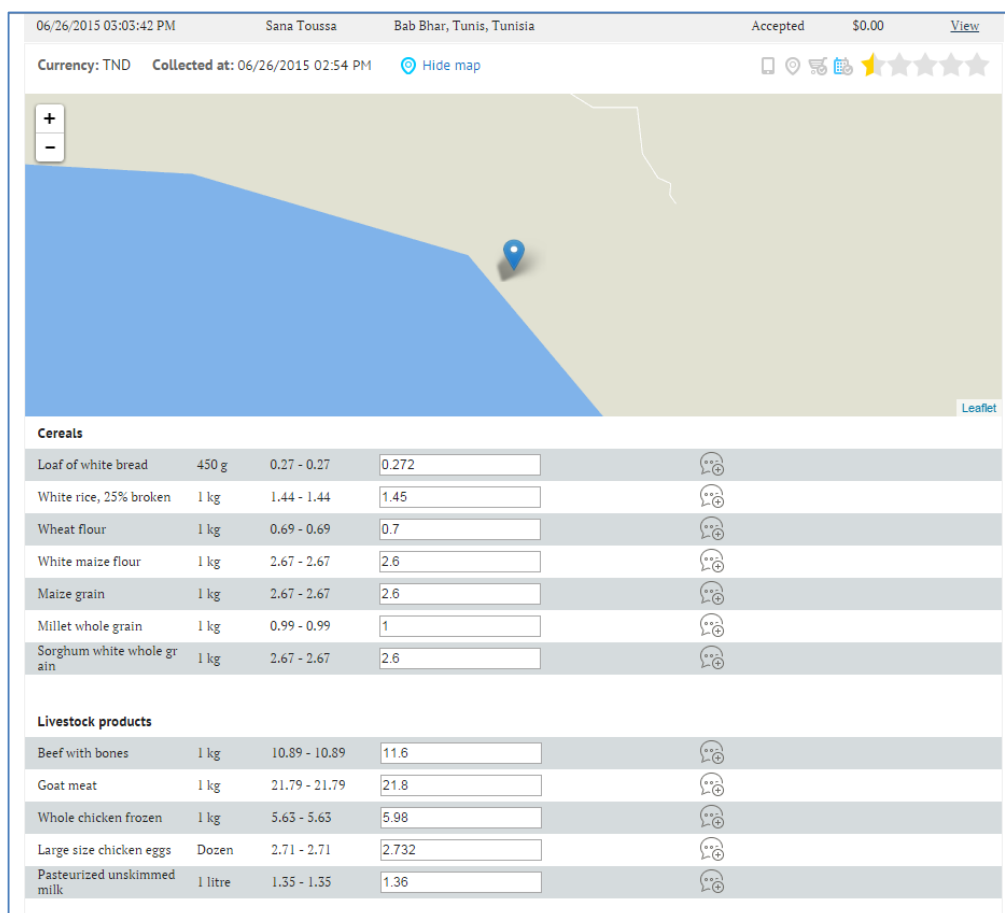
4.2.4 Local currency conversion to US dollars

All collected data in the output dataset are provided both in the local currency and in US dollars so that we can do cross-country price comparisons. Since most prices are collected in the local currency, the exchange rates published by XE (http://xe.com) were used to convert them to US dollars. In some countries, such as Somalia, there is a huge difference between official exchange rates and 'black market' exchange rates. Therefore, for some countries prices in US dollars may not reflect the real market situation.

4.3 Data collection through the mobile application

During the AFPC project, it was decided to develop a mobile version of the data collection tool to enable more people to participate in the project (bearing in mind the need to build a crowd) and minimise the period between the time of the data entry and the time when the data become available to use. Since it also lessens the number of steps to insert the data into the system (by not using paper-based entries), mobile phone applications were expected to help minimise bias in data entry.

The mobile application for Android phones was developed to support real-time, on-the-ground data collection at the markets. It was tested between February and June 2015. Data collectors were guided in using the mobile app to collect and submit data. The main difference between the mobile application and the website for data submissions is that the mobile app captures exact GPS coordinates and collection time for each item of collected data and it is easy to use at the spot where data are collected. These additional metadata enable data moderators to perform deeper and more thoughtful checks of collected data. Certain behavioural patterns can be examined to confirm that submitted

data were collected from real markets. The normal weekly data collection exercise usually takes between 1 and 2 hours to complete by data collectors moving around the market area and collecting prices for different commodities. Having the precise GPS and timing information, data moderators look for patterns and ask additional questions of data collectors if needed.

A smartphone mobile app was introduced for data collection. It is easy to use and also helps to record the GPS coordinates while recording the price. **Figure 7** displays some screenshots of the application. The application is available at Google Play Store for everyone (free to download):

https://play.google.com/store/apps/details?id=com.knoema.collection&hl=en.

However, it was observed that Android smartphones were not affordable for the data collectors in almost all African countries. The price of an Android phone may be around USD 100-150 and many of the collectors would have preferred a subsidy to buy a mobile phone for the project. Instead of subsidising a smartphone for them, we came up with an incentive scheme for people who use the mobile app for data submission. With these additional incentives, data collectors could recover the cost of the smartphone over the period. We piloted this incentive schemes in three cities – Nairobi, Kenya; Kampala, Uganda; and Freetown, Sierra Leone – and take-up was low. A rating mechanism was intended to be introduced that would evaluate the performance of data collectors by various parameters such as regular submission, data submission using mobile app, data submission straight from the market location, and prompt and clear response to the queries raised by the moderator. That may help to identify the best data collectors of the month or quarter in the network and provide incentives that may help to increase the number of data collectors using smartphones.

Figure 7 Smartphone application workflow
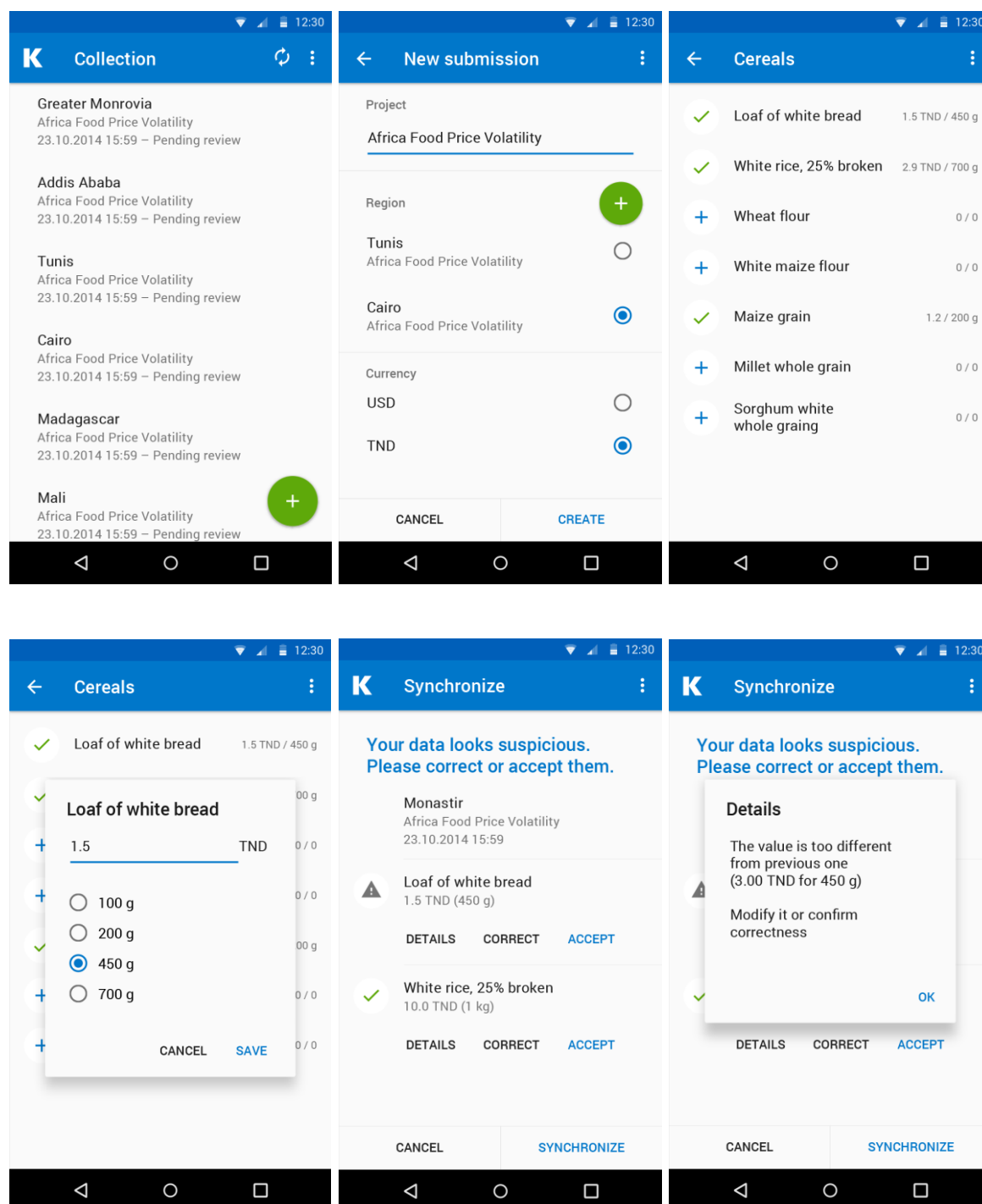
4.4 The dissemination tool

A new website was developed to disseminate information about the project and the data. It is open to the public. Users need to register to use the tool, but registration is free and is for the purpose of keeping records of usage. It is available at http://africafoodprices.io and provides the following information and data:

- project description and stakeholders
- geographical coverage of the project with the list of locations and markets grouped by country as well markets' GPS coordinates

- product list and set of common measurement units for each product
- output dataset with interactive access to data
- interactive dashboard that allows users to easily visualise and monitor price developments across countries, regions and commodities
- country profiles
- country rankings.

Figure 8 Website's dashboard page

Source: http://africafoodprices.io/
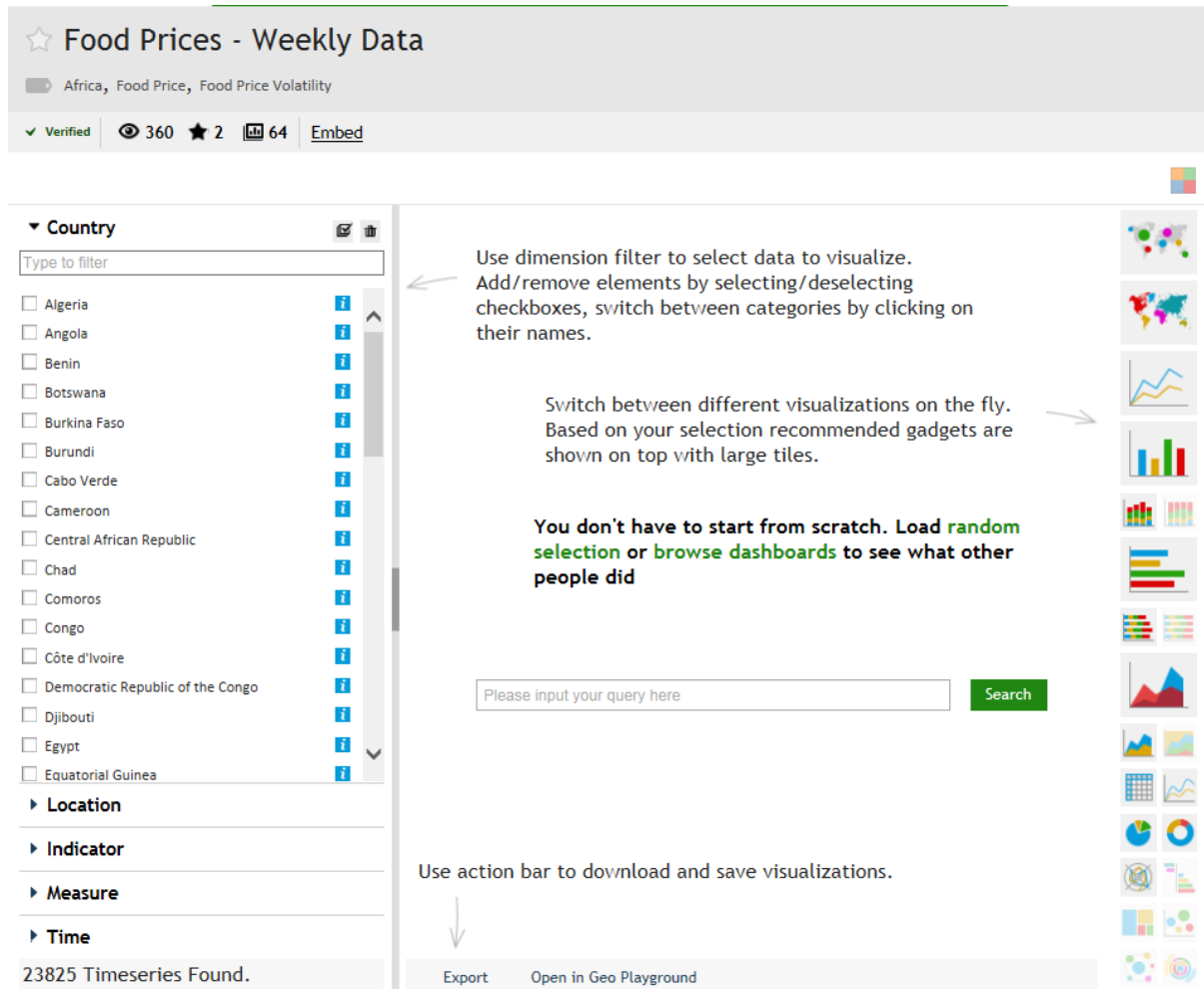
5 Description and assessment of data quality aspects and project outcome

Innovative methods and technologies for data collection, e.g. data from citizens' contributions, are increasingly being tested as means for obtaining up-to-date food prices even from regions that are remote and susceptible to food insecurity, where data are usually sparse. However, there are several concerns regarding the use of these data. The main problem relates to quality, a concern that can lead to these data not being used. Moreover, if used without taking into account the measurement of the reliability and accuracy of these datasets, they can lead to wrong analysis and poor decisions.

The quality of data is usually defined in terms of several dimensions. In particular, in the ESS, quality of statistics is assessed according to the following quality components or criteria: relevance, accuracy, timeliness, accessibility, comparability and coherence (Eurostat, 2003). In this section we first describe and analyse the quality components of the AFPC output dataset. Second, we also describe and analyse the AFPC solution in terms of the following three criteria (Robinson and Obrecht, 2016): experience and new knowledge generation; comparative improvement in effectiveness, quality, or efficiency over current approaches; and adoption of the solution. Finally, we provide an overall assessment of all criteria.

5.1 Data relevance

Relevance is the degree to which statistics meet current and potential user needs. The need for food price data disseminated regularly, frequently and in a timely manner, in near real time, is related to their use in food security analysis by enabling the monitoring of food price levels and trends, warning of areas potentially at risk of food insecurity and supporting evidence-based policy responses. Official food price statistics are typically available with a lag of several weeks and often focus on urban areas, leading to a lack of representation of small townsor rural areas (Beegle et al., 2016). Most indices, such as the CPI, are published with no detail at the level of food product or geographical location, attributes needed to identify areas of price-related food insecurity. Furthermore, timely access to food market price information is key for all users, including farmers, in their decision-making process. Finally, if this type of initiative collects data otherwise not available (e.g. prices in rural and remote areas), the potential for complementarity with public data is high. In fact, the urban bias in price collection for CPI calculation seems to be larger in African countries than elsewhere. Logistic difficulties and high costs associated with regular price collection in remote and rural areas, or the difficulties of including mobile vendors from street markets, are suggested by the literature as possible reasons for the lack of timely data from those areas (Gibson and Rozelle, 2005; Gaddis, 2016; Beegle et al., 2016). Innovative data collection methods, ICT tools and mobile phones can have the potential to overcome these challenges. In turn, several mechanisms have been identified through which mobile phones can provide economic benefits to both consumers and producers in sub-Saharan Africa (Aker and Mbiti, 2010). Those benefits are mainly related to improved access to and use of information, factors that may lead to reducing costs and increasing market efficiency, as well as improved connection and communication between actors and places, and access to services, such as agricultural, educational, financial and health services.

The AFPC prices allow the monitoring of price levels and trends for a basket of commodities in several locations (**Figure 9**). From the spatial perspective, cross-country comparisons and cross-regional comparisons within countries are possible (**Figure 10**).

Figure 9 Weekly prices for several food commodities (left) and average price by item (right) in Oromiya, Ethiopia

Source: http://africafoodprices.io/vxccckd/food-prices-weekly-data
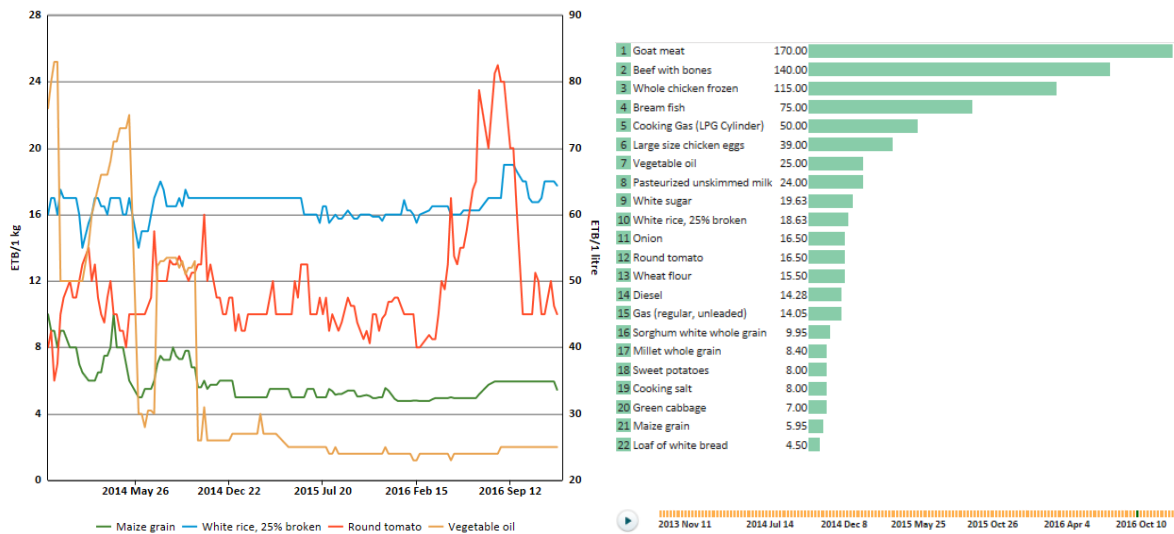
Figure 10 Prices for white rice, 25 % broken, in Nigerian regions (NGN) (left) and a selection of countries (USD) (right)

Source: http://africafoodprices.io/vxccckd/food-prices-weekly-data
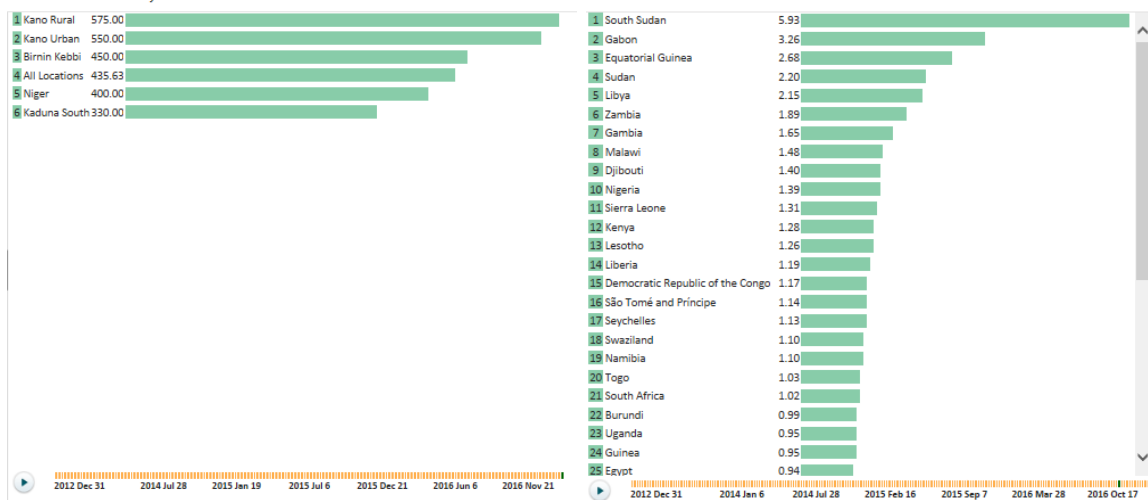
A drawback is that the AFPC initiative lacks clear defined final users and uses to which the dissemination tool(s) can be oriented. Also, with regard to the geographical coverage, one or two market locations per country might not be enough to provide information on price-related food security that can be complementary in coverage and time frequency to other traditional approaches to price data collection.

5.2 Timeliness

By timeliness we refer to the length of the time gap between the availability and actual collection of the food market price data. The prices collected by the AFPC project can be considered near-real-time data, as they were made available within less than 1 week from collection.

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5.3 Accuracy of contributed data

Accuracy is the degree to which the data match the phenomena they are designed to measure. We have measured three aspects of accuracy: the degree of completeness of data over time; how up-to-date the prices are; and how they compare with other price sources (Hamadeh et al., 2013; Blumenstock and Keleher, 2015; FSIN, 2015).

5.3.1 Time series completeness

To allow a proper assessment of price-related food insecurity issues (i.e. households' lack of access to food), prices must reflect current trends and be regularly available. The completeness of the data is evaluated by the number of non-missing data points, which is in turn reflected by the percentage of weekly price data reported for each food commodity and location over the total lifespan of the collection:

$$C_{ij} = \frac{\sum_{t=1}^{t=n}(Ind_{i,j,t})}{T}$$

where C_{ij} is the completeness index for commodity i and market j, $Ind_{i,j,t}$ is a count variable that takes the value 1 if there are data for commodity i in market j for time period t, and T is the total number of periods for which the data collection effort was made. When a series is complete (data for commodity i and market j available for all periods), C_{ij} takes a value of 1. When the series is incomplete, C_{ij} takes a value between 0 and 1. Data completeness is a necessary (but not sufficient) condition for accuracy and very important for adequate policy analysis.

For the purpose of the analysis we consider two different timespans: the duration of the AFPC project (June 2014 to August 2015) and the whole collection period starting with the AFPV project in 2013 and continued by the AfDB until the end of December 2016. We arbitrarily set a threshold to define a price series as complete at 0.7. We compute the completeness index for all commodity market/location pairs. Finally we count per country the number of price series with a completeness rate equal to or above 0.7 and the ones with a rate below 0.7.

Between June 2014 and August 2015, out of 4 176 identified price series or commodity/location pairs in 53 African countries (see section 3.2), 2 947 (71%) have a completeness rate above 70%. By the end of December 2016 and for the whole collection period, the number of commodity/location pairs increased to 6 522 through the expansion to new markets and one additional country (Congo) but also through the inclusion of price series related to markets from the AFPV collection exercise before June 2014 (in Ethiopia, Kenya and Zambia), some of which were then discontinued. Of them, 2 957 (45%) showed a completeness rate above 70%.

The upper panel (a) of Figure 11 depicts the number of price series and their completeness rates for 53 countries during the timespan of the AFPC project. The lower panel (b) shows the same picture for a total of 54 countries where data continued to be collected after the end of the AFPC project through the AfDB in partnership with Knoema.

At the top of the ranking during the period 2014-2015, Kenya has 225 price series or commodity/location pairs with a level of completeness above 70%. These price series include 25 food commodities from nine different markets or locations in the country. Next in the ranking come Sierra Leone with 144 commodity/location pairs (approximately six markets or locations) and Madagascar, Burundi and Uganda with approximately five markets or locations. Then six countries cover three or four market locations and 33 countries have about 50 commodity/location pairs per country, corresponding to two market locations. Achieving at least two markets per country was part of the project objectives. A further six countries cover 25 price series each (one market). Finally Zambia, Sudan and Nigeria have the lowest number of price series achieving 70% completeness.

Looking at the picture at the end of 2016, we see a slight increase in the number of commodity/location pairs with a level of completeness above 70%, partly due to the expansion to new markets but also to the improvement of completeness rates in existing markets. Some shifts between countries can be appreciated. For example, Sierra Leone reduced the market coverage from six to two markets while Nigeria increased from zero to four markets or locations with regular price submissions.

Several reasons explaining intermittent submissions are described in section 4.1.3.

Figure 11 Number of commodity/location pairs by country and degree of completeness, (a) 2014-2015 (above) and (b) 2013-2016 (below)
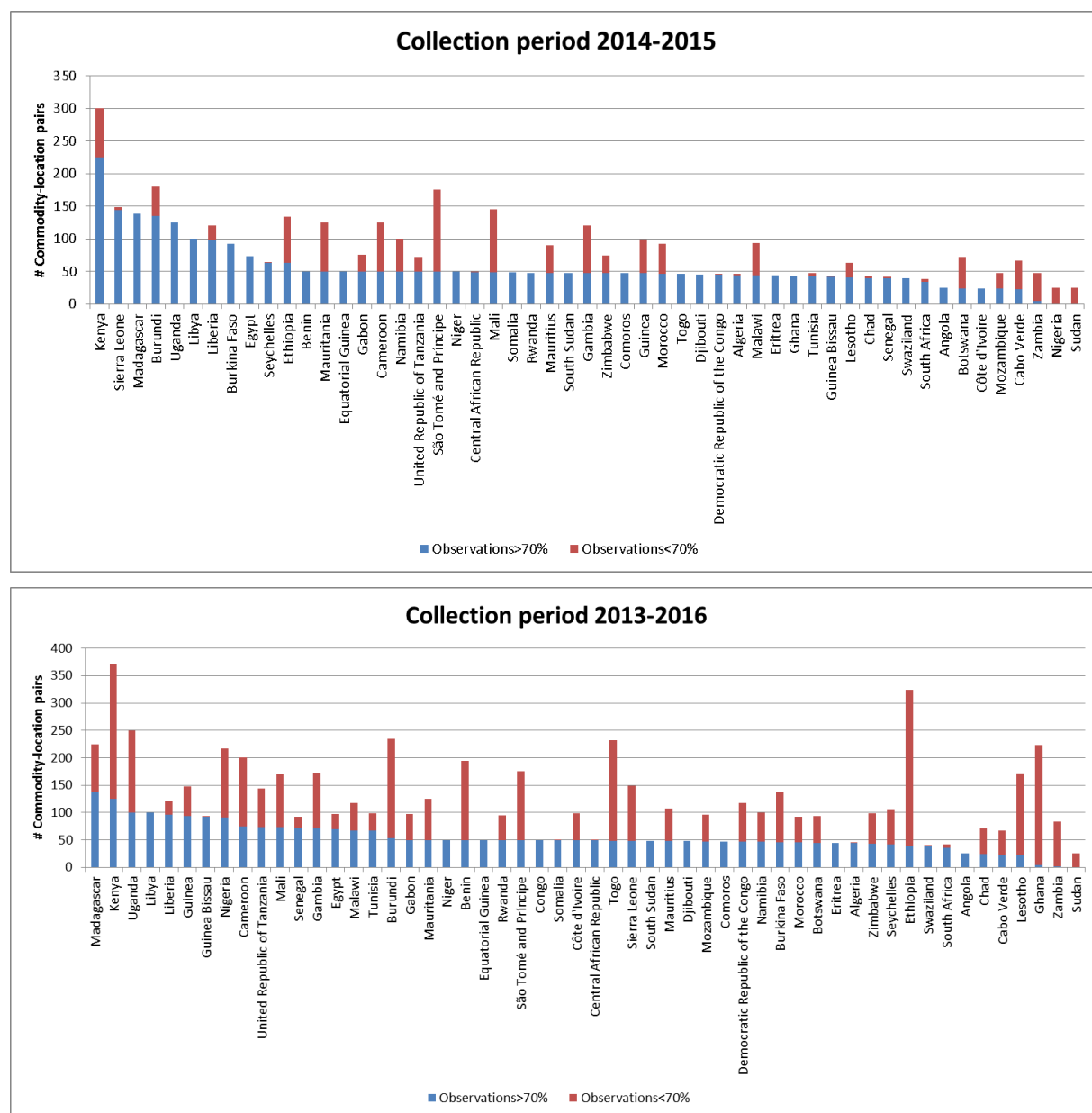
Note: Only series with at least one value are considered in the computation, to avoid taking series or commodity/location pairs that do not exist in the country

5.3.2 How up to date are the prices?

The percentage of price series updated in the previous week increased overall from 54% to 59% between December 2014 and August 2015. By the end of August 2016 the

percentage stood at 51% and at the end of the year it declined to 41%. For comparison purposes, FSIN (2015) calculated the percentages of data series updated in the previous month by the Global Information and Early Warning System of the Food and Agriculture Organization of the United Nations[1] (FAO GIEWS) and the UN World Food Programme's Vulnerability Analysis Mapping[2] (WFP VAM) as 75% and 51% respectively.

5.3.3 Comparison with other price sources

Here we aim to evaluate to what extent the data collected converge with a reference or benchmark dataset. This type of external evaluation approach is usually based on the calculation of quality measures that assess the discrepancies between the collected data and the 'true' data by comparing them with official national statistics, reference datasets or control data (Senaratne et al., 2017; Jonietz and Zipf, 2016).

Sources such as the WFP VAM and the FAO GIEWS publish monthly average wholesale and/or retail prices of several commodities for both national and several individual market locations (FSIN, 2015). The Regional Agricultural Trade Intelligence Network[3] (RATIN) publishes daily retail and wholesale price data from April 2012 onwards for the East African countries: Burundi, Kenya, Rwanda, Tanzania, Uganda, South Sudan and Malawi.

These data sources publish prices for most of the food items included in this project. However, comparability is difficult, as prices are published for multiple varieties of each commodity. One example is the monthly retail average price for rice, which is available for 35 different varieties in the WFP VAM database. Furthermore, for some commodities and locations only wholesale and not retail/market consumer prices are provided by the reference datasets. Moreover, for many market locations a benchmark is not available. Finally, the time dimension of the prices reported is not the same (i.e. daily, weekly, monthly) and further conversions need to be made, adding further sources of noise to the data besides quality.

Comparison of metadata

Table 7 describes the possible set of commodities for which AFPC prices can be compared with other sources.

Table 7 Commodity list mapping

AFPC project	FAO GIEWS	WFP VAM	RATIN
Legume and cereal products (7)			
Loaf of white bread	Bread (white), Bread, Bread (Brotchen), Bread (Vetkoek), Bread (loaf), Bread (Traditional), Bread (brown)	Bread	
White rice, 25% broken	Rice (short grain, imported), Rice (American), Rice (Belem), Rice (local), Rice, Rice (imported), Rice (basmati), Rice (long grain, imported), Rice	Rice (paddy), Rice (denikassia, imported), Rice (white, imported), Rice (imported), Rice, Rice (imported, Tanzanian), Rice (low quality,	Imported Rice, Rice, Kilombero Rice, Paddy Rice, Kahama Rice, Mbeya Rice, Morogoro Rice

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AFPC project	FAO GIEWS	WFP VAM	RATIN
	(paddy), Rice (milled)	local), Rice (high quality, local), Rice (local)	
Wheat flour	Wheat (flour, imported), Wheat (flour)	Wheat flour	
White maize flour	Maize (flour)		
Maize grain	Maize (imported), Maize, Maize (yellow), Maize (yellow, feedlot, imported), Maize (local), Maize (white), Maize (white, local)	Maize (white), Maize	Maize
Millet whole grain	Millet	Millet, Millet (white)	Millet
Sorghum white whole grain	Sorghum (Feterita), Sorghum (red), Sorghum (white)	Sorghum (white), Sorghum (taghalit), Sorghum (food aid), Sorghum (red), Sorghum	Sorghum
Animal products (7)			
Beef with bones	Beef meat	Meat (beef)	
Goat meat	Mutton meat		
Whole chicken frozen	Chicken meat		
Large chicken eggs		Eggs (white, AA)	
Pasteurised unskimmed milk	Milk	Milk (cow, pasteurised)	
	Milk (local, raw)	Milk	
Bream fish			
Nile perch			
		Fish (bonga)	
Oils and fats (1)			
Vegetable oil	Palm Oil, Soybean Oil	Oil (palm), Oil (vegetable, imported), Oil (vegetable), Oil (groundnut)	
Fruits and vegetables (5)			
Onion	Onions (dry)	Onions (local), Onions (imported), Onions	
Round tomato	Tomatoes	Tomatoes (greenhouse), Tomatoes	
Green cabbage	Cabbage (Chinese)	Cabbage	
Sweet potatoes	Potatoes (sweet), Potatoes	Sweet potatoes, Potatoes (Irish), Potatoes	

AFPC project	FAO GIEWS	WFP VAM	RATIN
Spotted beans	Beans	Beans (haricot), Beans (dry), Beans, Beans (red), Beans (white)	Mixed Beans, Yellow Beans, Red Beans, Beans
Key minerals/flavourings (2)			
White sugar	Sugar, Sugar (white)	Sugar	
Cooking salt		Salt	
Non-agricultural (3)			
Gas (regular, unleaded)		Fuel (petrol-gasoline)	
Diesel		Fuel (diesel)	
Cooking gas (LPG cylinder)			

Table 8 describes the possible set of market locations for which prices can be compared.

Table 8 Market-location list mapping

Country	AFPC project	FAO GIEWS	UN WFP	RATIN
Benin	Kétou, Plateau		Kétou	
	Tanguiéta, Atakora		Tanguiéta	
Burkina Faso	Dédougou, Mouhoun		Dedougou	
Burundi	Bujumbura Mairie	Bujumbura	Bujumbura	Bujumbura
	Gitega		Gitega	Gitega
	Ruyigi		Ruyigi	
Ethiopia	Addis Ketema, Addis Ababa	Addis Ababa	Addis Ababa	
	Adwa, Central Tigray		Adwa	
	Ambo, West Shewa		Ambo	
	Bahir Dar Special wereda, Amhara	Bahirdar	Baher Dar	
	Dire Dawa City Administration	Diredawa	Dire Dawa	
	Gambella Zuriya, Agnewak		Gambela	
	Jijiga-Wereda, Jijiga		Jijiga	
	Semen, Mekele Special wereda	Mekele	Mekele	
Ghana	Greater Accra	Accra	Accra	
Guinea	Conakry	Conakry		
Kenya	Kisumu West, Kisumu	Kisumu	Kisumu	Kisumu
	Mombasa, District, Mombasa	Mombasa	Mombasa	Mombasa
	Nairobi North, Nairobi (City)	Nairobi	Nairobi	Nairobi

Country	AFPC project	FAO GIEWS	UN WFP	RATIN
	Westlands, Nairobi (City)	Nairobi	Nairobi	Nairobi
	Nairobi West, Nairobi (City)	Nairobi	Nairobi	Nairobi
	Nairobi East, Nairobi (City)	Nairobi	Nairobi	Nairobi
Lesotho	Maseru	Maseru		
	Mokhotlong	Mokhotlong		
Liberia	Foya, Lofa		Foya	
	Voinjama, Lofa		Voinjama	
Malawi	Area 3, Lilongwe City	Lilongwe		
	TA Mtwalo, Mzimba	Mzimba		
	Katoto Ward, Mzuzu City	Mzuzu		
Mali	Kita, Kayes		Kita	
Mauritania	Boghé, Brakna		Boghé	
	Nouakchott-Ouest	Nouakchott	Nouakchott	
Mozambique	Cidade de Maputo, Cidade de Maputo (Mozambique)	Maputo		
Niger	Tera, Téra		Tera	
Sierra Leone	Bo Town, Bo	Bo	Bo	
	Wilberforce, Freetown	Freetown	Freetown	
	Kenema Town, Kenema	Kenema	Kenema	
South Sudan	Juba, Central Equatoria	Juba		Juba
	Malakal, Upper Nile		Malakal	
Sudan	El Hudeiba, Khartoum	Khartoum		
Swaziland	Siphofaneni, Lubombo	Lubombo		
	Manzini South, Manzini	Manzini		
Uganda	Kabale			Kabale
	Kampala	Kampala		Kampala
	Lira	Lira		Lira
	Mbale			Mbale
United Republic of Tanzania	Arusha District, Arusha	Arusha		Arusha
	Kinondoni, Dar es Salaam	Dar es Salaam		

Out of a total of 54 countries (AFPC and the AfDB expanded collection), prices can be compared for 20 countries, varying from one to three locations depending on the country. Furthermore, we encounter only 202 time series or commodity/location pairs

that can be potentially compared, covering the 20 countries, 48 locations, 14 food commodities and 2 energy items.

Further comparisons of commodity/location pairs could be made at a higher geographical aggregation level (e.g. province or state level).

Statistical comparison of price series

The WFP VAM, FAO GIEWS and RATIN published prices are helpful to compare and verify the prices gathered from the AFPC data collectors. To assess statistically how the AFPC-prices compare with the reference prices, we measure the accuracy or discrepancy through the computation of root mean square errors[4] (RMSEs) and Pearson correlation coefficients (Blumenstock and Keleher, 2015). The RMSE is a measure that delivers the result in the same unit as the original price series. The RMSE (price difference) as a percentage of the average reference price provides the relative differences and allows comparison across commodities, currencies and countries. In addition, we compute the price-to-price ratios and plot them by dividing the AFPC price by the reference price (dashed lines in Figures 12-15).

Table 9 summarises some figures resulting from the comparison.

Table 9 Results in terms of the number of price series

Indicator	AFPC	AFPC-FAO	AFPC-WFP	AFPC-RATIN
Total number of price series	6 522			
Number of matched price series (location and commodity group)[a]	202	68	127	67
% of total price series or of matched price series	3	34	63	33
Number of matched price series (location and specific commodity)[b]	202	82	142	112
% of total price series or of matched price series	3	41	70	55
of which:				
Number of positively correlated price series (> 0.5) at location and commodity group levels	48	21	34	6
% of matched price series	24	26	24	5
Number of price series with significant correlations	43	15	29	4
% of positively correlated price series	90	71	85	67
Number of price series with RMSE < 40 %	87	6	62	27
% of matched price series	43	7	44	24
Number of price series with average price-to-price ratio close to 1	74	3	52	25
% of matched price series	37	4	37	22

[a] The total AFPC series do not match the sum of the number of series coming from different reference datasets because some series overlap in location and commodities.

[b] The total AFPC series do not match the sum of the number of series coming from different reference datasets because some series overlap in location and commodities and the reference data provide multiple varieties for each commodity.

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[4] The RMSEs are computed as follows: $RMSE_{ij} = \sqrt{\frac{1}{k}\sum_1^k\left(p_{ref,k} - p_{afpc,k}\right)^2}$, where i is the commodity, j is the market location, k is the number of periods, $p_{ref,k}$ is the reference price in period k and $p_{afpc,k}$ is the AFPC price in period k.

Of the 202 time series that can be potentially compared (covering 20 countries), 48 seem to be well correlated (43 significantly positively correlated) with the reference, and 87 show low percentage RMSEs. In some cases the lack of significance might be related to the short length of the time series available for comparison.

Table 16 in Annex 3 shows the results of the comparison for a selection of prices series at the level of the reference specific commodity and price type (i.e. wholesale or retail) with correlations above 0.5 (*p*-values are provided and scores below 0.1, 0.05, and 0.01 indicate significant correlations at 10 %, 5 % and 1 % significance levels respectively).

Table 9 and Table 16 reflect several difficulties for the comparison. First, a benchmark is not available in most cases. In fact, out of 6 522 time series (i.e. commodity/location pairs), for 6 320 no information could be found in the selected reference datasets. This means that either the market location or the commodity, or both of them, is not covered by the reference datasets in the given time frame. Second, a potential reference dataset is available for a commodity in a given market location but the commodity specification or commodity variety is not the same. A third difficulty arises with respect to the price type. While the AFPC project collected market (consumer) prices, some reference data series provide only wholesale prices. There are some examples (Table 16) of well-correlated time series where price discrepancies are very high, for example maize retail prices in Greater Accra, Ghana, where the AFPC prices are between four and six times as high as the reference prices. This bring us to another difficulty: even if we can compare prices for the same town, village or province, different markets, outlets or types of outlets within the same location might offer very different prices.

Nevertheless it is important to note that, even if price series are not well correlated, it does not necessarily imply that the collected prices are wrong. There are several sources of price differences besides data quality, for example different outlets (e.g. supermarket versus street vendor), different commodity type (e.g. 'broken rice' versus 'imported rice'), quality or freshness, different area within the same location or different time/day of collection. Price variation between different outlet types is considered to be generally larger than within the same type of outlet (Eurostat-OECD, 2012). Different sampling frequencies are additional sources of noise.

As examples, Figures 12 to 14 describe the monthly average price comparison for two commodities in Nairobi (Kenya) – milk and bread – and rice in Conakry (Guinea). For the purpose of the comparison and visualisation the AFPC weekly reported prices are averaged into monthly prices.

Figure 12 Milk market prices in Nairobi East (above) and Westlands, Nairobi (below), Kenya (KES/litre)

Pasteur. milk market prices in Nairobi East, Kenya

Pasteur. milk market prices in Westlands, Nairobi, Kenya
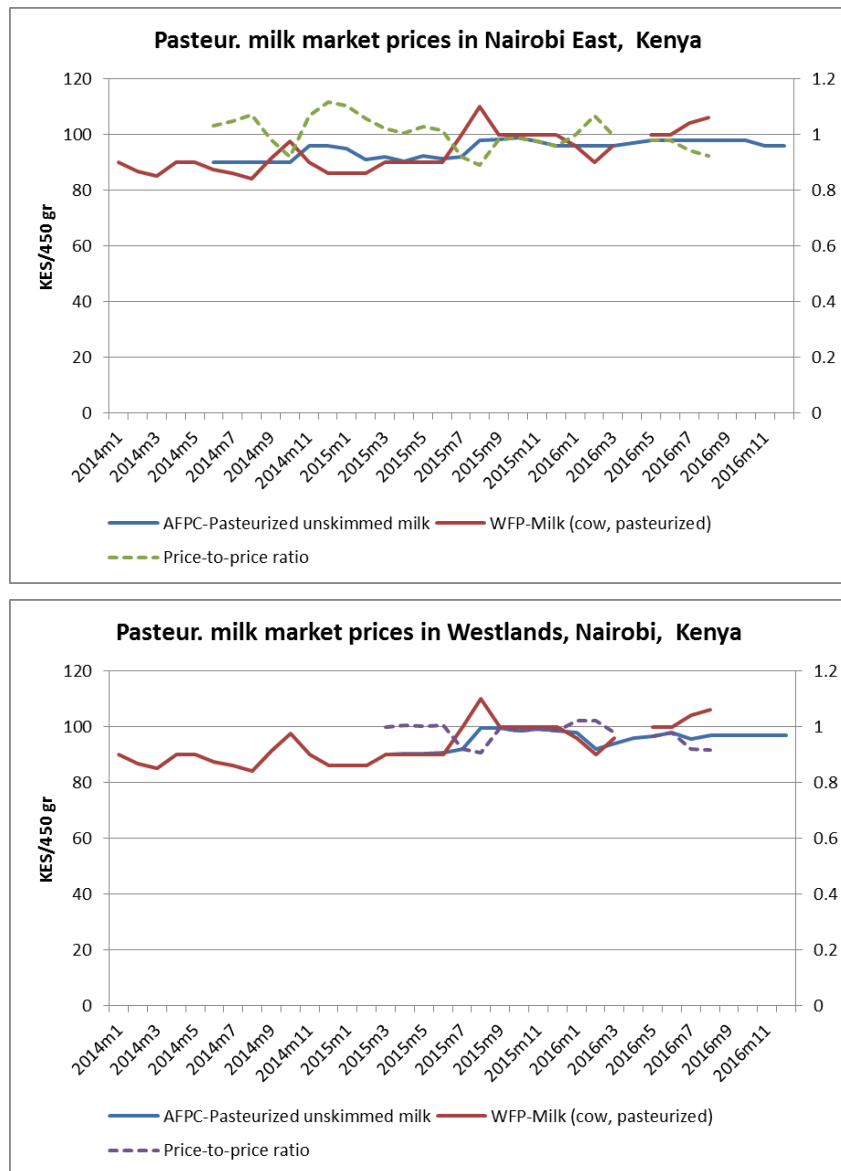
Observation of Figure 12 reveals the crucial difference of different sampling frequencies (weekly for the AFPC project versus monthly for the WFP), adding an additional source of noise to the data comparison besides quality.

Looking at the milk retail prices for Nairobi, Kenya, in two different areas of the capital (East and Westlands), the AFPC and WFP retail prices series have relatively high correlations (0.65 and 0.78) and low RMSEs (8 % and 5 %). In addition, the price-to-price ratios remain stable around 1. The indicators confirm the visualised similarities in value and trend, although a larger fluctuation can be observed in the WFP prices series that might be explained by, for example, a different sample of outlets/types of outlets or price collection in different areas within the same location. It is actually very common for the price for a specific food item to vary even within a single market location, depending on its quality, its freshness, the location of the stand in the market, the seller, the type of outlet, etc. (Eurostat-OECD, 2012). Differences in these characteristics can explain different levels of prices and variability between the AFPC prices and the reference ones.

Figure 13 Bread market prices in Nairobi East (above) and Westlands, Nairobi (below), Kenya (KES/450 g)
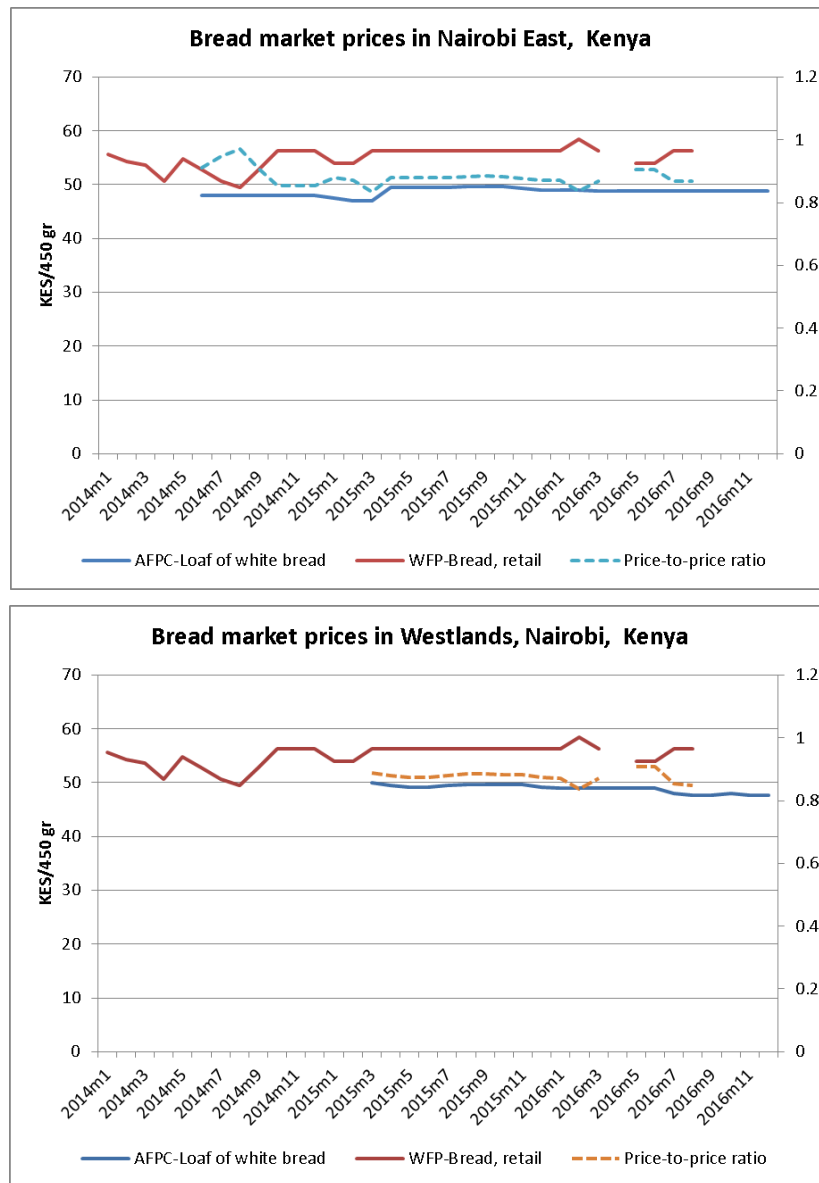
In the case of bread (**Figure 13**) price differences are relatively small, with RMSEs of 13 % in both cases and stable price ratios at about 0.8, indicating that AFPC prices are consistently below the reference. Besides the potential differences related to the area or outlet, this is an example of different commodity specifications – bread (WFP) versus loaf of white bread (AFPC) – and of potential price discrepancies caused by the difference in the units of measurement: 400 g/loaf (WFP) versus 450 g/loaf (AFPC). For comparison purposes the WFP prices for 400 g have been converted to prices per 450 g.

In the example below (Figure 14), average rice prices reported in Conakry, Guinea, by the AFPC collectors for white broken rice 25 % have since mid-2015 been approximately 1.5 (Rice, local) to 2.5 (Rice, imported) times as high as the FAO retail prices. Further details from the original AFPC price series, such as type of outlet or packaging units, could shed light on these differences.

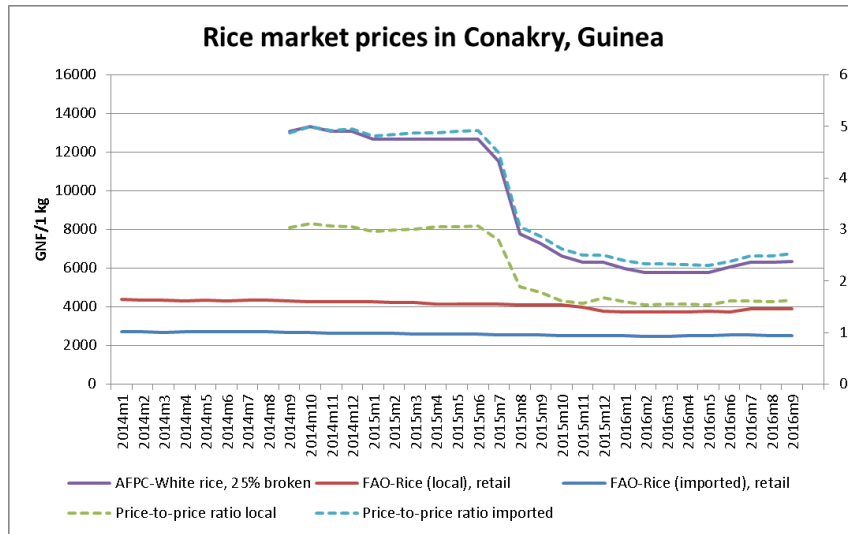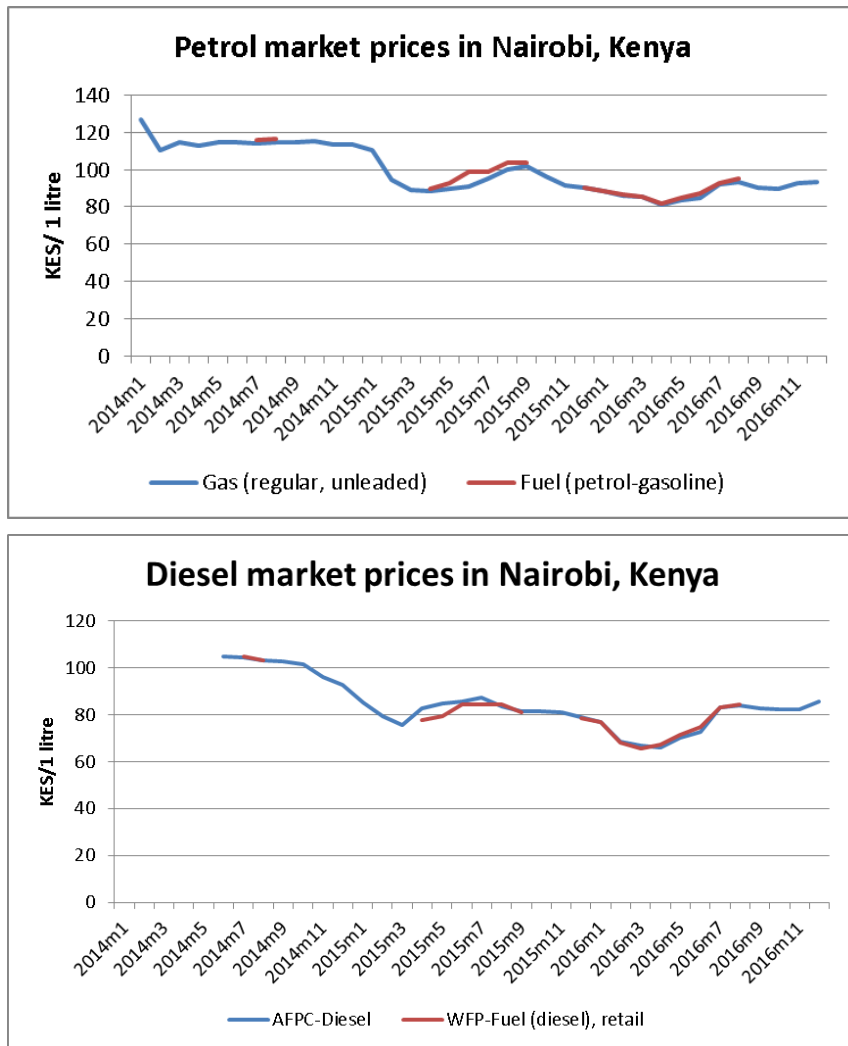**Figure 14** Rice market prices in Conakry, Guinea (GNF/kg)

Figure 15 Petrol (above) and diesel (below) prices in Nairobi, Kenya (KES/litre)

Looking at non-food commodities, **Figure 15** shows examples of high correlations and price convergence across different sources, probably driven by the fact that retail prices

of petroleum products are regulated by the government in Kenya so there is no price variability between different suppliers.

This section shows the difficulties in verifying prices by comparing them with external reference sources. All these difficulties raise the following questions: What are the right prices? Which is the most representative commodity variety, location, area or outlet/store? How can this information be extracted out of data collected through citizens' contributions and which intrinsic measures of quality can be defined? How can cross-regional and cross-country comparison be ensured?

In general, innovative initiatives in collecting prices establish different types of manual and automatic validation and verification processes (Zeug et al., 2017). To ensure accuracy and avoid price errors coming from outliers that can arise from human error or fraudulent behaviour, the AFPC established expert moderation and implemented several automatic controls that were built into the web and smartphone collection tools (e.g. alert for price variations above 30 % compared with previous week, or for prices not changing) (see section 4.2).

Nevertheless, a few observations per market can hardly capture the price variability among different types of outlets (e.g. supermarket versus street market) or different areas within the same market location. Crowdsourcing techniques (section 6), providing multiple price points for the same location, were tested as a potential solution but careful design of the collection and adequate aggregation rules is still required (see section 6). Further methodological work on crowdsourcing methods and methodologies to assess the intrinsic quality of those types of data collected through new technologies and the contributions of citizens (professional or not) is recommended.

5.4 Accessibility

A user-friendly open-source online platform was developed and prices were disseminated on a weekly basis. The potential needs of different type of users should be analysed to better define alternative means of dissemination.

5.5 Coherence and comparability

Coherence refers to the degree to which the same concepts, definitions, classifications and target populations and harmonised methods are used. Coherent outputs have the potential to be combined and compared. On the one hand, the use of the commodity list of the ICP enables the use of standard definitions of commodities and makes cross-country and cross-region commodity comparisons possible within the AFPC output dataset. On the other hand, there can be discrepancies between the standard commodities and what is actually available in local markets.

5.6 Project outcome

The APFC solution can be assessed in terms of its contribution to knowledge creation, comparative improvement over current approaches and degree of adoption (Robinson and Obrecht, 2016).

First, with regard to innovative methods and the use of web and mobile phone technologies for collecting price data in developing countries, the AFPC collection study is an example of new knowledge creation. A methodology for citizen data collectors has been developed, including a list of 25 food items comparable with the ICP list from the World Bank and a list of key markets. Challenges were identified during the process and solutions were documented and implemented where possible, enabling lessons to be learned for future endeavours. For example, different options for building and expanding the network of collectors were tested, such as social media, contacting local non-profit organisations and using native-language communication in non-English-speaking areas. Besides training, expert moderation and allowing trial submissions, the optimal solution to minimise possible human errors proved to be building in automatic features and alerts

in the tool (e.g. automatic unit conversion, multi-lingual platform, alerts for excessive price fluctuation or prices not changing over a period of 6 weeks). Different payment methods and a tracking and payment-recording system needed to be implemented to face several challenges, for example collectors with no bank account. Options such as mobile money transfer were suggested to be explored. Developing the mobile application and promoting its use allowed the recording of exact GPS coordinates and collection time, which moderators could use to perform improved checks including on the behavioural patterns of collectors. Introducing a rating mechanism that would evaluate the performance of data collectors by various parameters was considered but could not be implemented in the scope of the project. A well-functioning dissemination web tool was also developed and constituted a useful source of information (http://africafoodprices.io/).

Second, comparative improvement with regard to other approaches: In terms of effectiveness, despite the differences between countries and regions, the project offered a feasible method for weekly collection and timely dissemination of food price data. For most of the countries, prices for at least one or two market locations were regularly submitted and disseminated in a timely manner. When looking at the accuracy of the data, the main difficulty has to do with finding adequate benchmark datasets covering the same commodity varieties and market locations at the same sampling frequency. The price series from FAO GIEWS, WFP and RATIN offer some possibilities for comparison. Some selected examples reveal that, where the comparison is possible, the correlation of AFPC retail prices with retail prices from the benchmark for the same location and commodity is high. Nevertheless, discrepancies in prices do not necessarily imply that the data are wrong; different price levels and variability might have to do with different commodity varieties, different qualities, different samples of outlets and different areas within the same location. Other examples reveal differences that might be related to poor quality of data. In addition, different sampling frequencies add noise to the comparison besides quality. All of this points to the need to develop intrinsic measures of quality which can ensure the reliability of these types of datasets. Cost-efficiency aspects could be investigated by comparing the cost of traditional collection approaches with the method described here. Moreover, the impacts of different types of incentives on the costs and quality could be further investigated.

Thirdly, regarding innovation adoption, the AfDB further implemented the same collection approach and expanded it to new countries and markets, and the weekly collection and dissemination of prices was maintained until the end of 2016. Nevertheless, the ending of the collection reflects the fact that the long-term sustainability of these methods and their integration with other existing systems still remain a challenge.

5.7 Assessment summary

Table 10 summarises and assesses the different criteria considered and described in the previous sub-sections.

Table 10 Summary table of data quality aspects and the innovativeness of the project solution

Criteria	AFPC [b]	Assessment elements [a]
Quality aspects		
Relevance	++	+++ Price-related food security monitoring +++ Transparency in the value chain +++ Can support evidence-based decision and policy making - Final users and uses not clearly defined - Market coverage mainly limited to 1 or 2 markets per country
Timeliness	+++	+++ Dissemination in less than 1 week after

Criteria	AFPC [b]	Assessment elements[a]
		collection
Accuracy		
Completeness	++	+++ 8 countries with at least 4 markets with regular price submissions +++ 39 countries with coverage of 2 markets each + 4 countries with coverage of 1 market - 3 countries with no market covered
Up-to-dateness	++	++ 53% of time series updated weekly on average
Discrepancies	-	++ Validation/verification processes established through expert moderation and automatic alerts --- No intrinsic quality measure available ? External comparison possible for only 202 series, and some varieties different ? Price discrepancies may imply not wrong prices but different varieties, quality, freshness or area, or time of collection can lead to price differences besides data quality
Accessibility	++	+++ User-friendly open-source online platform - Other users' needs and tools not addressed (e.g. text messages)
Coherence	+	++ Commodity list of the ICP enables use of standard definitions of commodities and makes cross-country and cross-region commodity comparisons possible, but too few products selected from the list -- Standard commodities might be locally not available
Project outcome		
Knowledge generation	+++	+++ Methodology for citizen data collectors ++ Identification of challenges and implementation and documentation of solutions where possible
Comparative improvement	+	+++ Timely dissemination (less than 1 week) +++ Commodity- and location-level data +++ Open source --- Uncertainty regarding reliability and quality - Lack of cost-efficiency assessment
Adoption	+	+++ Implementation continued by the AfDB +++ Expansion to new markets and countries --- Collection ended in December 2016, highlighting need for integration with existing approaches (e.g. national statistical offices)
Overall[c]	+	

[a] Scale of measurement: +++ Excellent (5), ++ very good (4), + good (3), - fair (2), -- poor (1), ---bad (0)

[b] Following a conservative approach, the average scores are calculated on the basis that all assessment elements have the same weight.

[c] Following a conservative approach, the average score is calculated on the basis that all criteria have the same weight.

6 Steps towards crowdsourced data collection

Initially, the data company Knoema was focused on building data collector networks across African countries. At a minimum, at least one data collector for an urban location and one data collector for a rural location were identified and hired. In some countries, more data collectors could be recruited to increase geographical coverage within the country (Table 2). However, for certain locations, data were collected from only one market or store, so there is no other price observation available for comparison within the location.

In crowdsourcing, the tasks are directly outsourced to individuals, who are not required to be professional or hired data collectors as initially planned. The motivation structure is the key factor for making people supply input; i.e. enter data. Financial motivation constitutes only one type, since rewards can be of different kinds, including minutes or free text messages on a mobile phone. Unlike paper survey studies, which have been tested numerous times, this new technique with applications on modern technological instruments (mobile phones) has only recently started to be used. Therefore, crowdsourcing food prices still requires answers to some questions.

In this project, crowdsourcing supplied multiple data points for the same location by allowing many people to collect data from different markets or stores within the same location. We shortlisted five locations based on the presence of data collectors to test having many collectors collecting prices from multiple markets in each location, i.e. establishing crowdsourced data collection within a city. Such crowdsourced collection was tried in five locations: Nairobi, Kenya; Kampala, Uganda; Freetown, Sierra Leone; Windhoek, Namibia; and Gaborone, Botswana.

6.1 Building the crowd and collection

6.1.1 Establishing crowdsourced data collectors within the same city

As expected, establishing crowdsourced data collectors within a city is challenging, especially finding collectors across various parts of the cities to obtain good geographical coverage within the city.

We tried different alternatives that include reaching existing contacts who were not already active in the current project, taking referrals from collectors living in other parts of the country, Facebook advertisements, connecting with existing collectors' Facebook friends, etc. By running project for a long time and continuously advertising on Facebook, we could add more data collectors as a natural process of expansion. We could ramp up a crowd of collectors in the range of 10-20 for three locations; Nairobi, Kenya; Kampala, Uganda; and Freetown, Sierra Leone. The locations that failed to ramp up were Windhoek, Namibia, and Gaborone, Botswana. In Gaborone, close networks of family members showed an interest in joining, but we declined to enrol them. In Windhoek, many students came forward to join the project, but they were not reliable in collecting data on a regular basis. Hence, we could not build the crowd in these locations. Later, many people in cities such as Bamako, Mali, and Monrovia, Liberia, expressed interest in joining the crowdsourced collection exercise but no decision was made to include them in the crowd.

6.1.2 Crowd collector verification

When we attempted to expand the crowd of collectors in Gaborone, Botswana, we received an expression of interest from the members of one family. Their surname aroused our suspicion initially, and it was confirmed after checking with them. This raises the challenge of how to ensure our crowd data collectors are independent and are not from the same family or group of friends.

The issue was addressed by conducting background verification for all crowd collectors by obtaining their profiles, residence address details, contact numbers, photographs,

social media profiles, etc. With the help of these details, we could verify their identity and maintain profiles of the collectors. A few collectors declined to share their personal information to protect their identity, afraid of the possibility of misuse of their personal information. Such collectors were removed from the network to ensure the quality of the crowd of collectors. Promoting submissions using the mobile app also helped to keep track of collectors (**Table 11**).

Table 11 Number of collectors using mobile app for data submission

Country	Location (City)	Number of collectors
Kenya	Nairobi	3
Uganda	Kampala	2
Sierra Leone	Freetown	1

6.1.3 Price variation due to multiple types of market within the city

The exercise of crowdsourced collection within the city brings together data from various types of market or store, including supermarket, open street market, etc. (refer to **Table 3** Market classification by country). As expected, prices collected from a supermarket may not be same as in an open street market. When we started receiving data from crowd collectors, we observed wide ranges of price variation on certain items.

To verify price ranges, we conducted a brief cross-check submission exercise. In this exercise, besides the regular data collection in a market or store, we asked a few collectors to visit the other collectors' markets to collect the data. In other words, we asked a collector who regularly collected data from an open street market to collect data from a supermarket and vice versa. We conducted this exercise in Kampala, since it has numerous open street markets and supermarkets. In addition, we followed a methodology, explained in section 6.3, to reach a level of confidence in the data submitted.

The results of data collections (using crowdsourcing) can be explored using the following links:

- Database with confidence intervals and number of observations - http://knoema.com/AFPOD2015/africa-food-prices-output-dataset-may-2015. See example **Table 12**.

Table 12 Confidence intervals of maize grain market prices crowdsourced in Kampala, Uganda

Measure	2015 Apr 6	2015 Apr 13	2015 Apr 20
Average	1,278.125	1,313.158	1,315.385
Median	1,300.000	1,300.000	1,300.000
Standard Deviation	135.362	180.925	237.508
Confidence level – 95%, upper bound	1,344.451	1,394.510	1,444.493
Confidence level – 95%, lower bound	1,211.799	1,231.806	1,186.276
Confidence level – 99%, upper bound	1,365.293	1,420.073	1,485.062
Confidence level – 99%, lower bound	1,190.958	1,206.243	1,145.707
Number of Observations	16.000	19.000	13.000

Source: http://knoema.com/AFPOD2015/africa-food-prices-output-dataset-may-2015

- Nairobi - http://knoema.com/wjenvje/africa-food-prices-nairobi

- Kampala - http://knoema.com/mbyianb/africa-food-prices-kampala
- Freetown - http://knoema.com/aowvcz/africa-food-prices-freetown.

6.1.4 Market verification

With crowdsourced data collection, we want to make sure that the data are being collected from different parts of the city. To verify market details, we asked data collectors to share the name, address and GPS coordinates of the market that they visit to collect the data. With the help of GPS information, it can be ensured that markets in different parts of the city are included in the crowd collection.

In many cases, we were unable to verify the location of the market or store because it is not tagged either in Google Maps or in OpenStreetMap, or no information is published about it on the internet.

To address the issue, we built a map-based interface where data collectors can locate the market themselves using Google Maps and submit the details to us. **Figure 16** shows a screenshot of the market registration page.

Figure 16 Market definition screen

Source: http://knoema.com/isdsaje/africa-food-price-major-crowd-sourced-market-locations
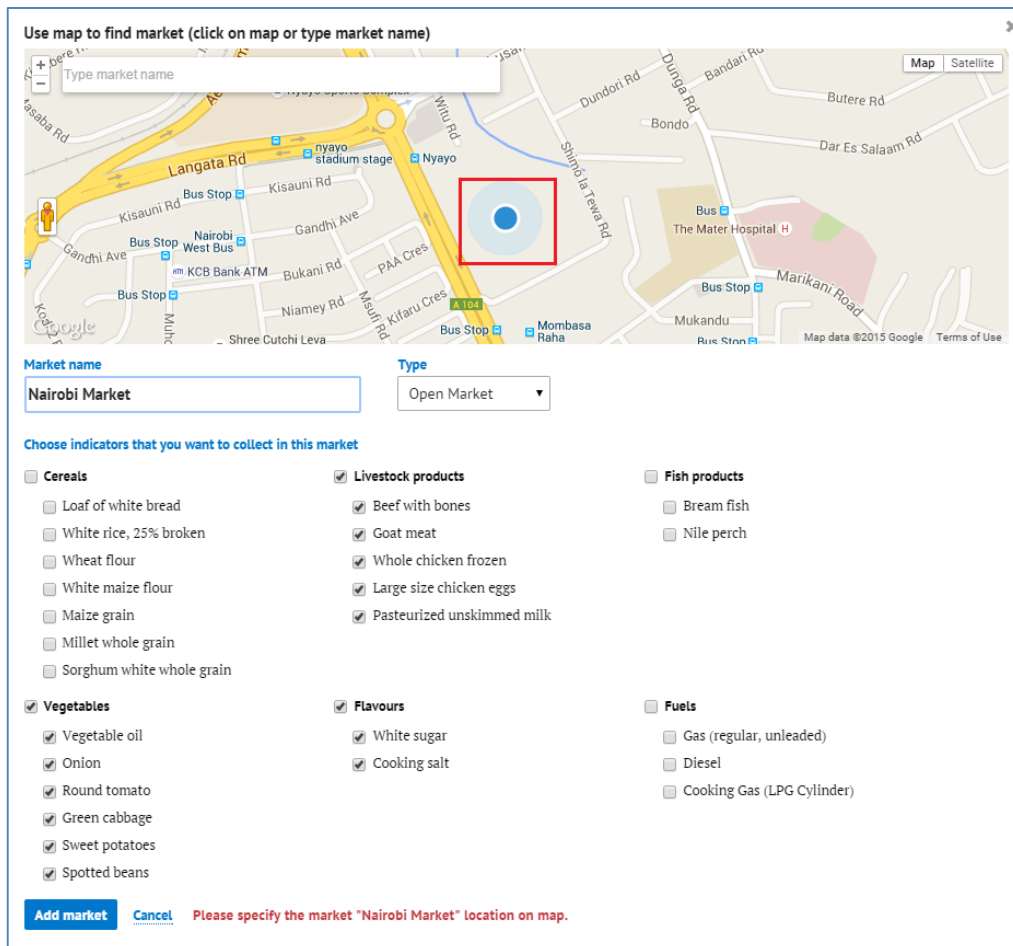
6.2 Markets for crowdsourced data collection

The list of markets for crowdsourced data collection is available in **Table 17** in Annex 4. Figures 17-19 outline markets for crowdsourced data collection at each location. The

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interactive version could be found at http://knoema.com/isdsaje/africa-food-price-major-crowd-sourced-market-locations.

Figure 17 Crowdsourced markets: Nairobi, Kenya
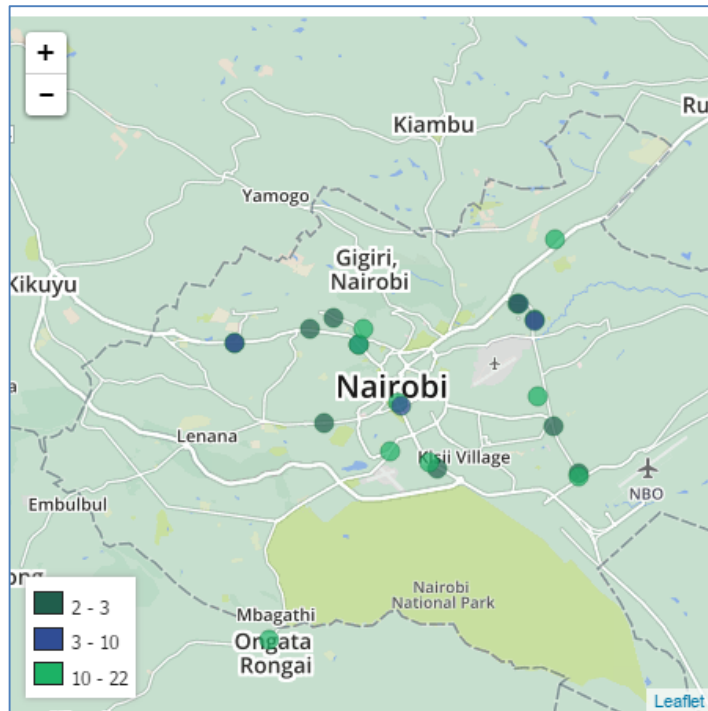
Figure 18 Data collection locations in Kampala, Uganda
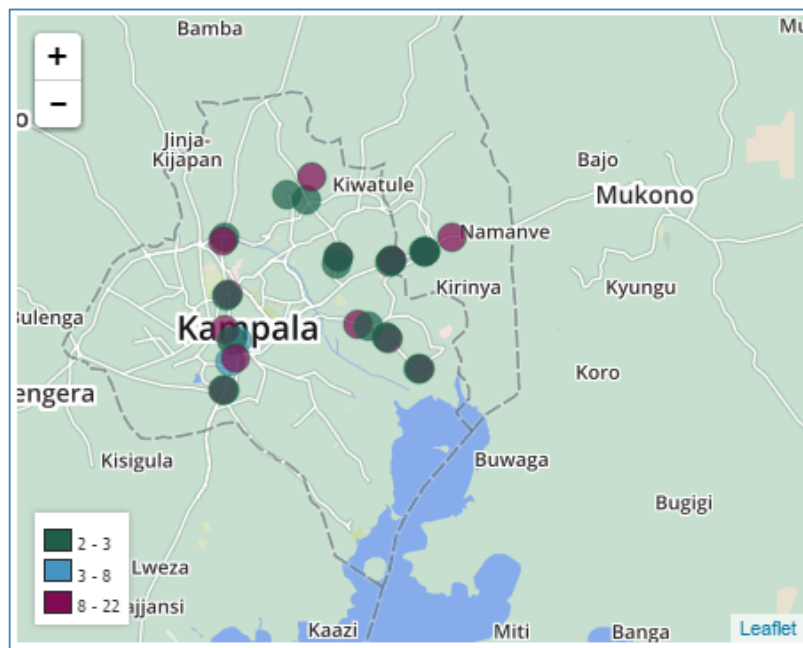
Figure 19 Data collection locations in Freetown, Sierra Leone
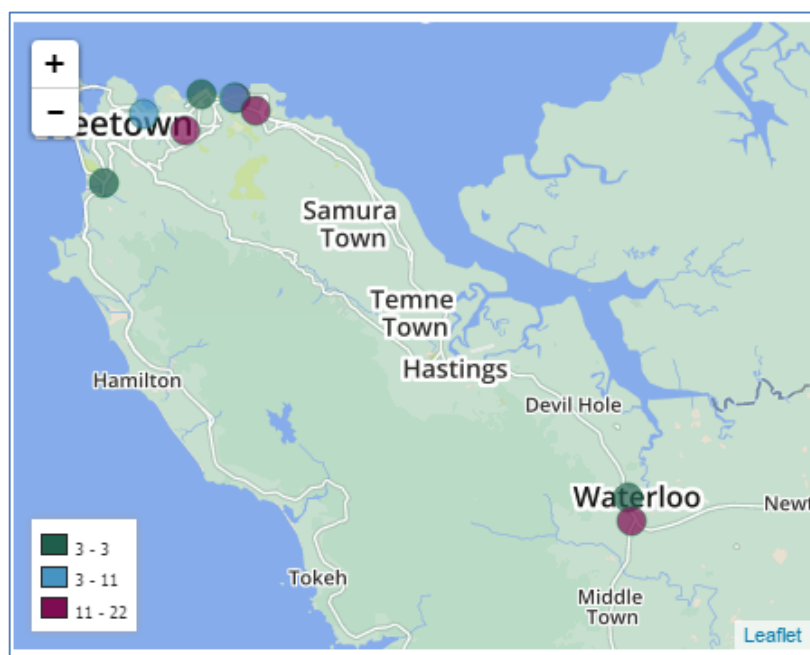
Table 13 represents the distribution of crowd collectors by their reported occupation.

Table 13 Crowdsourced collector profiles by occupation

Occupation	Kenya	Sierra Leone	Uganda
Credit officer		1	
Financial planner			1
Information counselling & referral officer (ICRO)			1
Information scientist, senior assistant librarian			1
ND in peace and conflict studies		1	
Secretary			
Self-employed			1
Student	1	1	1
Unemployed	2	2	
NGO		1	
Not declared	11	6	4

Table 14 shows the distribution of markets by type.

Table 14 Market summary

Country	Butcher	Butcher's shop	Butcher's shop/mini market	Fish market	Fish shop	Fish store	Fuel station	Petrol station	Market	Mini market	Central market	Open market	Specialised store	Supermarket	Total
Kenya	1		1	1		1	1	12	2	1		1		14	35
Sierra Leone								12	11			2		2	27
Uganda		4			1			16	2		3	1	1	11	39

6.3 An exploratory methodology for crowdsourced data quality checks

The goal is to obtain estimates of the confidence intervals (CIs) for the intraweek variation in prices to identify possible outliers and atypical observations (or groups). Assuming that the intraweek variability (or volatility) of the prices for the given commodity is relatively consistent through time, the task can be formulated as finding a suitable abnormality measure for the variation indicator. Box 1 presents a possible methodology for testing the quality of crowdsourced data.

Box 1 Exploratory methodology for crowdsourced data quality

To get rid of scale, first take the log values of prices. Then we take an absolute difference from the intragroup means as the simplest variation indicator (one could consider trying the median absolute difference instead).

Since the probability density function for the mean absolute difference is not known a priori, it should be estimated. Let us use the kernel density estimate for this, with some smoothing to better handle the ragged data from small samples.

If the density function has been estimated correctly, then the required abnormality measure is the attachment to distribution tails (i.e. tail quantiles).

Table to compare:

```
rbind(round(sample.quantiles,4),round(fhat.quantiles,4))

                    1%      2.5%      5%       25%      50%     75%      95%    97.5%     99%
sample.quantiles -0.1635 -0.1223 -0.1103 -0.0600  0.0096  0.0230  0.1169  0.1407  0.1407
fhat.quantiles   -0.1629 -0.1286 -0.1186 -0.0546  0.0089  0.0299  0.1227  0.1355  0.1460
```


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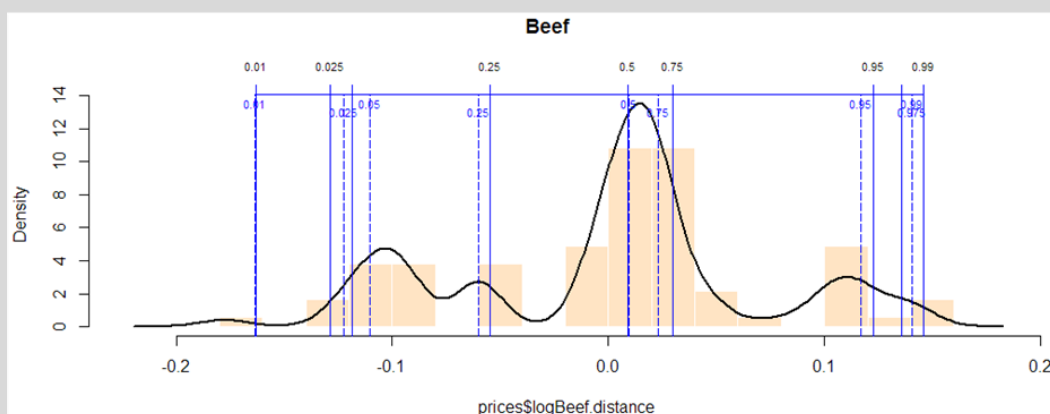
It is easy to see that the sample quantiles and the quantiles obtained through the kernel density estimate are similar, but differ at the distribution tails, and the estimated quantiles look more conservative. This is important because the tail probabilities are exactly what should be determined as accurately as possible. Most likely these differences are because of small sample sizes. Perhaps with large samples it is possible to use just a sample quantile.

The 98% CI is defined as $l = q(1\%) \leq d \leq q(99\%) = u$, where q is the corresponding quantile value of the estimated probability function, and l and u are the lower and upper confidence bounds. Back to price P: $L = \exp(l + m(\log(P))) \leq P \leq \exp(u + m(\log(P)))$, where m is the corresponding intraweek mean.

The 95% CI can be computed similarly for $q(2.5\%)$ and $q(97.5\%)$, as well as any other CIs for the given confidence level.

The CIs are interpreted as follows: with the given probability (98%, 95% etc.) the price for the commodity for given week is inside [L, U]. For the given confidence level, in the absence of specific factors, the price log for the given goods in the given week does not deviate from its mean further down than l and further up than u. Larger deviations can be caused by reporting from specific locations (outliers) or by local volatility jumps (e.g. because of sharp changes in the prices at delivery of new shipments of goods while some shops still have unsold stocks).

The true mean $m(d)$ equals $q(50\%)$ (Median) of the estimated function (it is symmetrical). Therefore, the estimate for the intraweek price mean is $M(P) = \exp(q(50\%) + m(\log(P)))$.

The results are shown in the next figure. Grey dots are raw data points; red dots are outliers, $p = 0.98$; magenta dots are outliers, $p = 0.95$; text labels are sample and estimated means.
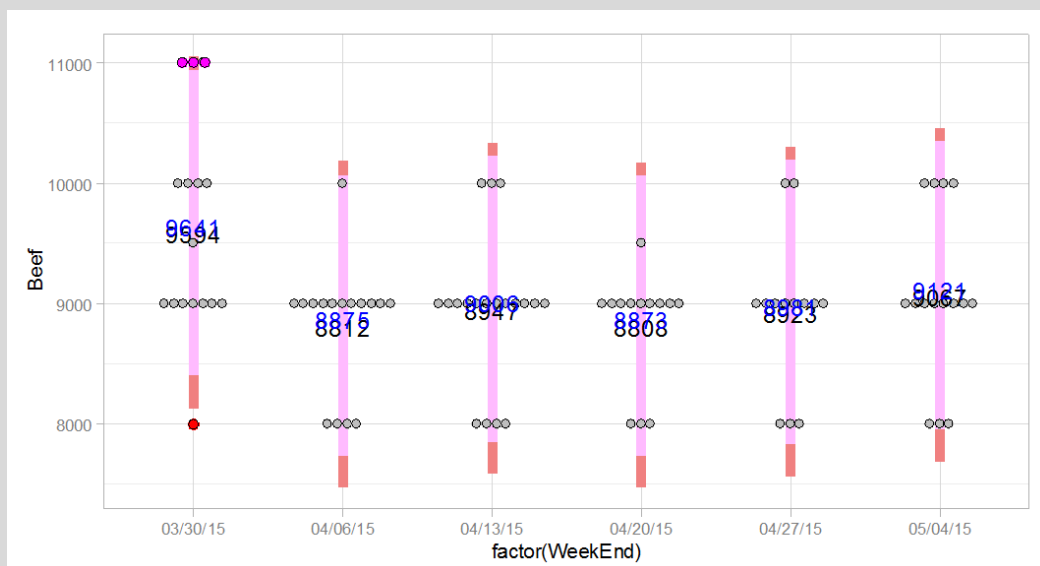
As the figure shows, only two cases from the first week of observations were marked as outliers by the algorithm and that week's observations have a larger range than the other five weeks.

Possible improvements to make the procedure more un-biased are suggested:

a) use Bayesian statistics for quantiles (e.g. those from the R BMS package: http://cran.r-project.org/web/packages/BMS/index.html);

b) compute a test statistic for several similar commodities from the same commodity group or for several cities.

7 Conclusions

The importance of timely food price data collection in developing countries are widely acknowledged for several purposes, such as monitoring food security for early warning, ex ante and ex post economic analysis to support better policy making, and improving transparency for participants along the food chain. For example, collection of high-frequency food price data disseminated in a timely manner is an important step to improve the information retrieved from price analysis. With the help of the timely data, we would be able to monitor the food affordability situation but also to capture the differences in local prices of the same commodity in different geographical locations faster, and to examine the relationship between the prices of related commodities in the same market but also competing commodities in the same or different markets. In turn, farmers can benefit from improved access to and use of information and reduced search and communication costs. All of this can contribute to more efficient food value chains.

In recent years there have been a number of initiatives in which new technologies are used to collect price information at different stages of the supply chain (farm gate, wholesale, retail), with hired (professional or amateur) collectors or based on crowdsourcing methods, which rely on distributing tasks by open call to unknown participants who contribute to the task in exchange for a reward that can be monetary or not. These initiatives aim to address drawbacks identified in classical ways of collecting survey data, such as the significant gap between the real time of collection and publication of the data series, or the time frequency of the disseminated data. Most of the national offices readily supply expertise and publish valuable data related to commodity prices; however, almost all of them are based on low frequencies of data collection, at more than weekly intervals. Besides, the series published are often indices, not the prices themselves, and clearly documented methodology and definitions (commodities, locations), including the microdata themselves, are mostly not easily available. Furthermore, if this type of initiative collects data not otherwise available (e.g. prices in rural and remote areas), the potential for complementarity with public data is high. This type of initiative can contribute to overcoming the urban bias that mainly stems from logistical difficulties and the high costs of regular and frequent price collection in remote and rural areas.

The analysis of several innovative initiatives in food price collection in developing countries, described in a JRC report (Zeug et al., 2017) shows the potential and challenges of such innovative collection methods in the African context of exponential growth in the number of mobile phone users. Challenges are mainly related to building and moderating the crowd of citizens and to ensuring quality, which in turn are related to finding the right incentives. The analysis highlights the fact that most initiatives work independently and the majority of them are based in only one country. The AFPC project has been an attempt to test if new mobile and web technologies and innovative collection methods are feasible ways of collecting and disseminating timely and reliable information on local food prices in the majority of countries in Africa.

Contrary to the strict sense of the definition of crowdsourcing, whereby a contract does not exist and the crowd remains typically unknown, the AFPC price collectors were recruited and hired and therefore contractual relationships were established. Moreover relevant markets in each country (urban and rural) were initially fixed. As a result of the project, a data collection methodology for citizens has been developed, including a list of 25 food items comparable with the ICP of the World Bank and a list of key markets. Data collectors were initially hired in 20 countries and collected data every week. The data submitted were supervised and moderated, and plugged into the web-based dissemination tool. A mobile application was developed for data collection and partly used by collectors. This allowed the prices collected to be combined with precise geo-location information. A similar approach was implemented in other African countries through funding provided by the AfDB and data continued to be collected and disseminated weekly until the end of 2016 in a total of 54 African countries.

In the final three months, further steps to crowdsourcing were implemented in three locations (Nairobi, Kampala and Freetown), allowing for multiple entry points and the determination of CIs for prices collected, but the time was short and several questions regarding a crowdsourcing approach remained open.

Many lessons can be extracted from the AFPC price collection initiative, which contribute to increased knowledge and empirical evidence on innovative food price collection methods in Africa. The main take-aways have to do with the different approaches to building, moderating and motivating the crowd, the web and mobile phone tools, and the controls and improvements implemented. The use of the commodities from the ICP list enabled cross-country and cross-regional comparisons; however, in practice not enough products were included in the data collection for that purpose. While this initiative represents an improved solution in terms of frequency and timeliness of collection and dissemination of prices, the result is more uncertain with regard to data quality. Even though strong validation processes were developed and implemented, accuracy of data could not be measured easily, especially in the absence of benchmarks for the same commodities and markets. Furthermore, price variability can be affected by different samples of outlets or stores (i.e. different store types) and areas of collection within the same market location, but also by different varieties, quality or freshness of the commodity. The lack of a measure of reliability and accuracy may lead to the tool not being used.

During the project the intermittent submissions from collectors led to the idea that this should not be a problem if sufficient contributions for each market are available. Crowdsourcing, which uses contributions from citizens ('crowd') and allows multiple data points per location, was tested. However, multiple contributors within a market location bring data from various types of market or store, including supermarkets, open street markets, etc., and from different areas within the same market location, and, as expected, the prices are not the same. Choosing the 'right' price or the right aggregation rule remained an unresolved problem. In addition, building and managing the crowd while finding the right type and level of incentives was challenging.

Further methodological research work is suggested to develop 'big data' approaches to the analysis of the quality of crowdsourced data that enable the assessment of the intrinsic quality and reliability of those datasets.

Cost-efficiency aspects, such as comparison with traditional data collection survey methods and the use of different types of incentives, could be further researched. In addition, the trade-off between the cost of paid contributions and quality, in terms of the quantity and accuracy of data contributed, can be further explored.

The AFPC collection methodology was successfully applied by the AfDB together with the data company Knoema to expand the number of countries, the number of markets and the collection period. Nevertheless, the fact that the price collection finished by the end of 2016 indicates that its long-term sustainability and integration with current collection systems remains a challenge. Furthermore, a clear definition of the final users and potential uses of crowdsourced food price data seems to be a condition for the development of a sustainable solution.

To conclude, this study has successfully investigated the potential of new technologies (i.e. web and mobile phones) and innovative data collection methods through citizens' contributions (professional or amateur). Some steps were taken to adopt crowdsourcing methods for food price data collection in Africa in the context of rapidly spreading technological improvements. The report summarises the main challenges of the method and lessons learned, and provides a detailed overview and assessment of different aspects of the collected data that can help the success of future food price collection projects through citizens' contributions.

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List of abbreviations and definitions

AfDB	African Development Bank
AFPC	Africa Food Prices Collection
AFPV	Africa Food Price Volatility
BH	Basic Heading
CI	Confidence Intervals
CPI	Consumer Price Index
DG DEVCO	Directorate-General for International Cooperation and Development
ESS	European Statistical System
FAO	Food and Agriculture Organization of the United Nations
GIEWS	Global Information and Early -Warning System
HoU	Head of Unit
ICP	International Comparison Program
ICT	Innovation & Communication Technology
JRC	Joint Research Center
PPP	Purchasing Power Parity
RATIN	Regional Agricultural Trade Intelligence Network
RMSE	Root Mean Square Error
SPD	Structured Product Description
WFP VAM	World Food Programme's Vulnerability Analysis Mapping

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Annexes

Annex 1. Details of markets and market types by location

Table 15 Detailed List of Markets

Country	Market Location	Market Name	GPS	Market Type
Benin	Ouidah, Atlantique (Rural)	Marché Kpassè	6.373983, 2.08803	Market
Benin	Ouidah, Atlantique (Rural)	SONACOP	6.37219, 2.355964	Fuel Station
Benin	Cotonou, Littoral (Urban)	Marché Dantokpa	6.371753, 2.434766	Market
Benin	Cotonou, Littoral (Urban)	SONACOP	6.361428, 2.422033	Fuel Station
Burkina Faso	Koubri, Kadiogo, Centre (Rural)	Marché de Koubri	12.187267, -1.40031	Market
Burkina Faso	Koubri, Kadiogo, Centre (Rural)	Boulangerie wend konta koubri	12.1897708, -1.3997256	Bakery
Burkina Faso	Koubri, Kadiogo, Centre (Rural)	Boutique	12.1897708, -1.3997256	Neighborhood shop
Burkina Faso	Koubri, Kadiogo, Centre (Rural)	Poissonnerie	12.1897708, -1.3997256	Fish Market
Burkina Faso	Koubri, Kadiogo, Centre (Rural)	Station Otam	12.1897708, -1.3997256	Fuel Station
Burkina Faso	Ouagadougou, Kadiogo, Centre (Urban)	Marché de Paagalayiri	12.333632, -1.532451	Market
Burkina Faso	Ouagadougou, Kadiogo, Centre (Urban)	Boulangerie la baguette Mixte	12.332294, -1.526898	Bakery
Burkina Faso	Ouagadougou, Kadiogo, Centre (Urban)	Total Service Station	12.356177, -1.529777	Fuel Station
Burkina Faso	Ouagadougou, Kadiogo, Centre (Urban)	Alimentation le bon samaritain	12.317824, -1.528809	Mini-market
Burkina Faso	Ouagadougou, Kadiogo, Centre (Urban)	Boucherie du Marché Pag-layiri	12.332023, -1.532142	Butcher Shop
Burkina Faso	Kokologho, Boulkiemde, Centre-Ouest	Marché Kokologho	12.1959531, -1.8716603	Market
Burkina Faso	Kokologho, Boulkiemde, Centre-Ouest	Boutique Kabore Lassane et frère	12.1946978, -1.8834649	Neighborhood shop
Burkina Faso	Kokologho, Boulkiemde, Centre-Ouest	Station	12.1967302, -1.8687204	Fuel Station
Burkina Faso	Kokologho, Boulkiemde, Centre-Ouest	Poissonnerie	12.1967302, -1.8687204	Fish Market
Burkina Faso	Dédougou, Mouhoun, Boucle du Mouhoun	Marché Dédougou	12.463131, -3.460092	Market

Country	Market Location	Market Name	GPS	Market Type
Burkina Faso	Dédougou, Mouhoun, Boucle du Mouhoun	Alimentation Doubassin	12.46350277, -3.46077865	Mini-market
Burkina Faso	Dédougou, Mouhoun, Boucle du Mouhoun	Poissonnerie	12.4602738, -3.4581787	Fish Market
Burkina Faso	Dédougou, Mouhoun, Boucle du Mouhoun	Boulangerie Wend Konta	12.46352303, -3.458991	Bakery
Burkina Faso	Dédougou, Mouhoun, Boucle du Mouhoun	Station Total Dédougou	12.4603629, -3.4583543	Fuel Station
Cape Verde	Praia (Urban)	Sucupira Market	14.922774, -23.5097	Open Market
Cape Verde	Praia (Urban)	Mercado Municipal da Praia	14.918838, -23.508632	Market
Cape Verde	Praia (Urban)	Shell e Enacol	14.928696, -23.509381	Fuel Station
Côte d'Ivoire	Abobo, Abidjan, Lagunes (Urban)	Marché d'aboboté	5.411693, -4.000945	Super Market
Côte d'Ivoire	Abobo, Abidjan, Lagunes (Urban)	Grand marché de Marcory	5.3039, -3.98206	Market
Côte d'Ivoire	Abobo, Abidjan, Lagunes (Urban)	Total Gas station	5.40465, -4.006344	Fuel Station
Côte d'Ivoire	Touih, Bas-Sassandra (Rural)	Touih main market	5.258889, 12.546111	Market
Ethiopia	Guder, Toke Kutayu, West Shewa, Oromiya (Rural)	Guder Farmers Market	8.972488, 37.762181	Market
Ethiopia	Semen, Mekele Special wereda, Tigray	NOC Petrol Station	13.509716, 39.489759	Fuel Station
Ghana	Greater Accra (urban)	Kaneshie Market	5.566459, -0.236634	Market
Ghana	Greater Accra (urban)	Total Filling Station	5.564881, -0.235827	Fuel Station
Ghana	Kasoa, Central (rural)	Kasoa New Market	5.562354, -0.441421	Market
Ghana	Kasoa, Central (rural)	Sky Filling Station	5.508606, -0.418401	Fuel Station
Guinea	Conakry Urban Zone, Conakry (Urban)	Marché Madina	9.542362, -13.667262	Market
Guinea	Conakry Urban Zone, Conakry (Urban)	Total Gas Station	9.577401, -13.653206	Fuel Station
Guinea	Coyah, Conakry Rural Zone, Conakry (Rural)	Coyah Market	9.707719, -13.384525	Market
Guinea	Coyah, Conakry Rural Zone, Conakry (Rural)	Total Gas Station	9.608408, -13.648302	Fuel Station

Country	Market Location	Market Name	GPS	Market Type
Guinea Bissau	Sector De Safim, Biombo, Norte (Rural)	Safi Market	11.9516, -15.648879	Market
Guinea Bissau	Sector De Safim, Biombo, Norte (Rural)	Petromar Gas Station	11.858184, -15.580238	Fuel Station
Guinea Bissau	Bissau City, Bissau, Bissau Province, (Urban)	Bandim market	11.85858, -15.595326	Market
Guinea Bissau	Bissau City, Bissau, Bissau Province, (Urban)	Petromar Gas station	11.858187, -15.580236	Fuel Station
Kenya	Westlands	Nakumatt Karen Supermarket	-1.3238896, 36.707895	Market
Kenya	Westlnds	Kobil petrol station, Karen	-1.3298634, 36.68944	Fuel Station
Kenya	Nairobi West, Nairobi (City), Nairobi	Tuskys Mall	-1.312143, 36.816783	Super Market
Kenya	Nairobi West, Nairobi (City), Nairobi	Shell Petrol Station	-1.310642, 36.817162	Fuel Station
Kenya	Nairobi East, Nairobi (City), Nairobi, (Urban)	Ukulima Co-Operative House - Open Market	-1.291987, 36.821118	Open Market
Kenya	Nairobi East, Nairobi (City), Nairobi, (Urban)	M-Pesa Nakumatt Mega Supermarket	-1.291047, 36.819662	Super Market
Kenya	Nairobi East, Nairobi (City), Nairobi, (Urban)	Shell Petrol Station	-1.292429, 36.821751	Fuel Station
Kenya	Bunyala, Busia, Western, (Rural)	Funyula market - Open Market	0.279506, 34.116508	Open Market
Kenya	Kismu (Urban)	Tuskys Supermarket United Mall	-0.098191, 34.76251	Super Market
Kenya	Kismu (Urban)	National Oil Service Station	-0.088726, 34.757329	Fuel Station
Kenya	Nairobi East, Nairobi (City)	Total Petrol station Outering rd	-1.301216, 36.888082	Fuel Station
Kenya	Nairobi East, Nairobi (City)	Uchumi Supermarket Buru Buru	-1.287941, 36.881127	Super Market
Kenya	Kikuyu, Kiambu, Central	Kikuyu Market Stalls	-1.245883, 36.664698	Market
Kenya	Westlands, Nairobi (City)	Nakumatt Ukay	-1.258824, 36.804644	Super Market
Kenya	Westlands, Nairobi (City)	Total petrol station Lower Kabete	-1.254012, 36.792088	Fuel Station
Kenya	Ongata rongai	Tuskys chap supermarket	-1.396386, 36.740955	Market
Kenya	Ongata rongai	Total - Ongata rongai	-1.396205, 36.737746	Fuel Station
Kenya	Migori, District, Migori, Nyanza	Shivling supermarket	-1.067031, 34.47126	Super Market

Country	Market Location	Market Name	GPS	Market Type
Kenya	Nairobi North, Nairobi (City)	MAASAI MALL	-1.394287, 36.763953	Super Market
Kenya	Nairobi North, Nairobi (City)	Total petrol Station	-1.396226, 36.737712	Fuel Station
Kenya	Nairobi East, Nairobi (City)	National Oil Fuel Station	-1.321622, 36.898969	Fuel Station
Kenya	Nairobi East, Nairobi (City)	Taj Shopping Mall	-1.32339, 36.898783	Super Market
Kenya	Kitui, District, Kitui, Eastern	Kitui super market	-1.367592, 38.009871	Super Market
Kenya	Kitui, District, Kitui, Eastern	Oil Lybia	-1.3601063, 38.008525	Fuel Station
Kenya	Nairobi East, Nairobi (City)	Phonelink (Capital centre)	-1.316661, 36.83393	Super Market
Kenya	Nairobi East, Nairobi (City)	Oilibya Service Station	-1.319497, 36.837212	Fuel Station
Kenya	Westlands, Nairobi (City)	Shell Petrol Station	-1.262764, 36.801035	Fuel Station
Kenya	Westlands, Nairobi (City)	Naivas Supermarket Westlands	-1.265133, 36.802883	Super Market
Kenya	Westlands, Nairobi (City)	Naivas Supermarket,Waiyaki Way,Westlands	-1.265132, 36.802884	Super Market
Kenya	Westlands, Nairobi (City)	Kangemi Market,Westlands	-1.264948, 36.748783	Super Market
Kenya	Westlands, Nairobi (City)	Fish Banda (Kangemi Market)	-1.264948, 36.748783	Fish Market
Kenya	Westlands, Nairobi (City)	Total Petrol Station	-1.258696, 36.781272	Fuel Station
Kenya	Eldama Ravine, Baringo, District, Baringo, Rift Valley	Uchuzi Supermarket	0.052702, 35.724873	Super Market
Kenya	Eldama Ravine, Baringo, District, Baringo, Rift Valley	Eldama Ravine Total	0.050348, 35.728027	Fuel Station
Kenya	Nairobi North, Nairobi (City)	Naivas Supermarket, Outering road, Ruaraka	-1.247633, 36.872725	Super Market
Kenya	Nairobi North, Nairobi (City)	Kariobangi Market Stall 340	-1.254931, 36.879743	Mini-market
Kenya	Nairobi North, Nairobi (City)	Abdi Karim Butchery, Kariobangi North	-1.254627, 36.879765	Butcher Shop/Mini Market
Kenya	Nairobi North, Nairobi (City)	Oil Libya Petrol Station,Outer ring Road	-1.247702, 36.872285	Fuel Station
Kenya	Nairobi North, Nairobi (City)	Nakumatt Prestige plaza	1.300067, 36.787355	Super Market
Kenya	Nairobi North, Nairobi (City)	Total petrol station, Ngong Road	-1.299983, 36.787618	Fuel Station

Country	Market Location	Market Name	GPS	Market Type
Kenya	Kisii Central, Kisii	Municipal Market	-0.673555, 34.770884	Super Market
Kenya	Kisii Central, Kisii	Nakumatt Kisii	-0.671855, 34.768467	Super Market
Kenya	Kisii Central, Kisii	Total KisiiStation	-0.671866, 34.76927	Fuel Station
Kenya	Machakos District, Machakos, Eastern	Mutumba Shop	-1.519021, 37.269849	Neighbourhood shop
Kenya	Nairobi East, Nairobi (City)	Mountain mall, Thika Road. Nairobi	-1.232597, 36.873748	Super Market
Kenya	Nairobi East, Nairobi (City)	Engen kahawa, thika road	-1.188946, 36.931533	Fuel Station
Liberia	Greater Monrovia (Urban)	Fish Market	6.281642, -10.76636	Fish Market
Liberia	Greater Monrovia (Urban)	Total Old Gas Station	6.270596, -10.676653	Fuel Station
Liberia	Todee (Rural)	Total Filling Station/ Mini Mart	6.311211, -10.668739	Fuel Station
Liberia	Greater Monrovia (Urban)	Duport Road Market	6.2715, -10.68192	Market
Liberia	Todee (Rural)	Red Light Market	6.293034, -10.690774	Market
Liberia	Ganta, Sanniquellie Mahn, Nimba (Rural)	Total gas Station /Super market	7.232795, -8.987104	Fuel Station
Liberia	Greater Monrovia, Montserrado (Urban)	Saksouk Shopping Center	6.336006, -10.754497	Super Market
Mali	Mpoti Cercle, Mopti	Sakarowel Market	14.490852, -4.192289	Market
Mauritania	Tevragh-Zeïna, Nouakchott (urban)	Marché capitale (Nouakchott)	18.086338, -15.979722	Market
Mauritania	Boghé, Brakna (Rural)	Marché de Boghé	16.590176, -14.276133	Market
Mauritania	Moudjéria, Tagant (Rural)	Errachid Market	17.880757, -12.330017	Market
Mauritania	Atar, Adrar (Urban)	Market Principal	20.519124, -13.054362	Market
Mauritania	Atar, Adrar (Urban)	Moulin Latrache	20.520278, -13.05361	Other Specialized Store
Mauritania	Atar, Adrar (Urban)	Station Total	20.516945, -13.054722	Fuel Station
Niger	Tera, Téra, Tillabéri (Rural)	Marché central Téra	14.005386, 0.753508	Market
Niger	Tera, Téra, Tillabéri (Rural)	Mobil station	14.008931, 0.769816	Fuel Station
Niger	5ème arrondissement communal, Niamey (Urban)	Marché Rond Point N6	13.491809, 2.097477	Market

Country	Market Location	Market Name	GPS	Market Type
Niger	5ème arrondissement communal, Niamey (Urban)	Oilibia station Niamey:	13.491136, 2.097745	Fuel Station
Nigeria	Zoo Road, Kano (Urban)	Sadaraki Stores	11.964794, 8.527571	Super Market
Nigeria	Zoo Road, Kano (Urban)	SHOPWRITE, Opposite Sahad Stores	11.979722, 8.52361	Bakery
Nigeria	Zoo Road, Kano (Urban)	Open Market, Zoo road by Court Road,	11.978888, 8.525	Open Market
Nigeria	Zoo Road, Kano (Urban)	Maitangaran Frozen chickens, Maitangaran House, Num 42 Zoo Road Kano	11.989167, 8.523056	specialized store
Nigeria	Zoo Road, Kano (Urban)	Total Petrol Pump, Num 1 Zoo road Kano	11.967507, 8.530133	Fuel Station
Nigeria	Dawanau, Kano (Rural)	Dawanau market left wing	12.086552, 8.439823	Market
Nigeria	Dawanau, Kano (Rural)	Kantin Sauki, Jangaru Babban Layi	12.062741, 8.478034	Neighborhood shop
Nigeria	Dawanau, Kano (Rural)	Rahama Shopping Complex	12.063637, 8.464156	Super Market
Nigeria	Dawanau, Kano (Rural)	Oando Filling Station	12.065976, 8.473793	Fuel Station
Rwanda	Bibare, Kimironko, Gasabo, Kigali City (Urban)	Kimironko Market	-1.949823, 30.126169	Market
Rwanda	Bibare, Kimironko, Gasabo, Kigali City (Urban)	Kobil Station	-1.940799, 30.043321	Fuel Station
Rwanda	Nyagatare, Eastern Province (Rural)	Nyagatare Central Market	-1.299987, 30.324999	Market
Senegal	Dinguiraye, Kaolack (Rural)	Market Kaolack	14.136036, -16.075413	Market
Senegal	Dinguiraye, Kaolack (Rural)	Petrol Pump	14.135699, -16.076234	Fuel Station
Senegal	Dakar (Urban)	Market Keur Massar/ Marché Cité Ainoumady Keur Massar	14.7736983333333, -17.315375	Market
Senegal	Dakar (Urban)	Shell Station	14.717681, -17.27683	Fuel Station
Seychelles	Active	ANSE ROYALE PETROL STATION	-4.739157, 55.518332	Fuel Station
Sierra Leone	Waterloo, Western Rural, Western Area	Waterloo Market Hall	8.33001, -13.071522	Market
Sierra Leone	Waterloo, Western Rural, Western Area	Old N.P gas station	8.3384639, -13.0733295	Fuel Station

Country	Market Location	Market Name	GPS	Market Type
Sierra Leone	Wilberforce Barracks , Freetown, Western Area Urban, Western Area, Sierra Leone	Wilberforce Market	8.4827524, -13.2572592	Market
Sierra Leone	Wilberforce Barracks , Freetown, Western Area Urban, Western Area, Sierra Leone	Duffcut Market	8.4886554, -13.2225396	Market
Sierra Leone	Wilberforce Barracks , Freetown, Western Area Urban, Western Area, Sierra Leone	Safecon Gas Station	8.4569542, -13.2720082	Fuel Station
Sierra Leone	Kenema City, Kenema Town, Kenema, Eastern (Urban)	Fisheries Market	7.8749551, -11.18442	Open Market
Sierra Leone	Kenema City, Kenema Town, Kenema, Eastern (Urban)	Total Fuel Station	7.8793925, -11.1818448	Fuel Station
Sierra Leone	Kenema rural, Kenema, Eastern, Sierra Leone (Rural)	Mano junction local market	7.9384599, -11.1393266	Market
Sierra Leone	Kenema rural, Kenema, Eastern, Sierra Leone (Rural)	Gas & Fuel Sales Point	8.0251762, -11.1061598	Fuel Station
Sierra Leone	Jinger Hall	Upgun Market	8.484125, -13.214734	Super Market
Sierra Leone	Tower Hill	Filling Station	8.489794, -13.234801	Fuel Station
Sierra Leone	Freetown	Congo Market	8.476614, -13.241179	Super Market
Sierra Leone	Freetown	Total Gas Station	8.477895, -13.247706	Fuel Station
Sierra Leone	Bombay Street, Freetown	Bombay Market	8.488756, -13.222301	Open Market
Togo	Lomé (Urban)	Ramco Supermarché Tokoin	6.130404, 1.221142	Super Market
Togo	Ketao, Bimah, Kara (Rural)	Marché de Kétao	9.656855, 1.307726	Market
Togo	Ketao, Bimah, Kara (Rural)	Bon prix Shop in Kétao market	9.656422, 1.307065	Market
Zambia	Kabwe, Central, Zambia	Kabwe Market	-14.446483, 28.434205	Market
Zambia	Lusaka (City), Lusaka, Lusaka	Shoprite Manda Hill	-15.397972, 28.306243	Super Market
Zambia	Lusaka (City), Lusaka, Lusaka	Puma Filling Station	-15.376807, 28.378242	Fuel Station

Country	Market Location	Market Name	GPS	Market Type
Zambia	Lusaka (City), Lusaka, Lusaka (Urban)	Arcades shopping center/Chelstone market	-15.368176, 28.38728	Super Market
Zambia	Lusaka, Lusaka (Urban)	Crossroads Shopping Mall	-15.435659, 28.354866	Super Market
Zambia	Lusaka, Lusaka, Zambia	Aracade Shopping center - Spar Super Market	-15.397005, 28.307304	Super Market
Zambia	Lusaka, Lusaka, Zambia	Zambeef	-15.439445, 28.308993	Other specialized store
Zambia	Lusaka, Lusaka, Zambia	Total Filling Station	-15.405768, 28.29634	Fuel Station

Source: http://knoema.com/qletxtd/food-price-collection-market-locations-in-africa

Annex 2. Food Price Collection Project - Survey

Figure 20 Food Price Collection Project - Survey

What Seafood available in your location? *

☐ Canned sardine

☐ Canned Tuna

☐ Fresh/Frozen Mackerel

☐ Fresh/Frozen Bream Fish

☐ Fresh/Frozen Nile Perch

☐ None of the Above

What type of Milk product available in your location *

☐ Unskimmed UHT Milk (Ultra-high temperature)

☐ Powdered Milk

☐ None of the Above

What Oil products available in your location *

☐ Palm Oil

☐ Sunflower Oil

☐ Soybean Oil

☐ None of the Above

What Fruits available in your location

☐ Orange

☐ Banana

☐ Plantains

☐ None of the Above

What Starchy roots available in your location *

☐ Cassava

☐ Yam

☐ Brown Potatoes

☐ Sweet Potatoes

☐ None of the Above

What Items are available in your location *

☐ White Sugar

☐ Mineral Water

☐ Beans

☐ Groundnuts

☐ None of the Above

Submit

100%: You made it.

Annex 3. Statistical comparison of prices

Table 16 Measures of time series correlation, %RMSE and price to price ratio for a selection of commodity-locations pairs (correlations >0.5)

Country	Market	% AFPC Obs.	AFPC vs. reference series	N	Corr	Pvalue	% RMSE	Price-to-price ratio		
								Avg.	Min	Max
Burkina Faso	Dédougou, Mouhoun	85%	AFPC-Millet whole grain vs. WFP-Millet, retail	19	0.74	0.00	107%	2.01	1.61	2.41
			AFPC-Sorghum white whole grain vs. WFP-Sorghum, retail	19	0.58	0.01	108%	2.01	1.53	2.71
Burundi	Bujumbura Mairie	97%	AFPC-Spotted beans vs. RATIN-Mixed Beans, retail	7	0.90	0.01	39%	1.42	1.05	1.91
			AFPC-Spotted beans vs. RATIN-Red Beans, retail	7	0.84	0.02	17%	1.15	0.96	1.34
			AFPC-Spotted beans vs. RATIN-Yellow Beans, retail	7	0.91	0.00	8%	0.96	0.83	1.00
			AFPC-Spotted beans vs. FAO-Beans, Retail	4	0.78	0.22	92%	1.93	1.84	2.06
			AFPC-White rice, 25% broken vs. RATIN-Imported Rice, retail	8	0.98	0.00	17%	0.84	0.79	0.85
			AFPC-White rice, 25% broken vs. RATIN-Rice, retail	13	0.97	0.00	20%	1.19	1.09	1.24
			AFPC-White rice, 25% broken vs. FAO-Rice, Retail	4	0.74	0.26	28%	1.28	1.15	1.37
	Ruyigi	57%	AFPC-Sweet potatoes vs. WFP-Sweet potatoes, retail	21	0.51	0.02	72%	1.88	1.27	3.46
Ethiopia	Addis Ketema, Addis Ababa	19%	AFPC-Gas (regular, unleaded) vs. WFP-Fuel (petrol-gasoline), retail	6	0.62	0.19	1%	1.00	0.98	1.00
			AFPC-Maize grain vs. WFP-Maize (white), wholesale	11	0.63	0.04	83%	1.81	1.37	2.08
	Bahir Dar Special wereda, Amhara	15%	AFPC-Maize grain vs. FAO-Maize, Wholesale	8	0.98	0.00	113%	1.96	1.75	2.07
			AFPC-Maize grain vs. WFP-Maize (white), wholesale	6	0.73	0.10	9%	1.08	1.01	1.16
	Jijiga-Wereda, Jijiga	15%	AFPC-Pasteurized unskimmed milk vs. WFP-Milk, retail	4	0.93	0.07	19%	0.77	0.63	0.87
			AFPC-White rice, 25% broken vs. WFP-Rice (imported), retail	5	0.76	0.13	12%	1.12	1.07	1.21
	Semen, Mekele Special wereda	44%	AFPC-Maize grain vs. FAO-Maize, Wholesale	22	0.81	0.00	130%	2.30	1.90	2.71

Country	Market	% AFPC Obs.	AFPC vs. reference series	N	Corr	Pvalue	% RMSE	Price-to-price ratio		
								Avg.	Min	Max
			AFPC-Maize grain vs. WFP-Maize (white), wholesale	17	0.59	0.01	23%	1.20	1.06	1.51
			AFPC-Sorghum white whole grain vs. WFP-Sorghum, wholesale	17	0.76	0.00	15%	1.14	0.86	1.44
Ghana	Greater Accra	56%	AFPC-Maize grain vs. WFP-Maize, wholesale	20	0.84	0.00	312%	4.35	2.92	5.70
			AFPC-Maize grain vs. FAO-Maize, Wholesale	20	0.78	0.00	599%	6.88	3.81	9.23
			AFPC-White rice, 25% broken vs. WFP-Rice (imported), wholesale	14	0.80	0.00	63%	1.67	1.34	2.00
			AFPC-White rice, 25% broken vs. WFP-Rice (local), wholesale	23	0.88	0.00	126%	2.43	1.84	2.95
Guinea	Conakry	93%	AFPC-White rice, 25% broken vs. FAO-Rice (imported), Retail	25	0.92	0.00	285%	3.55	2.31	4.99
			AFPC-White rice, 25% broken vs. FAO-Rice (local), Retail	25	0.89	0.00	148%	2.24	1.54	3.12
Kenya	Nairobi East, Nairobi (City)	82%	AFPC-Diesel vs. WFP-Fuel (diesel), retail	17	0.98	0.00	3%	1.01	0.98	1.07
			AFPC-Gas (regular, unleaded) vs. WFP-Fuel (petrol-gasoline), retail	17	0.98	0.00	2%	0.99	0.93	1.00
			AFPC-Maize grain vs. FAO-Maize, Wholesale	31	0.78	0.00	102%	2.06	1.67	2.31
			AFPC-Maize grain vs. WFP-Maize (white), wholesale	27	0.53	0.00	40%	1.41	1.12	1.62
			AFPC-Pasteurized unskimmed milk vs. WFP-Milk (cow, pasteurized), retail	27	0.65	0.00	6%	1.01	0.89	1.12
			AFPC-Vegetable oil vs. WFP-Oil (vegetable), retail	27	0.60	0.00	8%	0.99	0.83	1.21
	Nairobi North, Nairobi (City)	91%	AFPC-Diesel vs. WFP-Fuel (diesel), retail	15	0.94	0.00	3%	1.00	0.96	1.08
			AFPC-Gas (regular, unleaded) vs. WFP-Fuel (petrol-gasoline), retail	15	0.97	0.00	3%	0.98	0.93	1.00
			AFPC-Maize grain vs. FAO-Maize, Wholesale	20	0.95	0.00	101%	2.02	1.90	2.15
			AFPC-Maize grain vs. WFP-Maize	16	0.71	0.00	42%	1.43	1.25	1.64

Country	Market	% AFPC Obs.	AFPC vs. reference series	N	Corr	Pvalue	% RMSE	Price-to-price ratio		
								Avg.	Min	Max
			(white), wholesale							
			AFPC-Pasteurized unskimmed milk vs. WFP-Milk (cow, pasteurized), retail	16	0.55	0.03	6%	0.97	0.89	1.08
			AFPC-Millet whole grain vs. RATIN-Millet, retail	7	0.66	0.11	42%	1.43	1.20	1.63
			AFPC-White rice, 25% broken vs. RATIN-Rice, retail	4	0.92	0.08	8%	1.01	0.95	1.18
	Nairobi West, Nairobi (City)	90%	AFPC-Diesel vs. WFP-Fuel (diesel), retail	17	0.98	0.00	4%	1.01	0.96	1.08
			AFPC-Gas (regular, unleaded) vs. WFP-Fuel (petrol-gasoline), retail	17	0.97	0.00	3%	0.98	0.91	1.00
			AFPC-Pasteurized unskimmed milk vs. WFP-Milk (cow, pasteurized), retail	30	0.74	0.00	5%	1.01	0.91	1.11
			AFPC-Vegetable oil vs. WFP-Oil (vegetable), retail	30	0.58	0.00	12%	1.10	0.97	1.42
	Westlands, Nairobi (City)	91%	AFPC-Spotted beans vs. RATIN-Mixed Beans, retail	4	0.55	0.45	70%	1.70	1.66	1.74
			AFPC-Diesel vs. WFP-Fuel (diesel), retail	15	0.95	0.00	3%	1.01	0.98	1.09
			AFPC-Gas (regular, unleaded) vs. WFP-Fuel (petrol-gasoline), retail	15	0.96	0.00	3%	0.99	0.93	1.00
			AFPC-Maize grain vs. WFP-Maize (white), wholesale	17	0.51	0.04	47%	1.50	1.25	1.87
			AFPC-Maize grain vs. FAO-Maize, Wholesale	21	0.72	0.00	108%	2.13	1.95	2.87
			AFPC-Pasteurized unskimmed milk vs. WFP-Milk (cow, pasteurized), retail	17	0.78	0.00	5%	0.98	0.91	1.02
Lesotho	Mokhotlong	47%	AFPC-White rice, 25% broken vs. FAO-Rice, Retail	19	0.56	0.01	59%	1.60	1.53	1.64
Liberia	Voinjama, Lofa	91%	AFPC-Gas (regular, unleaded) vs. WFP-Fuel (petrol-gasoline), retail	13	0.59	0.03	390%	5.09	4.37	5.81
Malawi	TA Mtwalo, Mzimba	84%	AFPC-Maize grain vs. FAO-Maize, Retail	15	0.51	0.05	172%	2.77	1.48	4.52
	Katoto Ward,	84%	AFPC-Maize grain	23	0.69	0.00	174%	2.65	1.37	3.51

Country	Market	% AFPC Obs.	AFPC vs. reference series	N	Corr	Pvalue	% RMSE	Price-to-price ratio		
								Avg.	Min	Max
	Mzuzu City		vs. FAO-Maize, Retail							
Mauritania	Nouakchott-Ouest	20%	AFPC-Sorghum white whole grain vs. WFP-Sorghum (taghalit), retail	4	0.52	0.48	19%	0.82	0.79	0.86
Mozambique	Cidade de Maputo, Cidade de Maputo (Mozambique)	82%	AFPC-Maize grain vs. FAO-Maize (white), Retail	8	0.63	0.09	50%	1.42	0.79	1.67
			AFPC-Maize grain vs. FAO-Maize (white), Wholesale	9	0.68	0.04	44%	1.26	0.66	1.62
			AFPC-White rice, 25% broken vs. FAO-Rice, Retail	8	0.97	0.00	94%	1.85	1.65	2.02
Sierra Leone	Wilberforce, Freetown	93%	AFPC-Vegetable oil vs. FAO-Palm Oil, Retail	12	0.80	0.00	52%	1.34	1.04	2.70
	Kenema Town, Kenema	68%	AFPC-White rice, 25% broken vs. WFP-Rice (local), retail	7	0.74	0.06	80%	1.81	1.67	2.08
			AFPC-White rice, 25% broken vs. FAO-Rice (local), Retail	7	0.66	0.11	199%	2.92	2.68	3.37
Swaziland	Siphofaneni, Lubombo	95%	AFPC-White rice, 25% broken vs. FAO-Rice, Retail	30	0.78	0.00	61%	1.59	1.38	1.84
			AFPC-Wheat flour vs. FAO-Wheat (flour), Retail	30	0.81	0.00	50%	1.47	1.29	1.80
Uganda	Lira	17%	AFPC-Maize grain vs. FAO-Maize, Retail	8	0.61	0.11	74%	1.69	1.37	1.96
			AFPC-Maize grain vs. FAO-Maize, Wholesale	8	0.56	0.14	91%	1.81	1.55	2.27

Annex 4. Details of crowdsourced data collection

Table 17 The Complete Market List of Crowdsourced Locations

Country	Location	Market Location	Market Name	GPS Coordinate	Market Classification
Kenya	Nairobi	Westlnds	Kobil petrol station, Karen	-1.3298634, 36.68944	Gas Station
Kenya	Nairobi	Westlands	Nakumatt Karen Supermarket	-1.3238896, 36.707895	Market
Kenya	Nairobi	Nairobi West, Nairobi (City), Nairobi	Tuskys Mall	-1.312143, 36.816783	Super market
Kenya	Nairobi	Nairobi West, Nairobi (City), Nairobi	Shell Petrol Station	-1.310642, 36.817162	Gas Station
Kenya	Nairobi	Nairobi East, Nairobi (City), Nairobi, (Urban)	Ukulima Co-Operative House - Open Market	-1.291987, 36.821118	Open Market
Kenya	Nairobi	Nairobi East, Nairobi (City), Nairobi, (Urban)	M-Pesa Nakumatt Mega Supermarket	-1.291047, 36.819662	Super market
Kenya	Nairobi	Nairobi East, Nairobi (City), Nairobi, (Urban)	Jesman Butchery		Butcher
Kenya	Nairobi	Nairobi East, Nairobi (City), Nairobi, (Urban)	Fish Banda		Fish Market
Kenya	Nairobi	Nairobi East, Nairobi (City), Nairobi, (Urban)	Shell Petrol Station	-1.292429, 36.821751	Gas Station
Kenya	Nairobi	Nairobi East, Nairobi (City)	Uchumi Supermarket Buru Buru	-1.287941, 36.881127	Super market
Kenya	Nairobi	Nairobi East, Nairobi (City)	Total Petrol station Outering rd	-1.301216, 36.888082	Gas Station
Kenya	Nairobi	Westlands, Nairobi (City)	Nakumatt Ukay	-1.258824, 36.804644	Super market
Kenya	Nairobi	Westlands, Nairobi (City)	Total petrol station Lower Kabete	-1.254012, 36.792088	Gas Station
Kenya	Nairobi	Ongata rongai	Tuskeys Shopping centre,		Super market
Kenya	Nairobi	Ongata rongai	Tuskys chap supermarket	-1.396386, 36.740955	Market
Kenya	Nairobi	Ongata rongai	Total - Ongata rongai	-1.396205, 36.737746	Fuel Station
Kenya	Nairobi	Nairobi North, Nairobi (City)	MAASAI MALL	-1.394171, 36.763924	Super market
Kenya	Nairobi	Nairobi North, Nairobi (City)	Total petrol Station	-1.396226, 36.737712	Gas Station
Kenya	Nairobi	Nairobi East, Nairobi (City)	Taj Shopping Mall	-1.323390, 36.898783	Super market
Kenya	Nairobi	Nairobi East, Nairobi (City)	National Oil Fuel Station	-1.321622, 36.898969	Gas Station
Kenya	Nairobi	Nairobi East, Nairobi (City)	Phonelink (Capital centre)	-1.316661, 36.833930	Super market

Country	Location	Market Location	Market Name	GPS Coordinate	Market Classification
Kenya	Nairobi	Nairobi East, Nairobi (City)	Oilibya Service Station	-1.319497, 36.837212	Gas Station
Kenya	Nairobi	Westlands, Nairobi (City)	Naivas Supermarket Westlands	-1.265133, 36.802883	Super market
Kenya	Nairobi	Westlands, Nairobi (City)	Shell Petrol Station	-1.262764, 36.801035	Gas Station
Kenya	Nairobi	Nairobi North, Nairobi (City)	Naivas Supermarket, Outering road, Ruaraka	-1.247633, 36.872725	Super market
Kenya	Nairobi	Nairobi North, Nairobi (City)	Kariobangi Market Stall 340	-1.254931, 36.879743	Mini Market
Kenya	Nairobi	Nairobi North, Nairobi (City)	Abdi Karim Butchery, Kariobangi North	-1.254627, 36.879765	Butcher Shop/Mini Market
Kenya	Nairobi	Nairobi North, Nairobi (City)	Oil Libya Petrol Station,Outer ring Road	-1.247702, 36.872285	Gas Station
Kenya	Nairobi	Westlands, Nairobi (City)	Naivas Supermarket,Waiyaki Way,Westlands	-1.265132, 36.802884	Super market
Kenya	Nairobi	Westlands, Nairobi (City)	Kangemi Market,Westlands	-1.264948, 36.748783	Super market
Kenya	Nairobi	Westlands, Nairobi (City)	Fish Banda (Kangemi Market)	-1.264948, 36.748783	Fish Store
Kenya	Nairobi	Westlands, Nairobi (City)	Total Petrol Station	-1.258696, 36.781272	Gas Station
Kenya	Nairobi	Nairobi North, Nairobi (City)	Nakumatt Prestige plaza	1.300067, 36.787355	Super market
Kenya	Nairobi	Nairobi North, Nairobi (City)	Total petrol station, Ngong Road	-1.299983, 36.787618	Gas Station
Kenya	Nairobi	Thika Road	Mountain mall,	-1.262598, 36.873749	Super market
Sierra Leone	Freetown	Freetown	Congo Market	8.476614, -13.241179	Super market
Sierra Leone	Freetown	Freetown	Total Gas Station	8.477895, -13.247706	Gas Station
Sierra Leone	Freetown	Kissy Mess Mess Market	Kissy Mess Mess Market		Market
Sierra Leone	Freetown	Kissy Mes Mes	Black Hall Road community market		Open Market
Sierra Leone	Freetown	Kissy Ferry	Kissy Total Station		Gas station
Sierra Leone	Freetown	Kissy Mess Mess Market	Kissy Mess Mess Market		Market
Sierra Leone	Freetown	Savage Street	Total gas station		Gas Station
Sierra Leone	Freetown	Mends Street Market	Mends Street Market		Market
Sierra Leone	Freetown		Total Gas Station		Gas station
Sierra Leone	Freetown	Congo Town	King Jimmy market		Market
Sierra Leone	Freetown	Duffcout Market	Duffcout Market		Market
Sierra Leone	Freetown	Lumley Beach Road	Safecom gas station		Gas station

Country	Location	Market Location	Market Name	GPS Coordinate	Market Classification
Sierra Leone	Freetown	Jinger Hall	Upgun Market	8.484125, -13.214734	Super market
Sierra Leone	Freetown	Tower Hill	Filling Station	8.489794, -13.234801	Gas Station
Sierra Leone	Freetown	Tengbeh Town Market	Total gas station		Gas Station
Sierra Leone	Freetown	Tengbeh Town Market	Tengbeh Town Market		Open Market
Sierra Leone	Freetown	Goderich, Freetown	N.P gas station		Gas Station
Sierra Leone	Freetown	Goderich, Freetown	Lumley Regent Raod Market		Market
Sierra Leone	Freetown	Bombay Market Street, Freetown	Bombay Market		Market
Sierra Leone	Freetown	Bombay Market Street, Freetown	Nattional Petroleum Fuel Station		Gas Station
Sierra Leone	Freetown	Wilkinson Road	NP Gas Station		Gas Station
Sierra Leone	Freetown	Abadeen Market	Abadeen Market		Market
Sierra Leone	Freetown	Wilberforce Barracks , Freetown, Western Area Urban, Western Area, Sierra Leone	Wilberforce Market	8.4827524,-13.2572592	Market
Sierra Leone	Freetown	Wilberforce Barracks , Freetown, Western Area Urban, Western Area, Sierra Leone	Duffcut Market	8.4886554,-13.2225396	Market
Sierra Leone	Freetown	Wilberforce Barracks , Freetown, Western Area Urban, Western Area, Sierra Leone	Safecon Gas Station	8.4569542,-13.2720082	Gas Station
Sierra Leone	Freetown	Morrie Town	Filling station		Gas Station
Sierra Leone	Freetown	Morrie Town	Morrie Town Market		Market
Uganda	Kampala	Kampala (Kalerwe)	Kalerwe Market	0.350558, 32.571653	Super market
Uganda	Kampala	Kampala (Kalerwe)	Crane petrol Station	0.352167, 32.572358	Gas Station
Uganda	Kampala	Kampala (Katwe)	Usafi Market	0.305576, 32.576334	Super market
Uganda	Kampala	Kampala (Katwe)	Total Petrol Station	0.303942, 32.574347	Gas Station
Uganda	Kampala	Kampala (Luzira)	Wandegeya Market	0.330212, 32.573742	Super market
Uganda	Kampala	Kampala (Luzira)	Wandegeya Total Petrol Station	0.329792, 32.572928	Gas Station
Uganda	Kampala	Nankinga market	Nankinga market		Market
Uganda	Kampala	Kampala (New Ntinda Market)	J7 food store	0.344485, 32.616423	Central Market
Uganda	Kampala	Kampala (New Ntinda Market)	Meat man butchery	0.344485, 32.616423	Butcher Shop

Country	Location	Market Location	Market Name	GPS Coordinate	Market Classification
Uganda	Kampala	Kampala (Ntinda)	Shell petrol station	0.341898, 32.615506	Gas Station
Uganda	Kampala	Kampala (Banda Market)	Bugwere food store	0.343014, 32.636973	Central Market
Uganda	Kampala	Kampala (Banda Market)	Banda meat centre	0.343014, 32.636973	Butcher Shop
Uganda	Kampala	Kampala (Banda)	Hash petrol station	0.342707, 32.636352	Gas Station
Uganda	Kampala	Kampala (Kireka Market)	Kireka wholesale & retail food store	0.346647, 32.650097	Central Market
Uganda	Kampala	Kampala (Kireka Market)	Nkoba Zambogo butchery	0.346647, 32.650097	Butcher Shop
Uganda	Kampala	Kampala (Kireka)	Shell Gas station	0.346906, 32.649376	Gas Station
Uganda	Kampala	mbuya , kunya , kiwatule	mbuya , kunya , kiwatule		Market
Uganda	Kampala	Kampala (Bweyogerere)	Total Petrol Station	0.352409, 32.660813	Gas Station
Uganda	Kampala	Kampala (Kulambiro)	Gaz Petrol Station	0.366697, 32.604183	Gas Station
Uganda	Kampala	Kampala (Kisaasi)	Bytrust Petrol Station	0.368527, 32.596588	Gas Station
Uganda	Kampala	Kampala (Kulambiro)	Kulambiro Shop and Save	0.375810, 32.606247	Super market
Uganda	Kampala	Kampala (Bweyogerere)	Bweyogerere Market	0.352348, 32.660547	Super market
Uganda	Kampala	Kampala (Kisaasi)	Kisaasi		Open Market
Uganda	Kampala	Kampala (Kitintale)	Kitintale Market	0.313360, 32.635779	Super market
Uganda	Kampala	Kampala (Kitintale)	Petro City	0.313834, 32.634677	Gas Station
Uganda	Kampala	Kampala (Bugolobi)	Bugolobi market	0.318797, 32.623679	Super market
Uganda	Kampala	Kampala (Bugolobi)	Kobil station	0.317990, 32.628061	Gas Station
Uganda	Kampala	Kampala (Luzira)	Luzira Market	0.301556, 32.647789	Super market
Uganda	Kampala	Kampala (Luzira)	Total Luzira Service station	0.301096, 32.647579	Gas Station
Uganda	Kampala	Kampala (Urban)	Haji Siraj's shop		Specialized store
Uganda	Kampala	Kampala (Urban)	Fresh Ngara fish		Fish Shop
Uganda	Kampala	Kampala (Urban)	Nakasonga high quality beef		Butcher Shop
Uganda	Kampala	Kampala (Urban)	Shell Nakawa		Gas Station
Uganda	Kampala	Kampala (Owino)	Owino Market	3.378464, 31.787752	Super market
Uganda	Kampala	Kampala (Owino)	Total Adjumani service station	3.379984, 31.791252	Gas Station
Uganda	Kampala	Kampala (Nakivubo)	Nakivubo Market	0.316772, 32.572390	Super market
Uganda	Kampala	Kampala (Nakivubo)	Total Nakivubo Service station	0.312710, 32.574831	Gas Station
Uganda	Kampala	Kampala (Kibuye)	Kibuye Market	0.293390, 32.571758	Super market
Uganda	Kampala	Kampala (Kibuye)	Shell Fuel Station	0.293231, 32.572314	Gas Station

JRC Mission

As the science and knowledge service of the European Commission, the Joint Research Centre's mission is to support EU policies with independent evidence throughout the whole policy cycle.

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