ACCELERATING TECHNOLOGY INNOVATION PARTNERSHIP FOR INCLUSIVE GROWTH AND FOSTER ADOPTION: A Farmer-Centric Platform to revolutionize Moringa (superfood) value chain to address malnutrition and poverty.

John Baptist W. Kabo-Bah[1], Nana Ekow Nkwa Sey[2], Anaba Clement Issaka[3]

ABSTRACT

Globally 54% of children under 5 years are malnourished with an estimated 78.3 million and 57.5 million live in Asia and Africa respectively. However, with the advent of COVID-19, the situation is projected to worsen, as nations are already experiencing an imbalance of demand and supply within food value chains. Interestingly, nations with a high level of malnutrition are where Moringa a world reckon nutrient-dense plant thrives. Because, Moringa is livelihood, nutrition and afforestation. Based on this, our paper suggests the replication of a farmer-centric platform-Farmex as an avenue to promote smart farming within the Moringa value chain to correct the mismatch of Moringa yield, quality and market inefficiencies between farmers and stakeholders thereby enhancing stakeholder's capacity to meeting both domestic and global demand for superfood Moringa. Adopting Farmex in the Moringa value chain will be revolutionary to nourishing the world to curb malnutrition and poverty especially in Africa and Asia. The Farmex platform has the power to promote inclusion of all stakeholders by nature and enhance market ineffectiveness.

Keywords
Superfoods, Agro entrepreneur, Farmex, Moringa Oleifera, Value chain

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Acronym

FAO	Food and Agriculture Organization
GPI	Ghana Permaculture Institute
IFAD	International Fund for Agricultural Development
IUCN	International Union for Conservation of Nature
KPI	Key Performance Indicator
MSMEs	Micro, Small and Medium Enterprise
NGOs-	Non-Governmental Organizations
PPP-	Public- Private Partnerships
REMAs	Community Resource Management Areas
ROI	Return on Investment
SDGs	Sustainable Development Goals
UN	United Kingdom
UN	United Nations
UNDP	United Nations Development Programme
UNICEF	United Nations Children's Emergency Fund
USAID	United States Agency for International Development
WFP	World Food Programme
WHO	World Health Organization

INTRODUCTION

Children are the future generation. However, across the world, 1 in 5 children are chronically malnourished. These children grow up and often struggle with education translating to earning lesser incomes as adults. The situation deprives them of the opportunity to fully realize their full potentials and contribute to productivity. Today, across Africa and the world, we are facing the highest problems of our time regarding poverty and malnutrition. Cognitively we believe that staying healthy is dependent on the availability, accessibility, affordability and utilization of nutritious foods. Categorically, in agrarian communities, vulnerable groups like women and children are often deprived of this privilege leading to the rise of illnesses.

It is obvious that to accelerate inclusive growth and development, tackling poverty and malnutrition which are ravaging the African continent and parts of the world is very judicious. Therefore, leveraging on the surge for superfoods and robust technology that is inclusive and scalable, we stand a good chance of building better mechanisms to fight malnutrition and poverty in the world.

PROBLEM STATEMENT

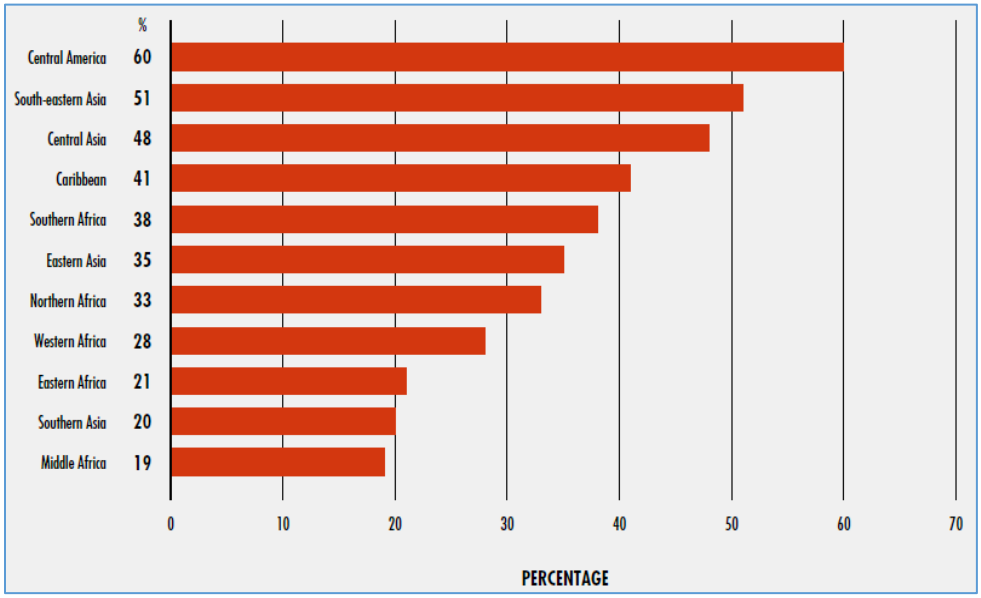
Poverty and Malnutrition

Malnutrition in developing countries is a major health problem as it causes an irrevocable effect on a growing population. Poverty is an omen of malnutrition, as it is recognized as the agent driver of hunger in Africa. Various fundamental causes of poverty identified include conflict, drought, climate change, population growth and unstable economic systems. For instance in recent years conflicts in Mali, Northeast Nigeria, South Sudan, Libya, Côte d'Ivoire, Burundi and the Central African Republic, the Democratic Republic of the Congo as well as droughts in Zambia, South Africa, Madagascar and Zimbabwe has disrupted these countries food security statuses and this protracted the instability of resilience of food value chains (FAO, IFAD, UNICEF, WFP, 2017, 2018; Relations Council on Foreign, 2018). Also, in Asia conflicts in Yemen and the Syrian Arab Republic have increased the situation of undernourishment due to the destruction of agricultural productions, food systems, infrastructures among others leading to the displacement of the majority of the populace resulting in a parallel effect on neighbouring countries. It is also worth

noting that many hungry people are found in developing countries and Asia. Conferring to the World Bank, Sub-Saharan Africa was identified as the second-largest with hungry people as compared to Asia with 512 million people (FAO, 2013).

Unfortunately, vulnerable groups involving women, children and the aged suffer most from malnutrition. According to (USAID, 2001), malnutrition in pregnant women and lactating mothers in many African countries often face higher risk and can lead to maternal mortality. The UNICEP, 2014 estimated that out of the 17,000 children who die every day under the age of 5 years, malnutrition accounts for half of the deaths. The World Health Organization (WHO) reveals 1 in 3 people in developing nations are faced with mineral and vitamin deficiencies (Adeyeye et al., 2017; WHO, 2018) causing the rise in malnutrition. Mineral and vitamin deficiencies situation in children is not surprising because many children in the world are not meeting the minimum dietary diversity with the highest in Central America (Figure 1).

Figure 1:Percentage of Children 6-23 months of Age not Meeting the Minimum Dietary Diversity



Source: *UNICEF Global Databases, 2019;* FAO, IFAD, UNICEF, WFP, 2020.

The number of people undernourished in 2019 has escalated before the recent emergence of the COVID-19 pandemic, from Asia (381 million), Africa (250million), American and the Caribbean 48 million (Fattibene et al., 2020) see Table 1. From Table 1 the 2030 projections show that Central Asia, Eastern Asia and the Caribbean would make some progress whilst Africa, Western and

Northern Asia, Latin America and Oceania situation of undernourishment projected to worsen in 2030 attributed to persistent factors of crises in the regions.

Table 1: Number of Undernourished People in the World, 2005-2019

	Number of undernourished (millions)							
	2005	2010	2015	2016	2017	2018	2019*	2030**
WORLD	**825.6**	**668.2**	**653.3**	**657.6**	**653.2**	**678.1**	**687.8**	**841.4**
AFRICA	**192.6**	**196.1**	**216.9**	**224.9**	**231.7**	**236.8**	**250.3**	**433.2**
Northern Africa	18.3	17.8	13.8	14.4	15.5	15.0	15.6	21.4
Sub-Saharan Africa	174.3	178.3	203.0	210.5	216.3	221.8	234.7	411.8
Eastern Africa	95.0	98.1	104.9	108.4	110.4	112.9	117.9	191.6
Middle Africa	39.7	40.0	43.5	45.8	47.2	49.1	51.9	90.5
Southern Africa	2.7	3.2	4.4	5.1	4.5	5.2	5.6	11.0
Western Africa	36.9	37.0	50.3	51.2	54.2	54.7	59.4	118.8
ASIA	**574.7**	**423.8**	**388.8**	**381.7**	**369.7**	**385.3**	**381.1**	**329.2**
Central Asia	6.5	4.8	2.1	2.1	2.2	2.1	2.0	n.r.
Eastern Asia	118.6	60.6	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.
South-eastern Asia	97.4	70.1	66.7	63.9	63.4	64.2	64.7	63.0
Southern Asia	328.0	264.0	263.1	256.2	245.7	261.0	257.3	203.6
Western Asia	24.3	24.2	27.6	29.2	29.5	30.4	30.8	42.1
Western Asia and Northern Africa	*42.6*	*42.0*	*41.4*	*43.6*	*45.0*	*45.4*	*46.4*	*63.5*
LATIN AMERICA AND THE CARIBBEAN	**48.6**	**39.6**	**38.8**	**42.4**	**43.5**	**46.6**	**47.7**	**66.9**
Caribbean	8.4	7.2	7.4	7.3	7.1	7.3	7.2	6.6
Latin America	40.1	32.4	31.4	35.1	36.3	39.3	40.5	60.3
Central America	11.8	12.4	13.4	14.7	14.4	14.7	16.6	24.5
South America	28.4	20.0	18.0	20.4	21.9	24.6	24.0	35.7
OCEANIA	**1.9**	**2.0**	**2.2**	**2.4**	**2.4**	**2.4**	**2.4**	**3.4**
NORTHERN AMERICA AND EUROPE	**n.r.**	**n.r.**	**n.r.**	**n.r.**	**n.r.**	**n.r.**	**n.r.**	**n.r.**
On track	Off track – some progress	Off track – no progress or worsening						

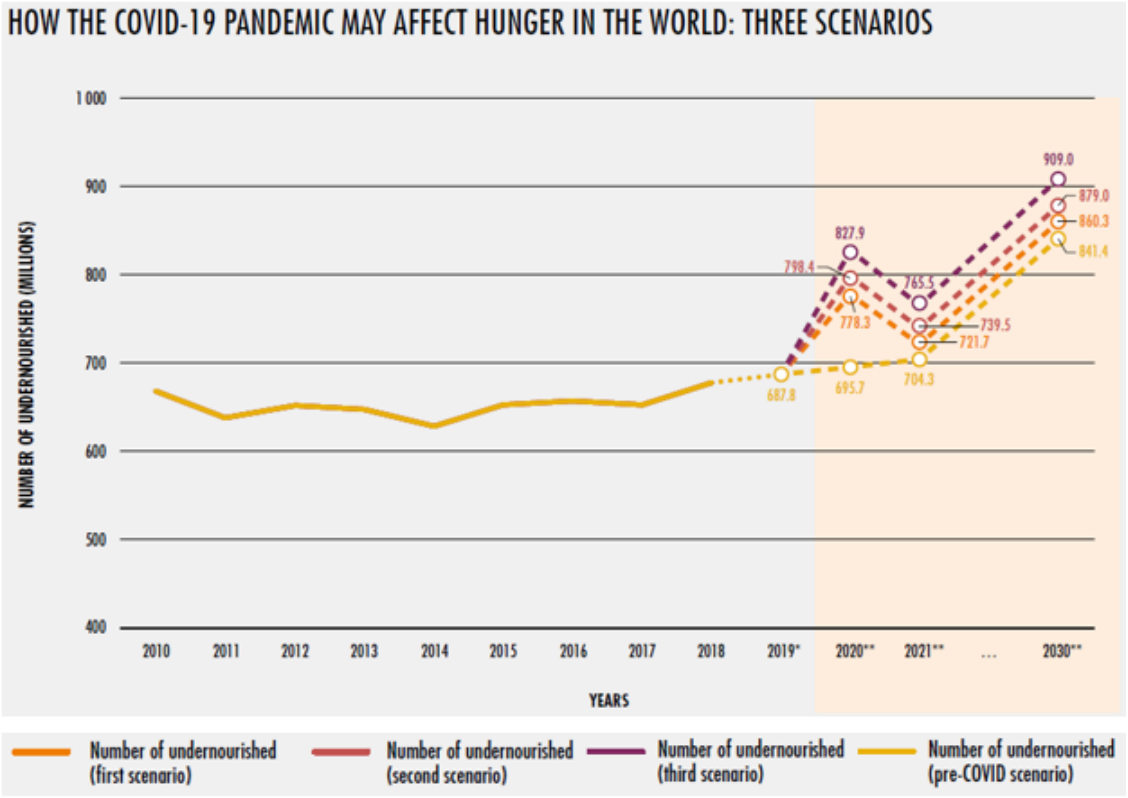
Notes: *****represents project values. ****** 2030 projections without the impact of COVID-19 Pandemic. n.r represents not reported as the prevalence is < 2.5 percent. Source: FAO

Globally, in 2019 before the pandemic, an estimated 144 million children under the age of 5 years were stunted, whereas 47 million were wasted and 38.3 million overweight (UNICEF et al., 2020). It is overwhelming that out of 54% of these children affected with chronic malnutrition an estimated 78.3 million lived in Asia while 57.5 million lived in Africa even before the advent of COVID-19. Likewise, the number of children overweight are also increasing with records of 17.2 million children focused in Central Asia, Oceania and 9.3 million in Africa. Nonetheless, since 2000 there has been a decline in stunting prevalence concentrated in Asia, however, stunted cases in children living in Africa continues to rise drastically (Demos & Segal, 2016; Fattibene et al., 2020). The trend of malnutrition across the world represents a historic challenge and the COVID-

19 impact was estimated to add 6.7 million children cases of wasting in 2020 with 57.6% cases in Asia and 21.8% in Sub-Saharan Africa (Headey et al., 2020).

Many years ago, the world committed to ending hunger, forms of malnutrition and food insecurity, till now just a few years to 2030 we are still wagging on the track to achieve the set goal. Research and data show that the world is not rapidly progressing to address access to nutritious and sufficient food for the growing populace. Following a report on the state of Food Security and Nutrition in the world; the 2017 and 2018 reports stipulated conflicts and extreme climatic conditions dented the world's ability to end food insecurity, malnutrition and hunger; 2019 report also revealed that existing economic shifts also weaken our efforts to SDGs agenda and likewise in 2020, the unprecedented COVID-19 obscured the economies progress to addressing hunger, food insecurity and forms of malnutrition (FAO, IFAD, UNICEF, WFP, 2020). It is more likely if the world does not take rapid actions; hunger, food insecurity and malnutrition would continue to rise at an unrivalled pace, therefore, leading to a compromised psycho-physical and intellectual development of children of the future. With just nine years until 2030, projections with COVID-19 impact shows that the world achieving SDG targets for hunger and malnutrition is under threat. The preliminary analysis in Table 2 shows that the COVID-19 pandemic has already twisted the food supply chain across the world and it is projected to expose nations to an increase in hungry people as there is already an imbalance of demand and supply in food value chains.

Table 2:How COVID-19 Pandemic may Affect Hunger in the World: Three Scenarios



***Notes**: Shaded portion represents projections from 2019 to 2030.*
Source: FAO

Previous studies like Adeyeye et al., 2017 concluded post-harvest loss, low agricultural productivity and lack of nutritious food as salient elements attributing to poverty and malnutrition. As such, recommended use of modern agricultural techniques, improve the transport system, and explore opportunities for the acceptability and adoption of new technologies among others to drive the right quality and quantity in agricultural productivity. It is however noted in Krishnan et al., 2020 that disruptive innovations have the ability to increased agricultural productivity, promote regional trade and cohesion, skills and formalizations of jobs, along with support in the reformation of how and where value is created or needed in a given value chain. Innovation and social inclusion were also identified in Khalid Anser et al., 2021 as key fundamentals to West Africa food security as they can increase food security by 41.5 % and 13.6 % respectively. Moreover, combating hunger according to the Kofi Annan Foundation, 2016 suggested the need for a strong political will to make the hunger agenda a top priority in both domestic and international agendas, build effective partnerships etc. Odusola, 2021 is of the view that to promote agriculture for sustainable

development, there is the need for a holistic approach to agricultural ecosystems where resource management(non-renewable), industrial output players, food production, innovative technologies should be at the pivot of national development processes to pursue agricultural revolution for a better future.

Going forward, there is a growing interest to find ways to engage the private sector in our food systems and obviously, UN Food Systems Summit in 2021 was conceived by global leaders on the quest to set a new agenda for nutrition, environmental sustainability and equity. Many of the PPPs must be constraint with unmatched power, limited resources, lack of prerequisite technical skills, and more importantly lack of trust. This means to victor transparency and accountability in PPPs, all stakeholders must be involved. The situation helps track progress and create the possibility of identifying challenges and creating inclusive solutions for growth.

SUPERFOODS AND CONSUMER TRENDS

Today, the market demand for nutritional diets known as ‘superfoods’ has triggered a major concern to satisfying consumers nutritional needs. Superfood is the umbrella term used for varieties of food with high nutritional benefits such as Moringa, Legumes, Garlic etc. The preference for superfoods is due to its relevance of health benefits as it contains high amounts antioxidants, vitamins, mineral. The increased demand for superfoods occasioned a 36% increase in newly launched products containing various superfoods. Following the surge for new superfoods, product launches in Spain(72%), France(72%), Italy(73%), Germany (71%) agree that natural foods are beneficial and should be part of functional foods (Mintel, 2016). Globally, it is estimated that by 2026 the superfoods market size would reach $209.1 billion leading to a rise of compound annual growth rate(CAGR) by 7.3% (ReportLinker, 2020). However, of late the cosmetics industry to have introduced natural beauty and body care products made with superfood ingredients such as Moringa, turmeric, avocado etc. resulting from the increase in the nutritional concerns raised by numerous customers. Currently, Moringa has captured global attention, relating to its potentials in the food, medicine and cosmetics industry (Kumar et al., 2019). Meanwhile, rural communities in Africa are taking part in sustainable agriculture projects and initiatives through superfoods with the support of emerging companies and NGOs.

Some common superfoods (Appendix 2) include;

Moringa *(Moringa Oleifera) is an indigenous and fast-growing drought-resistant tree that is well recognized due to its nutritional properties (rich in iron, calcium, amino acids, vitamins A, B, and C and protein) and numerous benefits. Leaves extracts (fresh leaves, powder, pods) nutrients help prevent malnutrition.*[4] *Cultivation of Moringa supports intercropping with vegetables which helps farmers to gain additional income for its ability to create jobs and alleviate poverty. Malawi Ministry of Agriculture, for instance, use Moringa as an intervention to combat vitamin A deficiency for being identified as a cost-effective indigenous plant that could improve the nutritional status of the local populations (Babu, 2000).*

Fonio *is used by many mothers in West Africa for feeding their babies as a source of nutrition for iron, zinc, magnesium, amino acids etc. It grows well in dry climates. In Senegal, many smallholder farmers are trained and equipped to increase productivity. The approach has supported agrarian communities to support themselves through sustainable agriculture.*

Spirulina *is another natural resource that has been around decades ago. In the 1980s, Spirulina was declared by the U.N. as a promising solution to address malnutrition in the world due to its rich in vitamins A and B12, iron, carbohydrates, nucleic acids and lipids. The production of spirulina has been known in the Democratic Republic of the Congo (DRC) as an alternative nutritional source that has improved the lives of communities.*

Gum Arabic *is another wild natural tree used in food supplements and in making inks, paints and ceramics. Notably, the majority of the above-mentioned superfood can grow in the wild making them exceptional crops capable to thrive in temperate zones especially in Africa.*

The study of Waterman et al., 2021 supports the use of Moringa as a smart crop to transpose economic empowerment of smallholder farmers. The study highlights the need for proper and fair market conditions to enhance Moringa yields and farmgate prices as well as public and private partnerships to improve the quality and quantity of Moringa produce available in markets.

[4] USAID, 2012

GLOBAL INSIGHTS OF MORINGA OLEIFERA (DRUMSTICK)

Previous scientific studies suggest that Moringa stands out in many of the above-mentioned superfoods as it possesses various properties of anti-inflammatory and detoxifying elements which can reduce chronic illness like obesity, diabetes, anaemia and cardiovascular diseases. Other research is of the view that Moringa can be useful in terms of increasing the production and quality of mothers breast milk. Prasanna Kumar. K, 2013 study of the effect of Moringa Oleifera on blood glucose concluded that the leaf powder of Moringa Oleifera can naturally support the reduction of glucose and cholesterol in obese people. Because of the growing beliefs regarding its nutritional and medicinal efficacy (Appendix 1), the demand for Moringa has drastically increased with numerous Moringa plantations and processors sprouting around the world thereby creating jobs opportunities and improving economic standards of rural communities. Although researchers, scientists are acknowledging the importance of the tree there are still some gaps due to the limited available data and therefore require the need for further scientific and clinical studies. The study of Alegbeleye, 2017 also apparently revealed Moringa as a potential tree to boosts the nutrition of poor households across the world.

Moringa fresh leaves are widely eaten as vegetables and recognized for their high nutritional value (Sagona et al., 2020; FAO, 1988) as compared to other foods (Table 3). Moringa was recognized in September 2014 by FAO of the United Nations for its notable relevance in fighting malnutrition. Aside, Moringa nutritional benefits it has many uses including water purification, fencing, intercropping, honey production, plant disease control among others that make it a one-stop plant with the ability to transform nations and continents to eradicate malnutrition and poverty (**Error! Reference source not found.**).

Table 3: Moringa oleifera leaves compared with other foods

Content in (mg/100 g)	Fresh *M. oleifera* Leaves	Dry *M. oleifera* Leaves	Other Foods
Vitamin A	7	18.9	Carrot: 1.89
Vitamin C	220	17.3	Orange: 30
Calcium	440	2003	Cow's milk: 120
Iron	085	28.2	Spinach: 1.14
Potassium	259	1324	Banana: 88
Protein	6700	27,100	Yogurt: 3100

Source: (Trigo et al., 2020; Sabín, 2014; Tahir Mahmood et al., 2010)

Table 4: Moringa oleifera medicinal properties

Part of the Plant	Medicinal Use
Roots	Analgesic, anti-inflammatory, antitumor, antidiabetic, snake bite, antiulcer, antispasmodic, cholesterol-lowering effect, antibacterial, anxiolytic, antifungal, antidiuretic and antihypertensive
Leaves	Anticatarrhal, antidiabetic, antiscab, antihypertensive, antiproliferative, antioxidant, anxiolytic, diuretic, pharyngitis, cholesterol-lowering effect, haemorrhoids, glandular swellings, anti-inflammatory and anti-hyperthyroidism
Flowers	Anti-inflammatory, antipsychotic and anti-tumour
Seeds	Antidiuretic, antitumor, genitourinary, antituberculous, anti-asthmatic, antibacterial and hepatoprotective

Source: (Trigo et al., 2020; Liu et al., 2018)

Moringa Market Insights

Following the regional insights, global Moringa trade in 2016 was estimated at USD 4.5 billion with a projection to reach USD 7 billion by close of 2020 ascribed on the demand rise for nutritional supplements, beverages, snack foods, and care products.[5] Going forward the ingredients Moringa market is value to reach USD 10 billion by 2025 where Moringa market demand in Europe is likely to surpass USD 2 billion by 2025 due to the high patronage of food supplements in Italy, UK, France and Germany; also, North America would witness USD 5 billion by 2025 due to the higher demands for plant-based supplements and cosmetics products driven by the U.S, Mexico and Canada. Asia Pacific market size is expected to grow further at 8% by 2025 driven by

[5]Global Entrepreneurship Summit, 2016. https://medium.com/global-entrepreneurship-summit/money-does-grow-on-trees-why-we-invested-in-Moringaconnect-774b50cf8d3f

India, Japan and China.[6] "Indian Moringa (drumstick) powder, henna powder, chillies, value-added tea have caught the fancy of the country's second-largest trading partner China and the Asian giant is keen to import these agricultural products from India."[7] Major industry players including Kuli Kuli, Ancient Greenfields and Earth Expo among others are undertaking new approaches to strengthen the relentlessness in meeting consumers demands and increasing their market presence. Grounded on this perspective we see leveraging on an already robust technology could unleash the potentials of Moringa industry players to revolutionize the Moringa value chain as a viable strategy to improve the nutritional status of the worlds galloping population leaving no one behind.

For example, a global industry player, Kuli Kuli an American based company is supporting the potential of Moringa to impact the lives of numerous Americans through its Moringa energy bar, shot and powder products. Since its operations it has supported in planting over 24.6 million Moringa trees[8] and has helped generate $ 5.2 million revenue for Moringa smallholder farmers and supported 3,224 livelihoods in 13 developing countries (e.g., Ghana, Uganda, Togo etc.), Latin America and Southeast Asia. In the year 2019, Kuli Kuli sold Moringa products in over 11,000 stores across America (Kuli Kuli, 2019).

Challenges in Moringa Value Chain

Despite the potentials of Moringa to curb Malnutrition in Ghana and the rest of the world, its value chain in Ghana is underdeveloped with constraints including subsistence production, disorganized producers, limited or weak access to quality inputs as well technical support to support farmers to thrive. Despite the availability of some processing companies (MoringaConnect, Ghana Permaculture Institute, READ etc.), Ghana has not been able to explore the possibilities of this miracle tree to meet the recent domestic and global market demands. The situations necessitate restructuring and formalizing of the value chain to meet market demands to curb malnutrition. Secondly in Malawi, the Moringa chain value chain is also seen as underdeveloped, making scaling up in the value chain unattractive in Malawi. Based on this, Sagona et al., 2020 study stipulated innovations as a critical avenue to add value to the Moringa species and value chain as it would

[6] Global Market Insights,2019. https://www.globenewswire.com/news-release/2019/09/24/1919750/0/en/Moringa-Ingredients-Market-value-to-hit-10-billion-by-2025-Global-Market-Insights-Inc.html
[7] 2nd Edition of the China International Import Expo in Shanghai
[8] Improve the forest cover of degraded landscapes in rural communities.

lead to the emergence of new opportunities and economic boom for growers, producers, processors, and distributors. Additionally, Farm Africa, 2020 recent study, showed Moringa value chain in Tanzania constrained because of unreliable markets, lack of credit facilities, use of old-fashioned equipment and limited available packaging materials. The problem attributed to limited or no links between actors in the value chain to ensure timely access to information, transparency, fair pricing. And therefore, often results from a mismatch between information on price and quantity between producers, processors and other stakeholders. Going forward, the assessment recommended market information be made available to all market actors whilst making available credit facilities to all. Technology has the utmost chance to make this a reality.

OUR APPROACH

In 2020, having incorporated Afrivoices for Climate Change[9] to nourish the world through Moringa based on the pillars: Farms, Food and Future, we partner eKutir Rural Management Services Pvt Ltd (eKutir) - an India first Certified Benefit Corporation with a decade of experience in building sustainable digital and data-driven solutions for farmers to adopt its farmer-centric digital platform-Farmex[10] to help transform the Moringa value chain in Ghana as a viable solution to curb malnutrition, and poverty in agrarian communities. The partnership was facilitated after we participated in the 2020 SEED[11] Replicator[12] Programme in Accra (Ghana Hub) see pictures in Appendix 5: . eKutir founded in 2009 is a social enterprise that is supporting the transformation of smallholder farmers through its digital solutions. Through its digital solutions offered through a decentralized network involving stakeholders with access to low-cost digital mobile phones, it has impacted 85000 farmers across the world and still counting across.

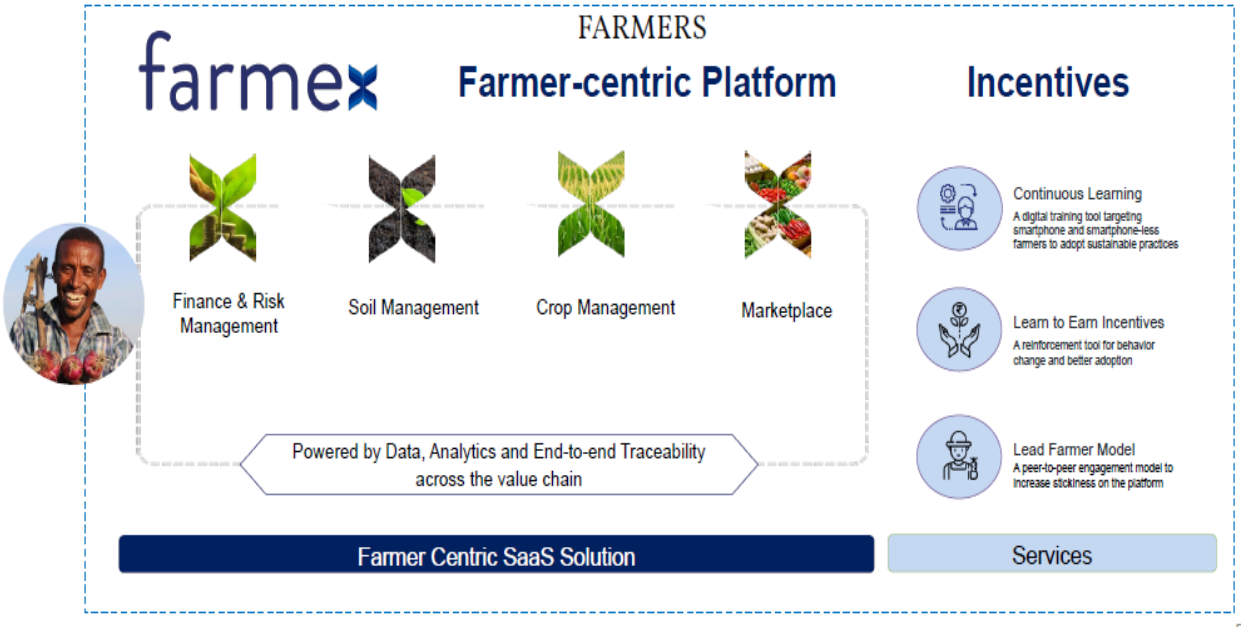
Solution-Farmex Platform

Reflecting on the woes of malnutrition across the globe, we proposed to adopt Farmex (formerly 14loom)- a comprehensive platform that assists in better decision making of smallholder farmers

[9] Visit: https://afrivoices.org/
[10] Visit: https://farm-ex.io/
[11] Global partnership for action on sustainable development and green economy. It was founded in 2002 by UN Environment, UNDP and IUCN. SEED programmes help unleash policy, financing and collaboration instruments that support the multiplication of social, environmental and economic impacts of entrepreneurship.
[12] SEED Replicator connects aspiring entrepreneurs with established enterprises that have implemented Eco inclusive business models in other locations. SEED hubs: Ghana, India, Indonesia, Malawi, Thailand, Uganda, Botswana, South Africa, and Zambia.

to ensure sustainable food supply. It is a simple mobile app that supports smallholders with cutting edge information, markets, finance and rationalizes the work for all actors within the value chain. Its adoption would revolutionize the Moringa value chain in Ghana with real-time information, the data-driven decision on soil management analysis, crop management, marketplace and finance and risk management (Figure 2) while ensuring end-to-end traceability to solve the complex challenges in access deprivation (knowledge, markets, services) by all value chain actors.

Figure 2: Soil-to-Shelf Platform



Key features

Finance and Risk Management: Through farm and farmer advisory, this feature would support Moringa smallholders identify, mitigate, monitor risk. On this basis, financial institutions would be in the best position to use farm and farmer data and insights in extending credit base on their ability to assess the risk of each farmer.

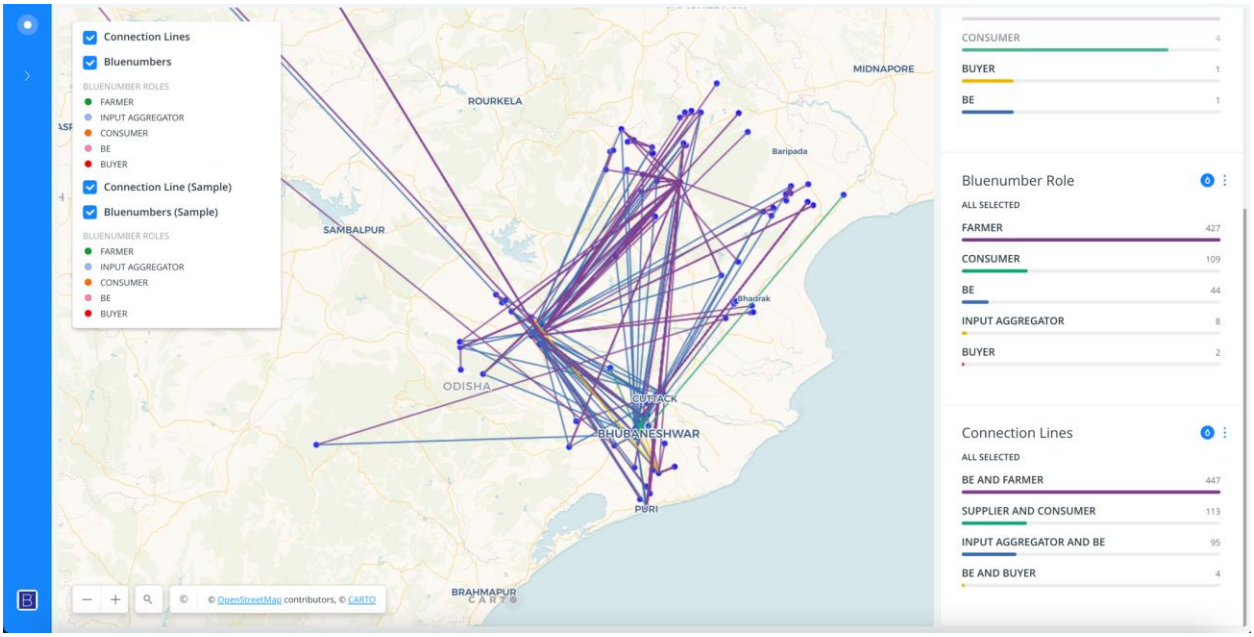
Soil and Crop Management: Despite Moringa being a drought-resistant tree, the nutrient management of soil is essential to better promote sustainable agriculture. This feature would support Moringa smallholder farmers with real-time advice on best practices and a mix of micro and macronutrients that need to be applied to the soil subject on the local availability of data regarding inputs, season, climate and soil. For example, farmers would have the ability to plan

Moringa cropping activities, improve seed and nutrient application as well easily diagnose pest/disease attacks with appropriate recommendations.

Marketplace: Assists smallholders with real-time advice to readily make appropriate choices on buying inputs and selling yields through the link to markets.

We leverage existing field workers in communities as Agro entrepreneurs who are tech-savvy and have access to a smartphone to act as a broker with Moringa farmers in the community. Agro Entrepreneurs act as proxies and manage farmer portfolios. Agro entrepreneurs are trained to digitally assist smartphone or smartphone less Moringa farmers on the usage of the platform to access real-time insights on planning farming cycle, nurture soil, markets and credit in the value chain to augment productivity and income deficits (Figure 4), see Appendix 3 the basic wireframe of the Farmex approach. The platform Analyses resonates on micro, and macro data of soil, crop and industry which promote the adoption of precision farming among Moringa smallholders. The idea of Agro entrepreneurs is to facilitate trust to aid inclusiveness, adoption and performance of farmers along the chain. Having people from the community serving as Agro entrepreneurs also promote peer-to-peer engagement which would lead to total inclusiveness of farmers without smartphones. Data generated to aid with end-to-end traceability, and solve mismatches of quantity and quality of Moringa yields. Sample visualization on each tracepoint of interaction amongst farmers, input aggregators, buyers in Odisha, India see (Figure 3)

Figure 3: Visualization of connected points of Interactions



Source: eKutir

Blue Number[13] is a partner of Farmex, making it possible for us to ensure end-to-end traceability along the entire chain. Other turnkey partners of Farmex include Earth Analytics/ SAR MAP[14], Microsoft[15] and South Pole[16]. Through Farmex, all stakeholders within the value chain would know where Moringa raw materials come from, how Moringa finished products are produced, and who uses them. The interesting part is every farmer owns and manages their digital identity account while delivering sustainability and value to all stakeholders. Farmex has the potential to aid data acquisition, smart farming, enhance farmer portfolio management, and informed insights (Figure 5) for policy decisions in the entire Moringa value chain.

[13]Blue Number provides a unique digital identity to each farmer and other stakeholders working with farmers. This enables legality, legitimacy and traceability.

[14] Earth Analytics support spatial data, including satellite-based crop monitoring and remote sensing for digital soil maps.

[15] Microsoft Partner on technological innovation and enhance digital operations, data visualization, machine learning and augmenting artificial intelligence

[16] South Pole advices on carbon reduction and sequestration audits Farmex carbon reduction and sequestration record while supporting the trade of resulting carbon credits.

Figure 4: Farmex Platform Approach

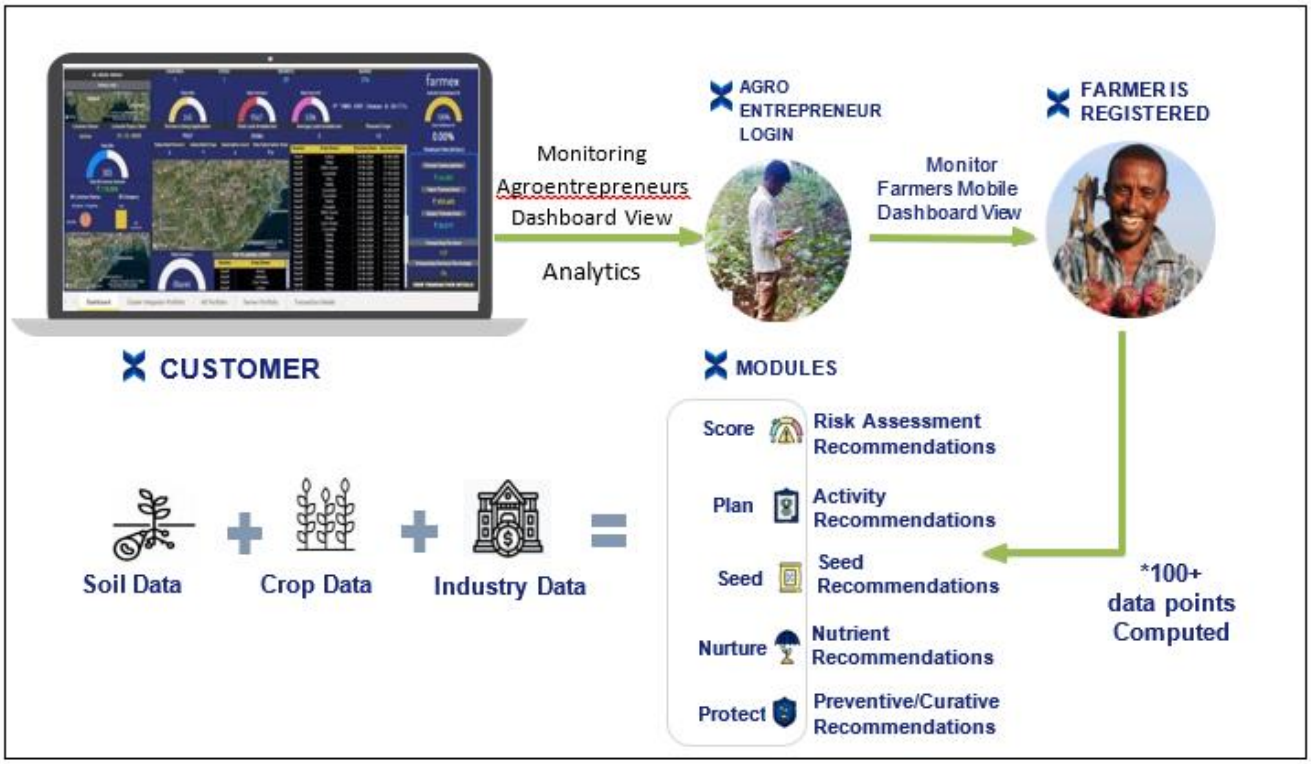
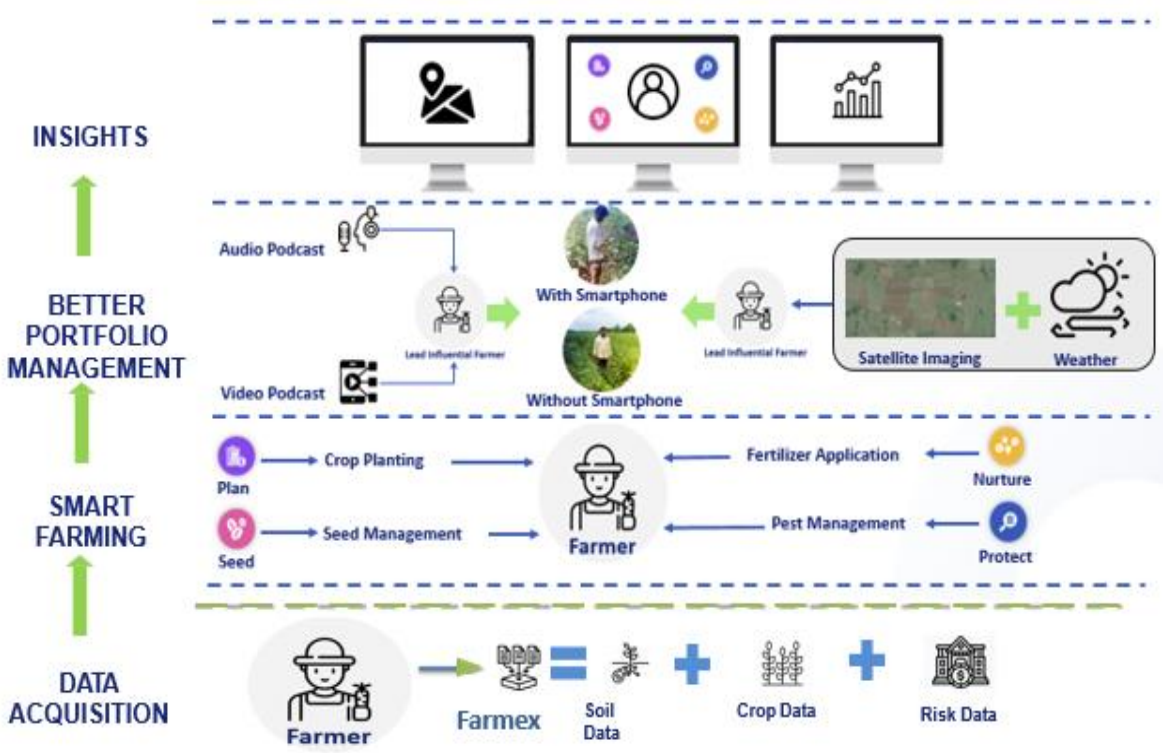


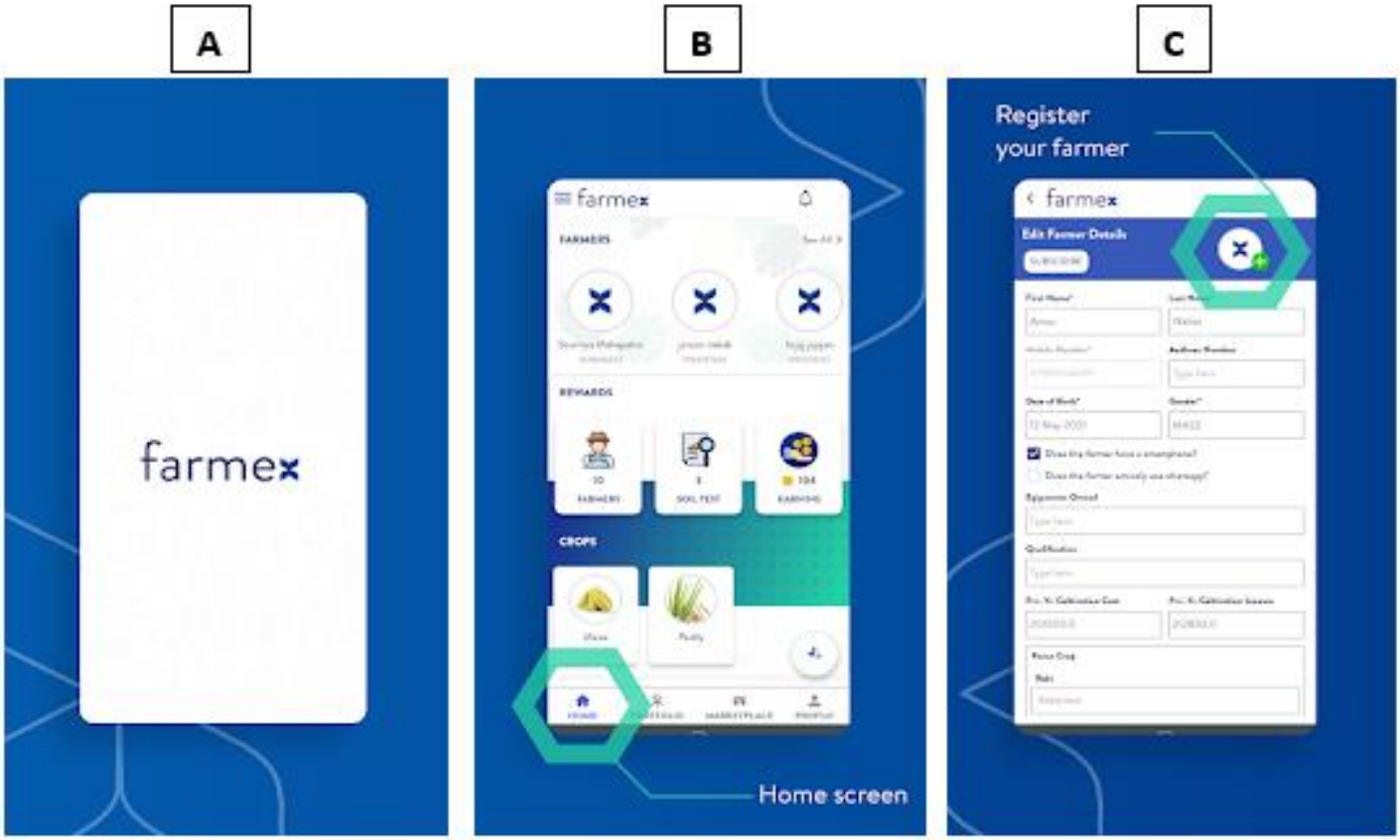
Figure 5: Farmex Solution Potential in Moringa Value Chain



Process of using the Farmex Mobile App.

Farmex mobile app is currently at google play store. All you need is an android phone to download the app and install it. (A) shows the loading interface of the app after it is installed and launch. After launched the user sees (B) as the home screen display.

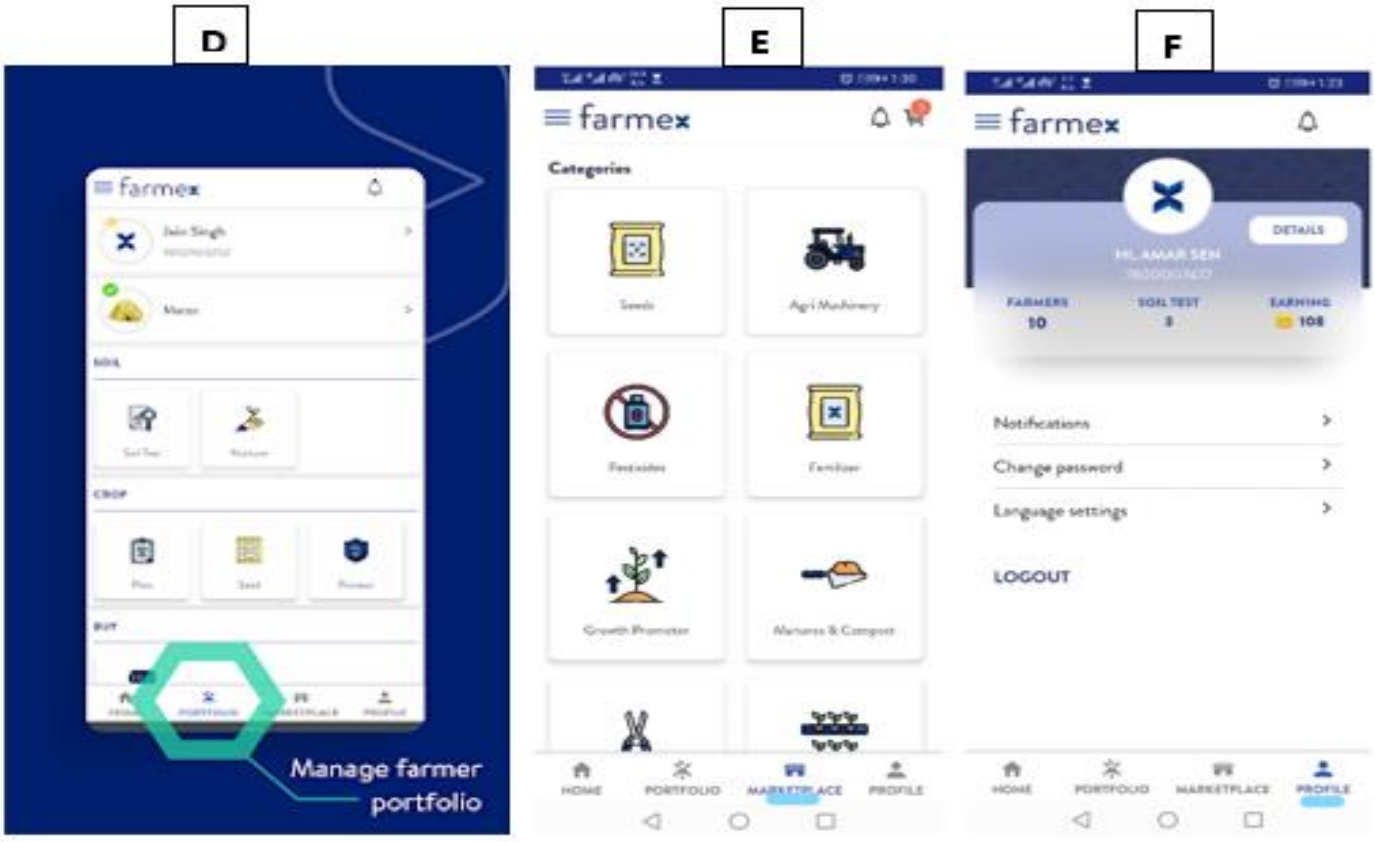
Home Screen displays the farmers' menu, Rewards menu, crops menu and categories menu which gives the user the option to easily navigate through to specific areas of interest. New farmers are registered within the farmers' menu and to register new farmers, the Agro entrepreneurs help new entrants to register by tapping on the farmers' menu in B' and subsequently on the button 'Register your farmer' in C'. New farmer entrant bio-data is taken such as avatar, name, gender, address, community, pin code, status on WhatsApp, district, country etc. and when submitted details of the new farmers are save in the farmers' portfolio and can be updated anytime.



The farmer portfolio is shown in D' support the farmer to ensure a better ROI on Moringa at a lower risk. As a decision-making tool, smallholders would be able to make a useful decision in respect to the type of Moringa seeds to use, fertilizer to apply, how to manage pests and diseases of Moringa. More so, smallholders would have the ability to access available markets for their produce, finance to upscale their productivity.

Marketplace embedded on the platform shown in E' is to deliver precise intelligence to support farmers to select quality inputs at competitive prices from its displayed quality sustainable inputs products examples includes; nursery material, manure and compost, fertilizer, seeds, etc.

Likewise, the farmer profile menu at F' gives a chance for all registered farmers the ability to edit or update their bio-data as and when is available. Farmers too would have access to notifications shared on the platform, ability to change the password as a security measure.



Farmex Value Proposition

Scalable

- One aspect of the platform is its ability to scale across different geographies and farmer ecosystems. Farmex generally can be applied in any crop value chain.

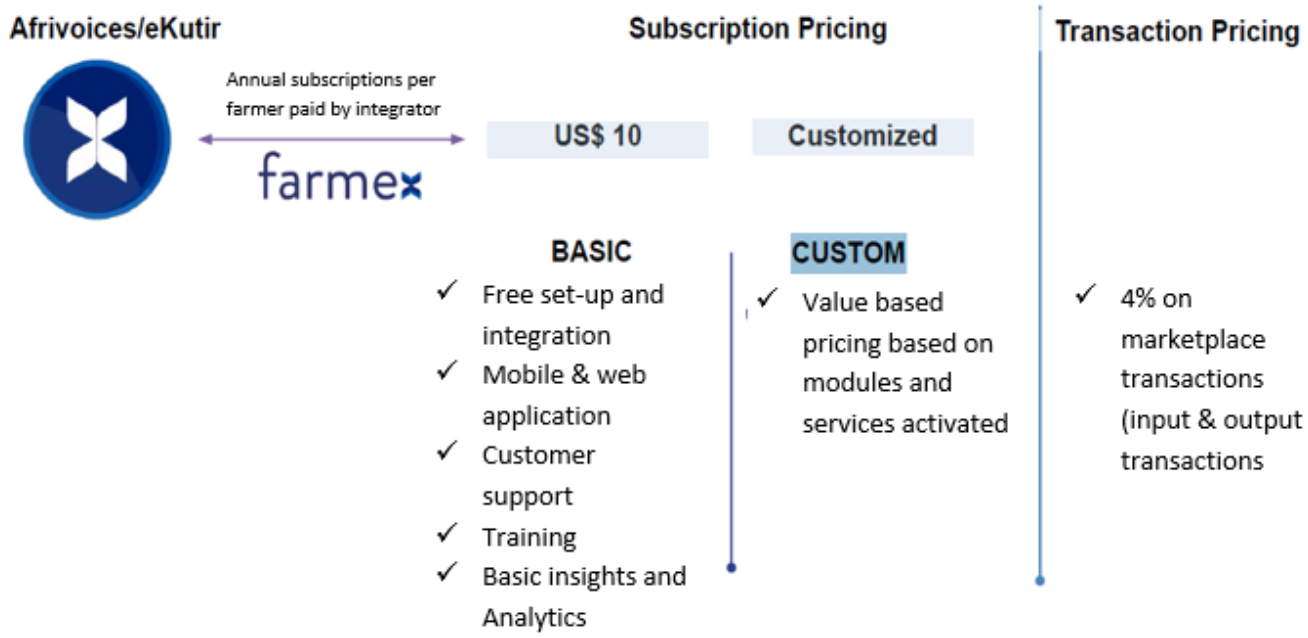
Cost efficiency

- Integrators, institutions, SMEs working can reach farmers at scale at a much lower cost
- Stakeholders would have the ability to manage all transactions with farmers through the web and mobile interface.

Delivering a full-stack solution

- Across the value chain, better real-time data will enable improved decision making for financial institutions and other stakeholders.
- All stakeholders have one source of data that can be traced across the value chain.

Business Model



Project Timeline

2020

- Moringa Market Survey and Baseline Study in Ghana-***completed***
- Participation in SEED replicator workshop-***completed***
- eKutir 3-year partnership agreement sign- ***completed***

2021

- Moringa crop logic developed with Farmex global team-***Completed***
- Identification and sensitization of Pilot Partner in Ghana-***Completed***
- 1st & 2nd Farmex platform Demonstration between us and Farmex Global Team-***Completed***
- Onboarding stakeholder engagement meeting (integrator, buyer and Agro entrepreneurs)-***Completed***
- Pilot Farmex KPI with GPI (pilot partner)- mid-July-late October 2021
    - Digital capacity building (integrator, Agro entrepreneurs and farmers)
    - Technical capacity building (integrator, Agro entrepreneurs and farmers)
    - Onboarding of farmers; 250 farmers
    - Soil tests
    - Digital advocacy activities in communities Moringa growing communities
- Conduct project evaluation survey and prepare for public release: November 2021
- Launching of Farmex in Ghana in partnership with MoFA[17]: December 2021

2022-Long term activities

- Scale-up stakeholder's portfolio by introducing Farmex to many stakeholders
- Establish a Moringa Alliance for all stakeholders in the value chain
- Partner with a research institution and other NGOs working in the field of Moringa to develop an annual research programme for young graduates to undertake more research on Moringa.

[17] MoFA-Ministry of Food and Agriculture

BENEFITS OF ADOPTING FARMEX-MORINGA VALUE CHAIN

The evidence of the impact of eKutir and its digital solutions has received several recognitions (Business Call to Action[18], IFC[19], TED, MIS Quarterly, and evidence-based publication in 20 case studies and scientific journals. Among some include; Dubé et al., 2020, conducted on the impact of eKutir ICTs on fruit and vegetable consumption revealed positive outcomes leveraging on ICTs and therefore suggested for farmers, consumers, and micro-entrepreneurs to fully scale to food and nutrition security calls for the need development of a digital ecosystem; Sustainable Brands, 2018 eKutir system across a range of value chains can impose an exponential impact by increasing returns on investment and reducing transaction costs; based on conditional acceptance of digitized business innovation conducted by Sengupta et al., 2021 on eKutir, it was revealed that accessibility, availability, affordability, awareness and acceptability are essential elements that contribute to stakeholder's adoption of digitized innovations; Larivee & Kristen Dobson, 2017 highlighted eKutir digitized solution as one working at the Base of the Pyramid hence, concluded enterprises working at the base of the pyramid help create impact, are sustainable and can scale. Our technology partner eKutir has operations across the world namely; India, Bangladesh, Nigeria, Nepal, Haiti, Kenya, Cambodia, Philippines and therefore being the first to pioneer its world-recognized digital platform Farmex would create a transformational impact for economic growth and development in Ghana and the world at large.

Social impact

20,000 plus smallholder farmers within five years would increase in quality Moringa yield (15%), incomes (25%), as well experience a reduction in input cost (10%) and post-harvest wastage (7%). This would path a long-term impact by enhancing digital inclusion, reduction of poverty, increase in food and nutrition sustainability among 20,000 smallholder farmers thereby benefiting over 10,000 households. Our impact would be measured by assessing the percentages in an increase in

[18] BCTA recognizes and support the advancement of inclusive businesses with focus to impact people in low and middle income markets and the sustainable development goals. https://www.businesscalltoaction.org/member/ekutir

[19] IFC , Corridors for Shared Prosperity: Intra south-Asia Replication of Inclusive Business Models https://farm-ex.io/wp-content/uploads/2021/03/World-Bank-Corridors-for-Shared-Prosperity-Intra-South-Asia-Replication-PUBLIC.pdf

farmers income, availability of Moringa healthy produce in markets, increase in climate resistance of smallholder farms.

Environmental impact

Our 2 million Moringa trees planted within 5 years would Support the sequestration of carbon dioxide since Moringa sequestrates 20X CO_2 as compared to natural vegetation. The use of organic growth promoters allows farmers to apply 30% less N-synthetic fertiliser. The annual emissions reduction potential resulting from the reduced use of synthetic fertiliser is 0.07 tCO_2e/ha. The annual emissions removal potential resulting from soil carbon increase is 0.46 tCO_2e/ha.

OUR KEY PARTNERS TO TRANSFORM MORINGA VALUE CHAIN

Name	Description	Role in Project	Status
eKutir Rural Management Services Private Limited (eKutir) *Location-India*	Founded in 2009, has led the way in developing data-driven, networked technologies to solve complex societal challenges. They are known for co-designing solutions with isolated and marginalized communities. Its mobile app Farmex connects farmers and Agro entrepreneurs to different stakeholders.	Digital client	Contacted and Partnership agreed
Ghana Permaculture Institute *Location-Ghana*	GPI purchases Moringa leaves and seeds from smallholders and processed them into dry powder and oil for medicinal care products to feed both local (Ghana) and export markets (UK, Austria,	Pilot integrator to reach out to smallholders, and Agro entrepreneurs	Contacted and Partnership agreed

	South Africa, USA, Namibia, Portugal, Switzerland and Nigeria). More so, the organization promotes permaculture systems training and social enterprises to overcome social and environmental degradation		
DPC DATA PROTECTION COMMISSION *Location-Ghana*	DPC is an independent body established under the Data Protection Act, 2012 (Act 843) to protect the privacy of individuals through the regulation of personal information.	Data protection	Registration completed however awaiting Certificate.
Ministry of Food and Agriculture *Location-Ghana*	The Government agency is responsible for the development and growth of agriculture in the country. http://mofa.gov.gh/site/	Food policy and strategy support partner	Not yet contacted

CONCLUSION

Moringa is a future food and we strongly envisaged adopting the Farmex platform play a pivotal role in developing this underutilized natural resource (traditional crop). Hence, we as people and the world could stand the test of time to addressing the woes of malnutrition, poverty and deforestation issues of our time. Optimizing Moringa value chain operations through Farmex would not only improve the lives of the rural poor, and farmers, it would also help marginalized communities transition Moringa trees propagation in Community Resource Management Areas(CREMAs) to reach peak production that supports the ecosystem of degraded landscapes in rural communities. Also, it would also enhance the Moringa commercialization to fuel both domestic and international markets which in turn could stimulate new industry entrants and more opportunities for small investors to reconsider the funding in nutritional programs to save our future generation and reach the SDG goal by 2030.

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APPENDICES

Appendix 1:

Uses of Moringa Comparing Ghana and other Countries

Use	**Description**	**Africa**	**Asia**	**Elsewhere**
Food	Leaves, flowers and pods are eaten as vegetables	Malawi, Ethiopia, Ghana, Kenya, Sudan, Madagascar, Somalia, Benin and Zimbabwe	India, Pakistan, Philippines, Indonesia, Bangladesh	Europe, Latin America
Fodder/Animal feed	Leaves fed to or browsed by livestock such as goats, cattle, sheep and rabbits but also food for fish	Malawi, Ethiopia, Ghana, Kenya, Sudan, Somalia and Zimbabwe	India, Pakistan, Indonesia	Mexico
Medicine	Every part of the tree used widely for a variety of traditional medicine. Diseases treated include conjunctivitis, diarrhoea, diabetes, cancer, fever, cardiovascular diseases, HIV and Aids, scorpion bites, excising evil spirits and charm against witchcraft.	Malawi, Ghana, Sudan, Ethiopia, Kenya, Zimbabwe and Benin	India, Indonesia and Pakistan	Mexico

Oils	Moringa seeds can be pressed to yield high-quality oil which has both nutritional and industrial applications. The oil is said to be pleasantly flavoured, resembling olive oil The oil from the seeds has also been used as industrial oil popularly known as Ben or Behen within the oil trade.	Malawi, Zimbabwe, Sudan, Ghana, Ethiopia, Kenya, Tanzania and Madagascar	India, Bangladesh, Pakistan and Philippines	United Kingdom, Mexico
Water purification	Pounded Moringa seed can be used for small-scale water purification especially in rural areas where there is a great need to improve water quality to avert the risk of using contaminated water and water-borne diseases. It is reported that powdered seeds are used to treat highly turbid river water where coagulation and sedimentation for 1–2 h remove 98–99% of coliform bacteria. The seeds have flocculating	Malawi; Sudan, Egypt, Ethiopia, Zimbabwe, Kenya and Benin	India, Indonesia and Pakistan	United Kingdom

	and anti-microbial properties.			
Live fencing	In most areas, the tree is primarily planted as live fence posts around houses, cattle enclosures, bathing enclosures and toilets. The stakes are spaced at 1.5 to 2.5 m as support for grass fencing. The spacing for fencing also happens to be suitable for the production of leaves, flowers and pods. The species is termite resistant and grows well where other tree species hardly grow.	Malawi, Benin, Sudan, Ghana, Ethiopia, Zimbabwe, Kenya and Tanzania	India	Mexico
Alley cropping/inter cropping	Moringa trees are one of the best multi-purpose trees for use in alley cropping systems. The species is also traditionally grown in mixed multi-storey stands with food crops. This is	Malawi, Ethiopia, Benin, Ghana and Kenya	Indonesia	Mexico

	due to the tree's rapid growth, long taproots, few lateral roots, minimal shade and a large amount of biomass yield rich in protein			
Honey production	Flowers are a good source of nectar for honey bees.	Malawi and Ethiopia		
Ornamental	Moringa trees are planted in gardens and along streets as ornamental plants	Ethiopia, Sudan, Kenya, Zimbabwe and Malawi	India and Bangladesh	
Plant disease prevention	Incorporating Moringa leaves into the soil before planting can prevent damping off disease (Pythiumdebaryanum) among seedlings.	Ethiopia and Malawi		

Source: (Sagona et al., 2020)

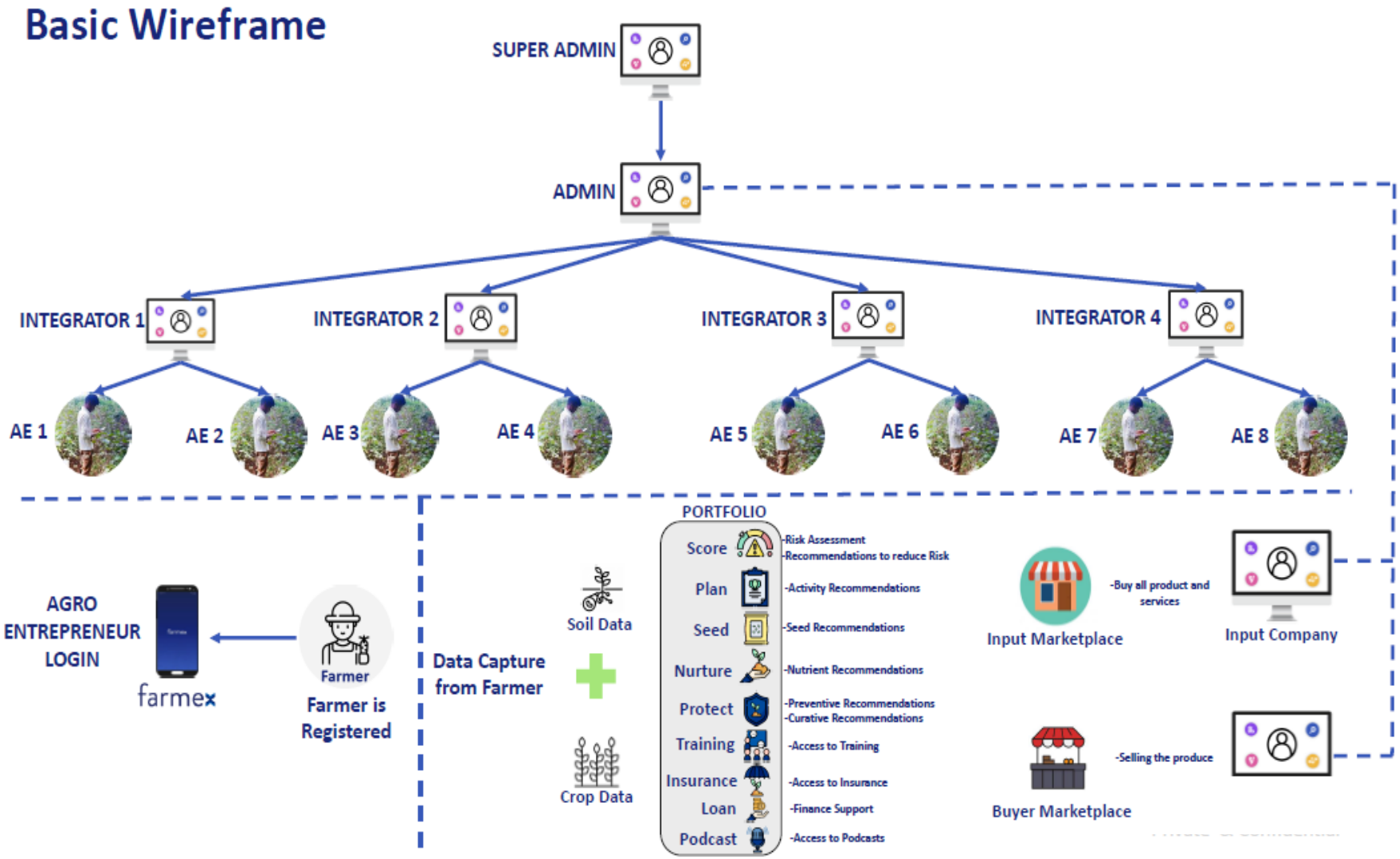
Appendix 2:

Pictures of Superfoods

Moringa Oleifera 	*Fonio* 
Gum Arabic 	***Spirulina*** 

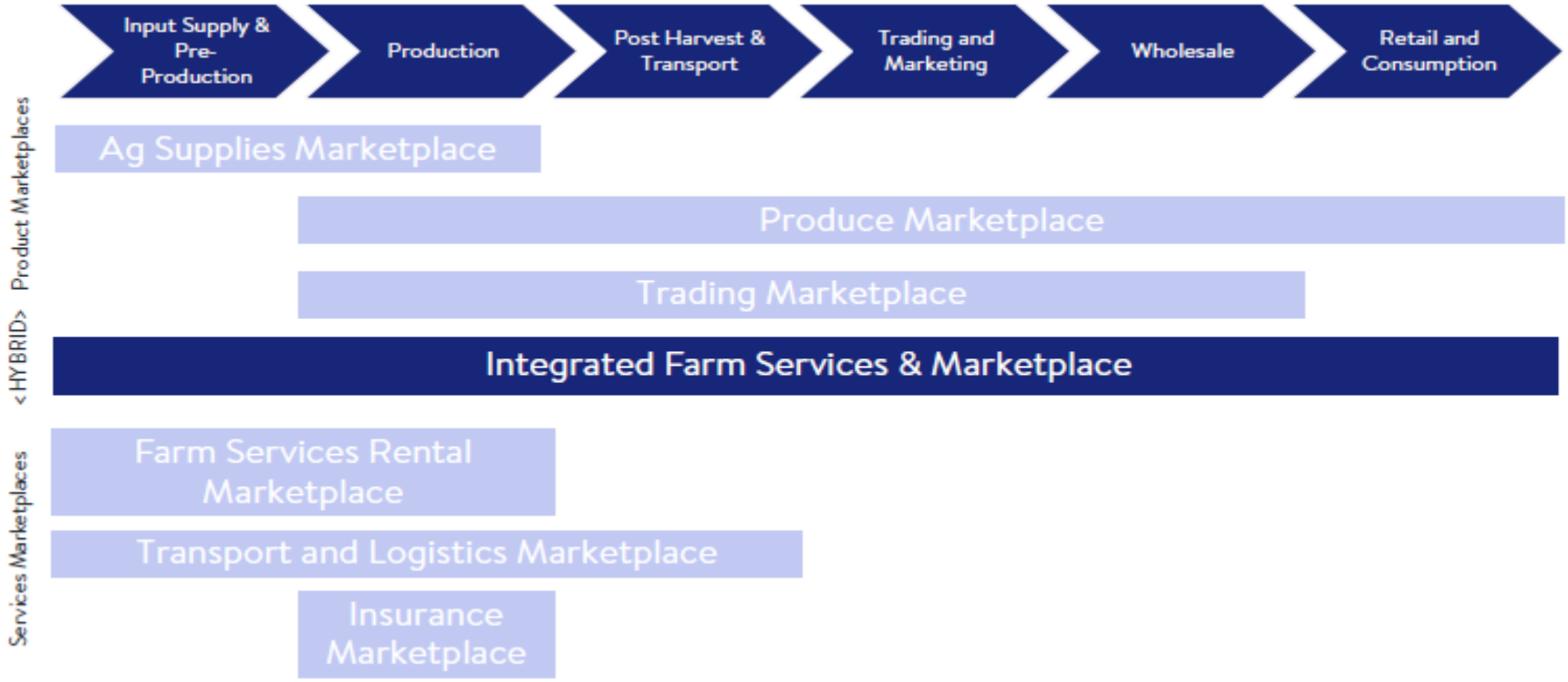
Appendix 3:

Farmex Detail Process Wireframe



Appendix 4:

Farmex compare with platforms not fully integrated



Source: eKutir

Appendix 5:

Seed Replicator Workshop

Government officials during SEED Replicator workshop