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M-Agri Services amongst Dairy Farmers in Western Nigeria: Is the Time Ripe?

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M-Agri Services amongst Dairy Farmers in Western Nigeria: Is the Time Ripe?

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List of Acronyms

ACET	African Center for Economic Transformation
CAP	Common agricultural policy
CLWs	Community livestock worker
CNDDD	Center for Nigerian Dutch Dairy Development
CRV	Coöperatie Rundveeverbetering
CSR	Corporate social responsibility
DAPs	Digital Agriculture Platforms
DDP	Dairy development program
DOI	Diffusion of Innovations
FC	Royal FrieslandCampina N.V.
FCW	FrieslandCampina WAMCO Nigeria PLC
FFMP	Fat-filled milk powder
HCI	Human-computer interactions
HCI4D	Human-computer interactions for development
ICT4D	Information and communication technologies for development
2SCALE	Toward Sustainable Clusters in Agribusiness through Learning in Entrepreneurship
UAES	Unified agricultural extension services
WST	World-systems theory
WTO	World Trade Organisation

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1: Introduction

Since the turn of the century, Africa started experiencing a food trade deficit. Since then, this deficit has increased, leading to a large cash outflow which damages African economies.^{1,2} One of the industries for which this trend is visible, is the Nigerian dairy industry. 64% of the dairy products that Nigerians consume is produced by milk powder that is imported from countries like the Netherlands, Denmark, New Zealand and the United States. This causes a yearly cash outflow of 1.3 billion USD.³ Currently, Nigeria's net food trade deficit is 10 billion USD.⁴ The Nigerian dairy demand is expected to increase tremendously as a result of both extraordinary population growth and an increasing demand for fat- and protein-rich products such as dairy products.⁵

To protect the Nigeria against an even higher import bill, the Nigerian government requires the dairy companies which import the milk to source milk locally. For instance, it has the power to grant and withdraw licences to operate and recently, it added dairy to a forex restriction list. For dairy companies, this means that they cannot import unlimited amounts of milk powder and that they are incentivised to source milk locally instead.⁶

With a market share of approximately 75%, the dairy company FrieslandCampina WAMCO Nigeria PLC (FCW), a subsidiary of the Dutch parent company and cooperative Royal FrieslandCampina N.V. (FC) is the market leader in the Nigerian dairy industry.⁷ Currently, FCW imports between 85% and 98% of the dairy that it sells in Nigeria.^{8,9} Because Nigeria is FC's most profitable country, FC wants to secure the future.¹⁰ To comply with government demands, it started initiatives to increase the share of locally sourced milk. FCW's most significant project to realise this is the mDairy project.¹¹ mDairy is a digital platform designed for smartphone use which enables milk tracing, agriculture extension to farmers, and communication and value chain transparency.

The use of m-Agri services, which refers to "*mobile-phone enabled application initiative(s) for agriculture*", has increased during the past decades. Amongst others, they foster health tracking, receiving weather forecasts and updates about actual prices and other forms of information sharing

¹ Ousmane Badiane, Sunday Pierre Odjo, and Julia Collins, *Africa Agriculture Trade Monitor 2018* (Washington, DC: International Food Policy Research Institute, 2018): 5.

² Lemma W. Senbet and Witness Simbanegavi, "Agriculture and Structural Transformation in Africa: An Overview," *Journal of African Economies* 26, no. 1 (August 2017): 5-6.

³ Federal Ministry of Agriculture and Rural Development, *National Dairy Policy: March 2021 (Draft)* (2021): 13; 15.

⁴ International Trade Monitor, last modified October 13, 2021, <https://www.trade.gov/country-commercial-guides/nigeria-agriculture-sector>.

⁵ Badiane, Odjo and Collins, *Trade Monitor*, 111.

⁶ National Daily Newspaper, "CBN restrict forex for milk import to six companies," last modified February 11, 2020, <https://nationaldailyng.com/cbn-restrict-forex-for-milk-import-to-six-companies/>.

⁷ Ogbuagu Ekumankama, Abel Ezeoha and Chibuike Uche, "The role of multinational corporations in local dairy value chain development: case of Friesland Campina WAMCO (FCW) in Nigeria," *International Food and Agribusiness Management Review* 23, no. 1 (2020): 57.

⁸ Stijn Markers, "Interview with Stijn Markers, Dairy Development Manager at FC," interview by Robin van Seumeren, June 2, 2022, 09:00.

⁹ Ekumankama, Ezeoha and Uche, "The role," 57.

¹⁰ Stijn Markers, email correspondence, June 2, 2022.

¹¹ Ola Adeyinka, "Interview 3 with Ola Adeyinka, mDairy Pilot Manager," interview by Robin van Seumeren, July 8, 2022, 1:01:00.

and communication.¹² Various scholars talk about a fourth agricultural revolution and some argue that m-Agri services can significantly reduce Africa's food security issues.^{13, 14} Other scholars are more sceptical about the benefits that m-Agri services bring to African countries and point out that they are primarily effective in the global north. They warn against Eurocentrism and extrapolating findings from the global north to the global south.^{15, 16, 17}

Because there is a high urgency for better understanding whether m-Agri services can assist African countries in gaining higher agricultural yields, I designed a case study in which I evaluated mDairy. Because m-Agri services have proven to be successful in developed countries with productive dairy value chains, such as the Netherlands, I decided to compare the mDairy with m-Agri services that Dutch farmers use. I also wondered whether increased connectivity and knowledge exchange, both regarding m-Agri services and in general, could enhance the performance of Nigerian farmers. Because the contexts in which Dutch and Nigerian farmers operate are worlds apart, it is imperative to take contextual differences into account. All in all, these questions and considerations made me create the following research question:

How do Nigerian and Dutch dairy agriculture and m-Agri services compare and would increased interconnectivity, for instance through frugal innovation, be possible and value-enhancing for Nigerian farmers?

To answer this question, I take an interdisciplinary approach because successful digital agriculture requires input from a diverse range of sources, e.g. climate, governance, economy, infrastructure, research institutions. To assess the applicability of mDairy, I use the diffusion of innovations theory.¹⁸ To investigate the overarching theme of food independence in Africa, I juxtapose the factor endowment theory and the world-systems theory (WST).

I conclude that there are two changes required before m-Agri services like mDairy can reach their potential and develop value chains in Africa. One change I consider to be comprehensible and achievable, but the second is more structural and difficult, though not impossible. Firstly, Nigerian dairy farmers need to undergo an ideological and behavioural change before m-Agri services can flourish and develop the value chain. The traditional way of dairy farming is deeply embedded in the culture of most dairy farmers. mDairy, which promotes innovative dairy practices such as zero- or semi-grazing, can only be successful if farmers are firstly shown the way through active one-on-one interactions. Closer Dutch-Nigerian farmer connectivity is an important way through which Nigerian dairy farmers can be persuaded to adopt innovative dairy practices. This can happen through Nigerian extension officers, but it can also happen by connecting Dutch farmers to Nigerian farmers.

¹² Enzinne M. Emeana, Liz Trenchard, and Katharina Dehnen-Schmutz, "The Revolution of Mobile Phone-Enabled Services for Agricultural Development (m-Agri Services) in Africa: The Challenges for Sustainability," *Sustainability* 12, no. 2 (January 2020): 486.

¹³ Hannah Barret and David Christian Rose, "Perceptions of the Fourth Agricultural Revolution: What's In, What's Out, and What Consequences are Anticipated?" *Sociologia Ruralis* 62, no. 2 (April 2022): 162.

¹⁴ Emeana, Trenchard, and Dehnen-Schmutz, "Revolution," 485.

¹⁵ Ibid.

¹⁶ Laurens Klerkx, Emma Jakku, and Pierre Labarthe, "A review of social science on digital agriculture, smart farming and agriculture 4.0: New contributions and a future research agenda," *Wageningen Journal of Life Sciences* 90-91 (December 2019): 12.

¹⁷ Monchi Lio and Meng-Chun Liu, "ICT and agricultural productivity: evidence from cross-country data," *Agricultural Economics* 34, no. 3 (April 2016): 223-227.

¹⁸ Everett M. Rogers, *Diffusion of Innovations* (New York: The Free Press, 1983): 211.

Secondly, for mDairy and other m-Agri services to become nation- or continent-wide used services, which assist in reducing Africa's food dependency and insecurity, certain cases of food imports, which could be considered unfair, need to be reduced. Most scholars explain imports by pointing to factor endowments such as education levels, infrastructure and the climate and they insinuate that sourcing milk from countries with highly developed dairy value chains is cheaper than sourcing it locally. I find that this may only be the case because the imported milk is a different product than locally sourced milk. Nigerian farmers produce whole milk whereas the imported milk is fat-filled milk powder (FFMP). FFMP is made from skimmed milk, a by-product, to which cheap vegetable oils are added. Therefore, it can be sold at a very low price that Nigerian farmers cannot compete with. Nigerian farmers cannot produce FFMP because the required milk sprayers are absent in Nigeria. It can be considered unfair since the imported milk has a lower nutritional value than locally sourced milk and because sourcing whole milk locally may be cheaper than importing whole milk powder. The Nigerian government cannot address this problem effectively, for instance through protectionism, because the country is highly dependent on FC for its dairy supply. My findings are in line with WST as I identify a situation where the Nigerian dairy sector is trapped in a reciprocal system where it has difficulty freeing itself from the periphery. To alleviate the problem, the Nigerian government could import and promote milk sprayers and other ways to process milk.

Before proceeding to the remaining chapters, I firstly describe what they entail. Chapter 2 contains a literature review. I discuss the state of Nigeria's dairy sector and explanations thereof, as well as m-Agri services and the use of these by Nigerian farmers and African dairy farmers. With chapter 3, I present the conceptual framework. I discuss the theories and concepts that guide my research. In chapter 4, I explain my methodology. I explain why I did a case study on mDairy and I explain how I structured my analysis. In chapter 5, I address the first part of the research question by comparing Nigerian and Dutch dairy farming. Chapter 6 shows how m-Agri services benefit Dutch dairy farmers and it examines if mDairy adds value to Nigerian dairy farmers. Chapter 7 investigates whether increased connectivity, for instance through frugal innovation, could be value-enhancing. This chapter simultaneously fulfils the function of a discussion section. I look if connectivity could address problems identified in chapters 5 and 6 and I discuss my findings in relation to those of other scholars. At last, chapter 8 contains a conclusion. In this chapter, I also address limitations and recommendations for future research.

2: Literature Review

Because the broader theme of this thesis is food security in Africa, it is important to discuss how the state of the Nigerian dairy market matches with general characteristics and developments of food systems in Africa. Therefore, I begin with a broad discussion of the general state of food systems in Africa. I discuss how the dairy sector is a sector in which general agricultural developments, for instance a trade deficit, are highly articulated. Also, literature shows that Nigeria is a country for which these trends, both in general and specifically in the dairy sector, hold. Next, I discuss what arguments scholars have put forward to explain this situation of the Nigerian dairy industry. The second part of the literature review discusses literature regarding digital agriculture, particularly m-Agri services. I discuss what scholars said about the impact of m-Agri services, especially in the context of Nigeria and dairy systems in Africa. At last, I point out the research niche and I explain how I respond to this.

2.1. Nigeria's Dairy Market in the Context of Africa's Food Market

The agricultural sector is an important sector for many African countries. Although the contribution of agriculture to the GDP of Africa has declined from approximately 40% in 1970 to 25% in 2015, the percentage of the population employed in this sector remains high. For most countries, this percentage ranges between 20% and 50%.¹⁹ The fact that the percentage of the population employed in agriculture is significantly larger than the contribution of agriculture to the GDP indicates that the productivity is relatively low and that poverty is relatively high.

Around the turn of the century, Africa started experiencing a net food trade deficit. This deficit has been increasing ever since. Both agricultural imports and exports increase, but the imports increase faster. Whereas exports triples between 1998 and 2013, imports grew fivefold. In 2013, Africa's food imports were worth approximately 90 billion USD and food exports were worth 55 billion USD.²⁰ According to Senbet and Simbanegavi, Africa experienced a net food trade deficit of 50 billion USD in 2017 which they expect to triple by 2030.²¹ To put this in perspective, Sub-Sahara's exports of all industries were worth 241 billion USD and the imports 253 billion USD.²² Thus, the total trade deficit of Sub-Sahara Africa is 12 billion USD. This shows that the current food trade deficit, which is expected to triple, is a highly urgent matter. Apart from the trade-deficit, another reason for developing local food value chains is to reduce the poverty rate. Many of the poorest inhabitants of Africa practice agriculture so developing their businesses would reduce poverty rates.²³ Because Africa possesses 60% of the world's uncultivated land, scholars argue that there is large potential for agriculture in Africa.²⁴

For researching this problem, focussing on the dairy industry is useful since the characteristics described above are highly present for African dairy sectors. The African Center for Economic Transformation (ACET) explains that the demand for dairy products is increasing and that local dairy

¹⁹ African Center for Economic Transformation, *African Transformation Report 2017: Agriculture Powering Africa's Economic Transformation* (2017): 21-25.

²⁰ Badiane, Odjo and Collins, *Trade Monitor*, 5.

²¹ Senbet and Simbanegavi, "Agriculture and Structural Transformation," 5-6.

²² World Integrated Trade Solution, "Trade Summary for Sub-Saharan Africa," last accessed July 8, 2022, <https://wits.worldbank.org/CountrySnapshot/en/SSF/textview>.

²³ Senbet and Simbanegavi, "Agriculture and Structural Transformation," 4.

²⁴ African Center for Economic Transformation, *African Transformation Report 2017*, 35.

sectors are underdeveloped.²⁵ According to the report by the ACET, “*Dairy is probably Africa’s least developed agricultural sector*”. The authors say that the growing demand is “*increasingly met by imports*.”²⁶ Many African countries are net importers of dairy products. Therefore, developing local dairy industries is an important matter for many African countries. The ACET explains that the increasing demand for dairy products is in accordance with Bennett’s law, which states that people demand more nutrient-dense foods as their income increases.²⁷ Apart from the demand, the Nigerian supply is also increasing. However, this is clearly not happening fast enough. This increased supply is also merely the result of a higher number of cows and not the result of more productive cows.²⁸

This evidence shows that focussing on the dairy industry is legitimate. It is also legitimate to focus on Nigeria because Nigeria’s food situation is in line with the general trend amongst African countries which I described earlier. Nigeria currently is a net importer of 10 billion USD²⁹ and the food imports grow with 11% each year.³⁰ Numbers regarding the percentage of dairy important vary. According to the Nigerian government, it currently imports 64% of the dairy consumed. This amounts to an import bill of 1.3 billion USD. These imports primarily come from countries like the Netherlands, Denmark, New Zealand and the United States.³¹ In West Africa, dairy products are the sixth most imported products after rice, wheat products, vegetable oils, palm oil and sugar.³² When products are imported, this is often done by foreign owned multinationals that produce the products. In Nigeria’s dairy sector, FCW is the largest company that does so. It has a market share of 75%.³³

2.2. Explanations for Nigeria’s Problematic Dairy Market

There are various scholars who have put forward reasons to explain Nigeria’s trade deficit. I have structured this section according to themes that are relevant for my research. I firstly explain the increased demand. Afterwards, I explain the supply side. I do this by focussing on the traditional Nigerian dairy farming culture, the cheap imports from the global north and government policies by the Nigerian government.

Increasing Demand

The trade deficit depends on both the supply and the demand of dairy. The current Nigerian consumption is 1.6 billion litres, which implies on average a consumption of 2 litres per capita annually.³⁴ Scholars have identified various reasons for the increased demand for dairy products in Africa. The ACET firstly pointed to urbanisation. As people move to cities, they tend to buy food

²⁵ African Center for Economic Transformation, *African Transformation Report 2017*, 5

²⁶ Ibid, 109.

²⁷ Ibid, 100.

²⁸ I. Y. Ilu, A. Frank, and I. Annette, *Review of the Livestock/Meat and Milk value Chains and Policy Influencing them in Nigeria* (Rome: Food and Agriculture Organisation of the United Nations; Economic Community of West African States, 2016): 1.

²⁹ International Trade Administration, “Nigeria – Commercial Guide,” last modified October 12, 2021, <https://www.trade.gov/country-commercial-guides/nigeria-agriculture-sector>.

³⁰ Ifeanyi Onuka Onwuka, “Reversing Nigeria’s Food Import Dependency – Agricultural Transformation,” *Agricultural Development 2*, no. 1 (December 2017): 6.

³¹ Federal Ministry of Agriculture and Rural Development, *National Dairy Policy*, 13; 15.

³² African Center for Economic Transformation, *African Transformation Report 2017*, 101; 107.

³³ Ekumankama, Ezeoha, and Uche, “The role,” 57.

³⁴ Federal Ministry of Agriculture and Rural Development, *National Dairy Policy*, 13.

instead of producing it themselves. Secondly, they point to low productivity and thirdly, to high transportation costs to cities. Fourthly, people increasingly demand processed food, convenience food, meat and dairy, which is difficult to be met by African food production systems.³⁵ Badiane, Odjo and Collins also point out four main reasons, some of which are similar. They point to population growth, urbanisation, income changes and changes in food diets and demands.³⁶

Population growth and changing diets (resulting from higher incomes and urbanisation) are the most frequently mentioned reasons. Nigeria's population stands currently at approximately 200 million inhabitants. This number is expected to be doubled by 2050.³⁷ Table 1 shows that dairy has the second-highest sales CAGR between 2011 and 2016.

Categories	Sales Volume Growth				1998-11 CAGR	2011-16 CAGR
	1998	2005	2011	2016	(%)	(%)
Noodles	37.7	54.4	143.3	214.8	10.8	8.4
Bakery	599.8	913.2	1007.1	1146.4	4.1	2.6
Baby food	3.6	4.7	5.6	6.2	3.3	2.1
Dried processed food	927.9	1062.8	1348.7	1623.7	0.9	3.8
Sauces, dressings and condiments	7.0	92.1	103.8	112.7	2.3	1.7
Soup	1.7	1.7	2.0	2.3	1.3	3.4
Dairy	208.3	184.8	232.2	285.9	0.8	4.3
Frozen processed	6.6	6.0	7.4	8.7	0.8	3.3
Sweet and savoury	5.2	4.6	5.4	6.4	0.3	3.2
Canned or preserved	12.2	10.8	12.2	13.9	0.0	2.7
Ice cream	5.5	3.4	3.8	4.6	-2.7	3.7
Oils and fats	163	113.2	108.7	112.2	-3.1	0.6

Table 1: Growth in sales of packaged food products in Nigeria based on 2012 data³⁸

Nigerian Dairy Farming Tradition

Ebo explains that Nigeria has a large cow population of approximately 20 million cows. However, the large majority are cows that are used for meat production. Only 2.35 million cows are used for dairy production. Also, the productivity of these cows is low. She says that these cows produce 1 litre of milk per day on average.³⁹

The Nigerian government states that out of the 1.6 billion litres consumed, 570 million litres are supplied locally.⁴⁰ Scholars often distinguish between pastoralists and commercial farmers.⁴¹ Most of the pastoralists are Fulanis with an average of 18 cows. They mostly live in Northern Nigerian and

³⁵ African Center for Economic Transformation, *African Transformation Report 2017*, 5.

³⁶ Badiane, Odjo and Collins, *Trade Monitor*, 4.

³⁷ Federal Ministry of Agriculture and Rural Development, *National Dairy Policy*, 1.

³⁸ Frank Hollinger and John M. Staatz, *Agricultural Growth in West Africa* (Rome: African Development Bank; Food and Agriculture Organization of the United States, 2015): 175.

³⁹ Nathalie Ebo, *The Nigerian Dairy Sector* (Lagos: Sahel Consulting Agriculture and Nutrition Ltd., 2019): 3.

⁴⁰ Federal Ministry of Agriculture and Rural Development, *National Dairy Policy*, 13; 15.

⁴¹ Ekumankama, Ezeoha and Uche, "The role," 58.

migrate south during the dry season to look for water and grasses. According to Ebo, 95% of the locally produced milk comes from these pastoralists.⁴²

According to the Nigerian government, 95% of the Nigerian cattle is owned by pastoralist and 5% is owned by commercial small and medium enterprise farmers. The Nigerian government further categorises the pastoralists into non-settled pastoralists, settled peri-urban pastoralists, urban pastoralists (table 2).

	Non-settled pastoralists	Settled peri-urban pastoralists	Urban pastoralists	Commercial dairy farmers
Number of cows	300 (including sheep and goats)	20-100	5-20	50-1000
Cow productivity	0.5-1 litre	1-3 litres	8-10 litres	15 litres
Farming system	Nomadic/no crop farming/crossing long distances	Settled/grazing harvested areas	Settled/urban /zero- or semi-intensive grazing	Zero-grazing
Type of cows	Indigenous	Mainly indigenous	Indigenous with few crossbreeds	Exotic breeds or crossbreeds
Supplements	No	Sometimes agricultural by-products	Main source of nutrition	Intensified feed production
Reproduction	Natural	Natural	Natural or artificial insemination	Artificial insemination
Labour	Family labour	Family labour	Family and hired labour	Hired labour
Health care	No	Occasional medical assistance	Vaccination and other health interventions	Yes (advanced)
Processing of milk	Locally into local products	Locally into local products	Market oriented but little skills in processing	Commercial

Table 2: Types of Nigerian dairy farmers⁴³

Ekumankama, Ezeoha and Uche explain that the milk value chains that these pastoralists find themselves in, contain middlemen and informal ties.⁴⁴ Also, the large majority of this milk is not processed.⁴⁵ Because these farmers are large in number and possess small herds, and because of the middlemen and informal ties, they are difficult to be managed in a centralised way even though this would make production more efficient. Also, their traditional lifestyle, lack of knowledge on modern agricultural practices and a lack of capital impedes them from applying technologies, mechanisation, quality control and data analytics which is required for development.⁴⁶

⁴² Ebo, *Nigerian Dairy Sector*, 4.

⁴³ Federal Ministry of Agriculture and Rural Development, *National Dairy Policy*, 15-16.

⁴⁴ Ekumankama, Ezeoha and Uche, "The role," 56

⁴⁵ Federal Ministry of Agriculture and Rural Development, *National Dairy Policy*, 31.

⁴⁶ Ebo, *Nigerian Dairy Sector*, 2-5.

The low productivity amongst Nigerian farmers is also the result because of the breed of cow that Nigerian farmers mainly use, the Bunaji cows. Saleh et al. studied the performance and profitability of different cow breeds in Nigeria. The Bunaji, the crossbreed and the Frisian-Holstein respectively produced an average of 4.03, 8.83 and 15.22 litres milk per day in Nigeria. The scholars also did a gross margin analysis and recommended the use of crossbreeds or pure Frisian-Holstein cows as this was more profitable.⁴⁷

Cheap Imports from the Global North

Ekumkama, Ezeoha and Uche point out that the dairy companies in the Nigerian dairy industry are not motivated to integrate themselves with local value chains. Importing milk is cheaper than buying it from smallholder farmers.⁴⁸ This is also supported by Ilu and Annetta, who calculated in 2016 that the profit on locally produced dairy products is 8% whereas the profit on imported products is 15%.⁴⁹

Badiane et al explain that agricultural subsidies and export subsidies in the United States and the European Union play an important role in the African agriculture trade deficit. Zamani, Pelikan and Schott also expresses this concern when discussing the export of livestock products (including dairy) from the European Union to West Africa.^{50, 51} After the second world war, European countries wanted to be more self-sustaining in terms of food productivity. This is why they designed the common agricultural policy (CAP). Subsidies per litre milk caused an overproduction and surpluses were exported to developing countries such as those in Africa.⁵² The subsidies used to be in the form that farmers in Europe received a minimum milk price. Because of this guaranteed minimum price, farmers started to produce large amounts of milk which would not be consumed by European customers. This resulted in a “butter mountain” and led to exporting cheap dairy products to African countries. In the 80s, milk quotas were installed to combat this situation which was unnecessarily costly for European countries.⁵³ Over the decennia, the CAP expenditure percentage has decreased but it still constitutes 38%.⁵⁴ For understanding this percentage properly, it is important to know that the agricultural sector is the only sector for which public expenditure is pooled at the EU level. The European commission points out that CAP expenditure makes up less than 1% of public spending amongst EU members and that public expenditure on defence is on average three times as large.⁵⁵

Matthews and Soldi conducted an extensive study on the effects of CAP on agriculture in developing countries. They argue that agricultural production in the EU would be 5 to 6 percent lower if the CAP would not be present. However, the scholars primarily argue that the elimination of milk quotas in 2015 has been important in recent development in the European dairy systems. Because of the

⁴⁷ Salah et al., “Improved Dairy Cattle Technologies,” 10.

⁴⁸ Ekumankama, Ezeoha, and Uche, “The role,” 61-65.

⁴⁹ Ilu, Frank and Annatte, “Review,” 19.

⁵⁰ Badiane, Odjo and Collins, *Trade Monitor*, 103.

⁵¹ Omid Zamani, Janine Pelikan and Johanna Schott, *EU exports of livestock products to West Africa: An analysis of dairy and poultry trade data* (Braunschweig: Thünen Institute of Market Analysis, 2021): 3.

⁵² Alan Matthews and Rosella Soldi, *Evaluation of the impact of the current CAP on the agriculture of developing countries* (Brussels: European Committee of the Regions, 2019): 5; 67.

⁵³ Grant, Wyn Grant, *The Common Agricultural Policy* (London: Bloomsbury Publishing Plc, 1997): 106-116.

⁵⁴ European Commission, *CAP expenditure in the total EU expenditure* (Brussels: European Commission, 2019): 3.

⁵⁵ European Commission, “The common agricultural policy (CAP) and agriculture in Europe – Frequently asked questions,” last modified June 28, 2013, https://ec.europa.eu/commission/presscorner/detail/en/MEMO_13_631.

removal of these quotas, farmers in North-Western Europe, who have the most profitable businesses, started to produce more milk.⁵⁶ Matthews and Soldi also explain that the milk powder that the European countries export and that countries like Nigeria import, is mainly fat-filled milk powder (FFMP). For this FFMP, the butterfat is often replaced by palm oil. This technological development is separate from CAP but explains the increased competitiveness of the imported milk powder. The price of butter (which is made from milk fat) has increased significantly recently. Simultaneously, the price of vegetable oils has decreased.⁵⁷ The skimmed milk powder can be understood as a residue. Palm oil is added to skimmed milk powder to turn it into FFMP. Because skimmed milk is a by-product, it can be exported at a very low price.⁵⁸ Choplin also comments on this. He explains that FFMP has a lower nutritional value than whole milk. He argues that many people in West Africa do not understand the difference between the product and that this is partly due to dairy companies withholding information with their packaging.⁵⁹

Nigerian Government Policies

Many scholars criticise the Nigerian government for the poor state of Nigeria's agricultural systems and specifically, the dairy systems. For instance, Onwuka explains how the Nigerian government focussed primarily on the oil sector and neglected the development of agriculture. This is one reason why agriculture-related infrastructure, including roads, electricity and internet, are lacking.⁶⁰

The fact that the government does not take care of the agriculture can also be seen from the amount of public spending. In 2003, the African Union declared that public spending would not be lower than 10% in order to establish collective agriculture development on the continent. Yet, the Nigerian public spending has on average been less than 4% since then.⁶¹ Nigeria's current public spending on agriculture stands at 1.8%.⁶²

Apart from this physical infrastructure, Ekumankama, Ezeoha and Uche also point to the underdevelopment of institutional legislative infrastructure. This, in combination with Nigeria being a politically unstable and relatively unsafe country, impedes dairy companies from making long-term investments.⁶³

The Nigerian government acknowledges that previous policies have not led to the desired results. It writes that former policies to develop dairy systems were naïve and focussed primarily on production without taking into account other activities like, processing, marketing and consumption.⁶⁴ One way through which the Nigerian government currently tries to foster local production is by restricting companies from importing certain products. Recently, it put milk and other dairy products on a forex

⁵⁶ Matthews and Soldi, *Evaluation*, 68.

⁵⁷ Gérard Choplin, *Let's Not Export Our Problems* (Brussels: SOS Faim, Oxfam-Solidarité, Vétérinaires sans frontières, and Mon Lait est Local, 2019): 4.

⁵⁸ Matthews and Soldi, *Evaluation*, 68.

⁵⁹ Choplin, *Let's not Export Our Problems*, 4.

⁶⁰ Onwuka, "Reversing," 1.

⁶¹ Ebi Bassey Okon and Amaraihu Omeremma Christopher, "Agriculture Expenditure, Maputo Declaration Target and Agricultural Output: A Case Study of Nigeria," *International Journal of Economics, Commerce and Management* 6, no. 7 (July 2018): 516.

⁶² Mary Izuaka, "Nigeria's agric spending plan highest in four years but still far below AU benchmark," last modified October 15, 2021, <https://www.premiumtimesng.com/agriculture/agric-news/490001-nigerias-agric-spending-plan-highest-in-four-years-but-still-far-below-au-benchmark.html>.

⁶³ Ekumankama, Ezeoha, and Uche, "The role," 58.

⁶⁴ Federal Ministry of Agriculture and Rural Development, *National Dairy Policy*, 4-5.

restriction list and this has serious implications for FCW. With this action, FCW cannot import as much milk powder as it used to and it is motivated to source more milk locally.⁶⁵

2.3. M-Agri Services

The topic of m-Agri services in agriculture belongs to digital agriculture. Digital agriculture is an emerging and relatively new concept in the academic literature. Nevertheless, there have been many publications on this topic. Because the topic is emerging, there are still many unclarities. Multiple scholars have attempted to create an overview in the large and dispersed amount of literature that has been written in a short amount of time. Klerkx, Jakku and Labarthe refer to it as “*burgeoning but scattered*”.⁶⁶ Klerkx, Jakku and Labarthe, as well as Kuuku Sam and Saartjie Grobbelaar, respectively wrote an article and a book chapter in which they presented their in-depth review of the digital agriculture literature.^{67, 68} In both publications, the scholars categorised the publications that they review. This gives an overview of the diverse ranges of perspectives from which digital agriculture has been studied (table 3).

Klerkx, Jakku and Labarthe:	Kukuu Sam and Saartjie Grobbelaar:
Adoption, uses and adaptation of digital technologies on farm	Adoption, use and adaption of digital agriculture platforms
Effects of digitalization on farmer identity, farmer skills, and farm work	Impact of DAP
Power, ownership, privacy and ethics in digitalizing agricultural production systems and value chains	Economics and management of DAPs in agriculture value chains
Digitalization and agricultural knowledge and innovation systems	Digital platforms and agriculture knowledge and innovation (Eco)systems
Economics and management of digitalized agricultural production systems and value chains	DAP from the Policy/Politics/Governance/Perspective

Table 3: Common topics in literature on digital agriculture^{69, 70}

M-Agri services are a form of digital agriculture. They can improve productivity and profitability because communication and information-sharing are enhanced. For instance, local weather forecasts, actual prices and efficient agricultural practices can be communicated. Also, farmers can communicate with each other and with other members of the value chain. Farmers can be assessed individually and can receive tailored advice. This also enhances value chain connectivity and transparency. Responding to crises and doing so collectively will be easier. Another way through which they can optimise the agricultural sector is by facilitating digital payments. This makes money

⁶⁵ National Daily Newspaper, “CBN restrict”.

⁶⁶ Klerkx, Jakku, and Labarthe, “A review,” 1.

⁶⁷ Ibid.

⁶⁸ Abraham Kuuku Sam and Sara Saartjie Grobbelaar, “Research Trends, Theories and Concepts on the Utuilization of Digital Platforms in Agriculture: A Scoping Review,” in *Responsible AI and Analytics for an Ethical and Inclusive Digitized Society*, ed. by Gerhard Goos and Juris Hartmanis (Galway: Springer, 2021), 342.

⁶⁹ Klerkx, Jakku, and Labarthe, “A review,” 4.

⁷⁰ Kuuku Sam and Saartjie Grobbelaar, “Research Trends,” 346-348.

transfers more safe, reliable and time-efficient. Collecting and displaying data digitally more efficient and it fosters decision-making.^{71, 72}

There are certain scholars who are sceptical about the consequences of digital agriculture introductions. For instance, farmers could become dependent on the companies that implement these technologies. Once the farmers have started the trajectory with these technologies, they adapt their lives and farming practices to fit the technology, for instance by using certain seeds and fertilizers. Subsequently, it is difficult to abandon this lifestyle because it is highly integrated into the daily lives of the farmers. This concept is known as path dependency.^{73,74} Thatcher, O'Sullivan and Mahmoudi criticise the use of big data by agriculture multinationals in developing regions. They argue that these multinationals commodify the lives of the farmers, and they warn for power asymmetry and path dependency.⁷⁵

These concerns often relate closely to issues of data privacy that are raised in the debate about multinationals introducing technologies to farmers in developing regions. Ouman, Stenmanns and Verne argue that digital technologies are too often viewed as neutral. They argue for assessing who is in control and how responsible this control is dealt with.⁷⁶ Additionally, Laura Mann shows how large organisations use and commercialise personal data in Africa. According to her, foreign multinationals increasingly gain control over this data and she calls upon African governments to protect citizens against abuse and privacy violations.⁷⁷

Lastly, Burton, Peoples and Cooper explain that digitalisation can have significant impact on farming culture and conceptualisations of what it means to be a farmer, especially in rural areas. This is not necessarily a negative consequence, but it needs to be addressed since cultural change has important implications for people.⁷⁸

2.4. M-Agri Services in Nigerian Agriculture and in African Dairy Systems

M-Agri services in the Nigerian dairy industry have received limited academic attention. However, there are various articles which discuss m-Agri services in other agricultural sectors in Nigeria or in dairy industries in other African nations.

Theorists supporting the idea of a fourth agricultural revolution and ICT4D have positive views towards m-Agri services in Africa and argue that they can help alleviate Africa's food security

⁷¹ Emeana, Trenchard and Dehnen-Schmutz, "Revolution," 487; 497.

⁷² Klerkx, Jakku and Labarthe, "A review," 2.

⁷³ John Harriss and Drew Stewart, "Science, Politics, and the Framing of Modern Agricultural Technologies," in *The Oxford Handbook of Food, Politics and Society*, ed. Ronald J. Herring (Oxford: Oxford University Press, 2015) 44-45.

⁷⁴ Kelly Bronson and Irena Knezevic, "Big Data in food and agriculture," *Big Data & Society* 3, no. 1 (June 2016): 1-5.

⁷⁵ Jim Thatcher, David O'Sullivan and Dillon Mahmoudi, "Data colonialism through accumulation by dispossession: New metaphors for daily data," *Society and Space* 34, no. 6 (2016): 990-991.

⁷⁶ Stefan Ouma, Julian Stenmanns and Julia Verne, "African Economies: Simply Connect? Problematizing the Discourse on Connectivity in Logistics and Communication," in *Digital Economies at Global Margins*, ed. Mark Graham (Massachusetts: MIT Press, 2019): 354.

⁷⁷ Laura Mann, "Left to Other Peoples' Devices? A Political Economy Perspective on the Big Data Revolution in Development," *Development and Change* 49, no. 1 (2017): 28-30.

⁷⁸ Rob J.F. Burton, Sue Peoples, and Mark H. Cooper, "Building 'cowshed cultures': A cultural perspective on the promotion of stockmanship and animal welfare on dairy farms," *Journal of Rural Studies* 28 (2012): 174.

issues.^{79,80} Because the way in which m-Agri services affect productivity and profitability is context-specific, Klerkx, Jakku and Labarthe warn for Eurocentrism. They plead for more studies in non-Western countries.⁸¹ Emeana, Trenchard and Dehnen-Schmutz also question the extendibility of findings from the global north and point to cases that confirm and cases that reject the ICT4D proposition regarding Africa.⁸² In 2006, Lio and Liu found that the effects of ICT innovations in developing countries were on average only half as effective as they were in developed countries. They explained this by pointing to a lack of supporting ICT infrastructure, limited sources for finance and insufficient infrastructure.⁸³

Bateki et al. point out that the literature on ICT applications in developing countries merely pertains to crop production and neglects dairy. They evaluated the adoption of an m-Agri service which assisted farmers in satisfying their cows with the right amount of nutrients with locally available foods. This application resulted in higher milk yields and lower average costs per kg of milk produced.⁸⁴ Marwa et al. also investigate the dairy production amongst Kenyan farmers. They look into the role of m-Agri services. They found that the adoption of iCow, a mobile phone platform aimed at extending information, resulted in increased milk production. On iCow, farmers can receive information and digital assistance on nutrition, combating diseases, record-keeping and planning.⁸⁵

Emeana, Trenchard and Dehnen-Schmutz point out that many of the m-Agri services that are applied in African agriculture may increase productivity, but fail to be financially viable and are ultimately quitted, typically when donors quit supplying money. They found this after a study which involved a scoping review methodology on 64 publications.⁸⁶

There are a few common factors which can result in the innovation failing to be financially sustainable. A recurring constraint is a lack of electricity, internet and phone infrastructure. For instance, Godson-Ibeji, Chikaire and Anyaoha identified this as one of the main factors which hindered the e-wallet innovation. E-wallet is an electronic platform on which agricultural inputs such as seeds and fertilizers can be bought and distributed and on which the Nigerian government could support farmers.⁸⁷ Another issue is low literacy. Mobile literacy is also a common constraint as well as a low distribution rate of smartphone with which farmers can browse the internet.⁸⁸ Henze and Ulrichs warn for failing to take into account the demands of the farmers or their cultural contexts, such as local languages.⁸⁹ Agyekumhene et al. found that co-designing m-Agri services with farmers

⁷⁹ Alana Lajoie-O'Malley et al., "A review of social science on digital agriculture, smart farming and agriculture 4.0: New contributions and a future research agenda," *Ecosystem Services* 45 (2020): 7.

⁸⁰ Emeana, Trenchard and Dehnen-Schmutz, "Revolution," 485.

⁸¹ Klerkx, Jakku and Labarthe, "A review," 12.

⁸² Emeana, Trenchard and Dehnen-Schmutz, "Revolution," 1.

⁸³ Lio and Liu, "ICT and agricultural productivity," 223-227.

⁸⁴ Christian A. Bateki et al., "Of milk and mobiles: Assessing the potential of cell phone applications to reduce cattle milk yield gaps in Africa using a case study," *Computers and Electronics in Agriculture* 191 (December 2021): 1.

⁸⁵ Mwita Erick Marwa et al., "Impact of ICT Based Extension Services of Dairy Production and Household Welfare: The Case of iCow Service in Kenya," *Journal of Agricultural Science* 12, no.3 (February 2020): 141-142.

⁸⁶ Emeana, Trenchard and Dehnen-Schmutz, "Revolution," 2-6.

⁸⁷ C. C. Godson-Ibeji, J. U. Chikaire, and N. O. Anyaoha, "Assessing the effects of e-wallet scheme in farm inputs distribution to rural farmers in Imo State, Nigeria," *Journal of Agricultural Research and Development* 60, no. 2 (August 2016): 35-40.

⁸⁸ Emeana, Trenchard, and Dehnen-Schmutz, "Revolution," 14.

⁸⁹ J. Henze, and C. Ulrichs, "The Potential and Limitations of Mobile-learning and other services in the Agriculture Sector of Kenya Using Smartphone Applications," *12th European International Farming System Association, Edgmond, United Kingdom, July 12-15, 2016*, (2016): 8.

significantly improves the farmers' ability to understand and make use of the service.⁹⁰ Lastly, scholars agree that winning the trust of the farmers is critical in establishing financial sustainability. Ezezika, Lennox and Daar studied trust amongst farmers when genetically modified maize was introduced. They found that farmers tend to be more sceptical with external partners such as the government or private firms. This scepticism can be overcome by involving the farmers from the start and providing full disclosure at all times.⁹¹

2.5: Research Niche Occupation

The literature review on the state of Nigeria's dairy system, explanations thereof, m-Agri services and the successfulness of m-Agri services in Nigerian and in African dairy systems exposed various research gaps. There is limited research on m-Agri services in the dairy sector and there is little clarity regarding the circumstances under which m-Agri services can enhance productivity. In the Nigerian dairy sector, this topic has received little academic attention despite the practical relevance and political importance for Nigeria. Although cross-country comparisons are common in studies on agricultural practices, these types of studies are rare in the field of digital agriculture. Because m-Agri services tend to be more successful in the global north, I do a case study on mDairy where I compare it with m-Agri services in the Netherlands. This helps in better understanding what factors affect successful m-Agri services in the Nigerian dairy sector. This is important research as it helps policymakers to assess the potential of m-Agri services depending on the context. Ultimately, the following research question is asked:

How do Nigerian and Dutch dairy agriculture and m-Agri services compare and would increased interconnectivity, for instance through frugal innovation, be possible and value-enhancing for Nigerian farmers?

This question can be dissected into three guiding questions.

1. *How do Nigerian and Dutch dairy agriculture compare?*
2. *Does mDairy add value to the Nigerian dairy value chain?*
3. *Would Dutch-Nigerian farmer knowledge exchange, both generally and specifically regarding m-Agri services through frugal innovation, be value-enhancing for Nigerian dairy farmers?*

⁹⁰ Christopher Agyekumhene et al., "Making Smallholder Value Chain Partnerships Inclusive: Exploring Digital Farm Monitoring through Farmer Friendly Smartphone Platforms," *Sustainability* 12 (2020): 1.

⁹¹ Obidimma C. Ezezika, Robin Lennox, and Abdallah S. Daar, "Strategies for building trust with farmers: the case of Bt maize in South Africa," *Agriculture & Food Security* 1, no. 3 (2021): 1.

3: Conceptual Framework

To answer the questions presented above, it is important to explain what concepts and theories guide my research. The three main chapters of my thesis (5-7) are each guided by a sub-question. For each of the three topics, I discuss what concepts and theories are relevant.

My approach is interdisciplinary because implementing m-Agri services involves knowledge and policymaking from different sources. The academic disciplines that discuss the overarching concept digital agriculture include but are not limited to agricultural sciences, computer science, political science, economics, business administration and sociology. The literature review has shown the significant contributions from each of these disciplines. To study the suitability of m-Agri services in the Nigerian dairy industry and the potentiality of increased north-south farmer connectivity, it is highly useful to take an interdisciplinary approach. Leaving one perspective out of consideration would significantly reduce the soundness of my analysis. For instance, without the agricultural sciences lens, I neglect to pay attention on how the technological designs of digital agriculture benefit farmers. Also, without taking into account politics, the role that national governments and local institutions play, would not be addressed adequately. Taebi et al. also emphasises the necessity of taking an interdisciplinary approach when investigating the impact of digital innovations.⁹²

3.1. Development, Productivity and Development Theories

Because I discuss the state, i.e. the level of development, of the Dutch and Nigerian dairy sector, and because the ultimate purpose of m-Agri services is to foster development, it is important to point out how I use this term. Development is commonly understood as *“a process of creating and utilizing physical, human, financial, and social assets to generate improved and broadly shared economic well-being and quality of life for a community or region.”*⁹³ In my research, I operationalise development by looking at increased productivity. In the field of agricultural sciences, this is a common approach. Nevertheless, it is important to acknowledge that this narrows development down to income.

I use two theories pertaining to development. Firstly, I use the factor endowment theory. According to the factor endowment theory, countries excel in economic activities that they have the right resources for. For dairy production, the climate, the land, labour capital and entrepreneurship are some of the important factors.⁹⁴ Most scholars that comment on the Nigerian dairy industry discuss these factors to explain the low productivity and implicitly use the factor endowment theory. Secondly, I use the world-systems theory (WST). World-system theorists divide the world up into core regions, semi-peripheric regions and peripheric regions and they explain how core regions are dominant by analysing monetary, political and cultural structures. The focus is not necessarily on countries but can also be firms, depending on the type of research. For instance, regarding multinationals and international trade, WST emphasises unfair trade rules or the power that multinationals from core regions have over local governments or employees.⁹⁵ Together with stakeholder theory, which originates from the field of business administration and which explains firm behaviour by pointing to stakeholder demands, it can give insights in whether firms behave in

⁹² B. Taebi et al., “Responsible innovation as an endorsement of public values: the need for interdisciplinary research,” *Journal of Responsible Innovation* 1, no. 1 (2014): 119-120.

⁹³ Karl F. Seidman, *Economic Development Finance* (Thousand Oaks: Sage Publications, 2005): 5.

⁹⁴ Kenji Fujiwara and Koji Shimomura, “A factor endowment theory of international trade under imperfect competition and increasing returns,” *Canadian Journal of Economics* 38, no. 1 (February 2005): 274-277.

⁹⁵ Immanuel Wallerstein, “World-Systems Analysis,” in *Encyclopedia of Life Support Systems*, ed. George Modelski and Robert A. Denemark, (Paris: UNESCO, 2004): 13-17.

accordance with demands by core or periphery regions. Additionally, WST could help in explaining wider international and hegemonic implications of potential issues pertaining to the presence of multinationals or digitalisation. Together with insights from protectionism perspectives, it can also explain how peripheric countries can write policies to protect their economies.

3.2. M-Agri Services

Emeana, Trenchard, and Dehnen-Schmutz define m-Agri services as “*mobile-phone enabled application initiative(s) for agriculture*”. Next, they explain that these services include “*banking facilities, social networking platforms, or information such as market prices*” and that the services can convey content via “*graphics, videos, images, audio recordings, and text*.”⁹⁶ Because this definition captures well how I understand m-Agri services like mDairy, I decided to use this definition.

I also use the term fourth agricultural revolution in my thesis. Advocators of this term believe that the use of digital tools can significantly foster development in African countries. In line with this thinking, some scholars have promoted the term ICT4D (information and communication technologies for development). Emeana, Trenchard, and Dehnen-Schmutz also point to the importance of HCI4D (human-computer interactions for development). They argue that focussing on the human-computer interactions is important as the level of competence with digital tools differs significantly amongst people in developing countries.⁹⁷

An important theory which explains different rates in the uptake and performance of innovations is the diffusion of innovations (DOI) theory. This theory is developed by Rogers and according to this theory, the adoption of an innovation depends on the relative advantage, the compatibility, the complexity, the triability and the observability. Relative advantage refers to the superior performance compared to what occupied the niche before. Compatibility refers to how an innovation is in congruence with values. Complexity refers to the difficulty of understanding and using the innovation. Triability is the extent to which people can try out the innovation. Lastly, observability refers to whether the results of an innovation are visible and communicated.⁹⁸ The theory is often used digitalisation, also in agriculture.^{99, 100}

3.3. North-South Farmer Connectivity and Frugal Innovation

Farmer connectivity is an important theme in my research. With farmer connectivity, I refer to how close one farmer stands to other farmers. If farmers have close connectivity, they are aware of and understand each other’s practices. Because Dutch farmers run more successful dairy businesses, increased Dutch-Nigerian farmer connectivity could be beneficial for Nigerian farmers. This does not necessarily mean that Dutch and Nigerian farmers interact with one another. It could also be the case that Nigerian farmers are educated by fellow Nigerians about and farming practices that are used by Dutch farmers and hence, are more connected to Dutch farmers. I abstain from using the

⁹⁶ Emeana, Trenchard, and Dehnen-Schmutz, “Revolution,” 2.

⁹⁷ Ibid, 1-2.

⁹⁸ Rogers, *Diffusion*, 211

⁹⁹ Nicholas Mugabi et al, “Revolutionizing agriculture extension delivery through mobile telephony: The experience of village enterprise agent model in Greater masaka area, Uganda,” *Sustainable Development and Planning* 217 (2019): 963.

¹⁰⁰ Andrea Knierim et al., “Smart farming technology innovations – Insights and reflections from the German Smart-AKIS hub,” *Wageningen Journal of Life Sciences* 90-91 (December 2019): 1.

term Dutch-Nigerian knowledge transfer because the knowledge could also come from non-Dutch people and because the knowledge is not inherently Dutch. Zero- or semi-grazing is practiced by many dairy farmers around the world.

In the context of the development of digital technologies, North-South connectivity is captured by the term frugal innovation. According to Leliveld and Knorringa, frugal innovation is about:

"(re)designing products, services, systems, and business models in order to reduce complexity and total lifecycle costs, and enhance functionality, while providing high user value and affordable solutions for relatively low-income customers, the latter being either consumers or business in both the Global South and North".¹⁰¹

For my research, this implies that I look at m-Agri services that are used by Dutch farmers and investigate whether the product could be made simpler, cheaper or more compatible with local demands.

¹⁰¹ André Leliveld and Peter Knorringa, "Frugal Innovation and Development Research," *The European Journal of Development Research* 30 (2018): 1-2.

4: Methodology

This chapter presents the methodology. I firstly explain why I adopted a case study research design and I explain the case. Next, explained how I collected my data and I comment on my research ethics. Lastly, I explain how I conducted the analyses in my three main chapters and I provide analytical frameworks.

4.1. Epistemology

The research in this study is a qualitative case study. Qualitative studies allow for a more integrated, flexible, analysis that enable the researcher to approach different aspects of the research problem. As a result of this adaptability, the researcher is submerged in the research and this can result in subjectivity and bias.¹⁰² To make sure that readers understand the steps that I took, and to enhance the replicability and reliability, I took a structured approach and explained the steps that I took.

I decided to do a case study because m-Agri services have unique and complex characteristics, both in their design as well as in the environment that they are used in. Therefore, their success is to a large degree context specific. The case study method is common amongst research which assesses the adoption or impact of digital agriculture initiatives. Because I compare mDairy with m-Agri services used by Dutch farmers, I also make use of the cross-case analysis method.

For assessing the attempts of foreign multinationals to develop local agriculture value chains in Africa, which this thesis also does, the case study method has not been used frequently. Ekumankama, Ezeoha and Uche, identify this as a research gap.

“While this kind of theoretical contestation dominate public debate about the role of MNCs in the development of Africa’s local industrial bases, few case-by-case evidence exist in the literature to explain its microcosmic nature.”¹⁰³

Many non-African multinationals refrain from investing in local value chains and sourcing food locally. Instead, they import food. As explained in the literature review, African countries need to improve their agricultural productivity and the large multinationals need to be incentivised to source food locally. The introduction of mDairy by FrieslandCampina is an excellent example of a non-African food MNE that faces the decision whether or not to invest in the long term. The dairy industry is an excellent example because the large majority of the consumed dairy is imported and FCW is the largest player in the Nigerian dairy industry. In Nigeria, these food issues are very urgent since it is one of the countries with the highest importation rates in Africa.

Introducing FrieslandCampina

FC is a Dutch dairy cooperative. It is one of the largest dairy companies in the world with annual revenues of 11.5 billion euros. It is owned by approximately 15,000 Dutch, Belgium and German dairy farmers which finance FC for approximately 30%. For the remainder, FC is debt-financed. The company sources milk from 32 countries and sells milk in more than 100 countries.¹⁰⁴ 85% of the milk is sourced from the Netherlands and FC sells approximately one-third in the Netherlands, one-third

¹⁰² Ranjit Kumar, *Research Methodology: A Step-by-Step Guide for Beginners* (Thousand Oaks: Sage Publications Ltd, 2019): 226-227.

¹⁰³ Ekumankama, Ezeoha and Uche, “The role,” 57.

¹⁰⁴ Royal FrieslandCampina N.V., *2021 Annual Report* (Amersfoort: Royal FrieslandCampina N.V., 2022), 3.

to other EU countries and one-third to non-EU countries.¹⁰⁵ Nigeria is FC's most profitable country.¹⁰⁶ This is the case because the milk price is relatively high in Nigeria. Between 85 and 98% of the products that FC sells in Nigeria is produced with imported milk powder.^{107, 108} However, because of government intervention, FC is forced to increase the amount of locally sourced milk.¹⁰⁹

Introducing mDairy

With mDairy, FC wants to increase the amount of locally sourced milk. mDairy is currently FCW's most important dairy development program (DDP) activity.¹¹⁰ mDairy has two main functions, e-extension and milk tracing. Figure 1 shows the start screen of the mDairy app. The e-extension is the most important one of the two because the foremost purpose of mDairy is to increase the amount of milk sourced locally through educating Nigerian dairy farmers about innovative dairy practices such as zero- or semi-grazing. mDairy is the flagship product of the Nigerian tech start-up Tech4Ag, which started the development of mDairy in 2017. The pilot started in the beginning of 2021 and lasted for half a year. The pilot was aimed at profiling farmers and explaining important users of mDairy how they were supposed to use the m-Agri service.¹¹¹ After the pilot finished, the involved parties continued with this practice.¹¹² Figure 2 shows the screen of the e-extension function. There is information about a wide range of practices and the information is provided through text, photos and videos (figure 3). Also, the information is available in different languages (figure 4 and figure 5). However, this function is not fully developed yet. Also, on the right corner in figure 1, above the log-out button, the "Extension: Agent Platform" allows users to get in touch with FCW's extension officers. FCW's extension officers are veterinarians that are employed by FCW to assist farmers.¹¹³

The milk tracing is primarily useful for FCW. FCW has access to an mDairy system on which it can find information about the milk and it can analyse trends.¹¹⁴ For instance, this allows FCW to provide tailored intervention to farmers. Normal users of mDairy can also find this information on the app. With the buttons "Farmer's Profile", "Farmer's Milk Record", "Transporter's Profile" and "Transporter's Milk Record" in figure 1, users can find information about farmers and transporters. This information includes amongst others name, age, gender, phone number, number of cows, type of cows, litres of milk accepted, litres of milk rejected and residence (figure 6). This information allows farmers and transporters to see and compare how their operations are going. Figure 1 also shows other features that are completely or partly developed. I do however not focus on these extensively because they are not core functions.

¹⁰⁵ Stijn Markers, email correspondence, June 2, 2022.

¹⁰⁶ Markers, "Interview with Stijn Markers," interview by Robin van Seumeren, June 2, 2022, 25:00.

¹⁰⁷ Ibid.

¹⁰⁸ Ekumankama, Ezeoha and Uche, "The role," 57.

¹⁰⁹ Federal Ministry of Agriculture and Rural Development, *National Dairy Policy: March 2021 (Draft)* (2021): 40.

¹¹⁰ Adeyinka, "Interview 3," 53:00.

¹¹¹ Adaku Okeke and Chinaka Aliyu, "Interview 1 with co-founders of Tech4Ag," interview by Robin van Seumeren, June 30, 2021.

¹¹² Adaku Okeke and Chinaka Aliyu, "Interview 5 with co-founders of Tech4AG," interview by Robin van Seumeren, May 12, 2022, 11:00.

¹¹³ Adeyinke, "Interview 3," 56:00.

¹¹⁴ Adaku Okeke and Chinaka Aliyu, "Interview 2 with co-founders of Tech4AG," interview by Robin van Seumeren, July 20, 2021.

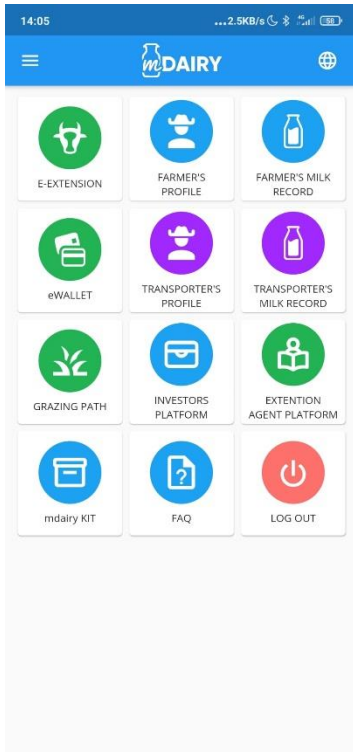


Figure 1: Home screen of mDairy

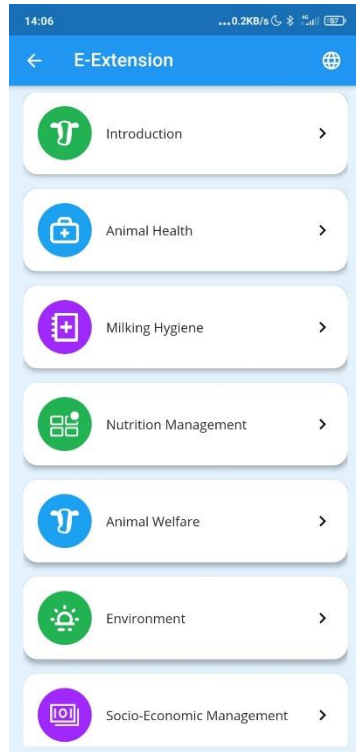


Figure 2: E-extension screen of mDairy

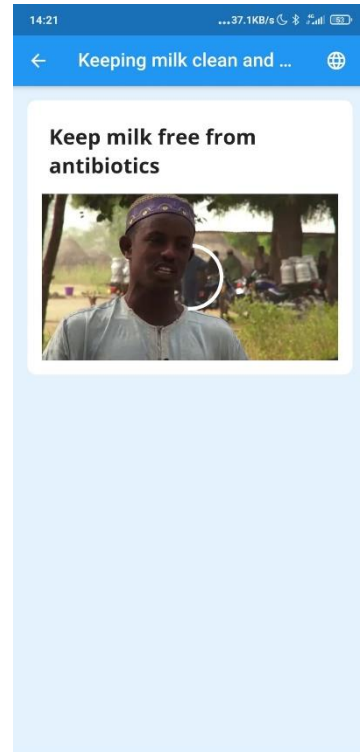


Figure 3: mDairy uses videos to educate farmers

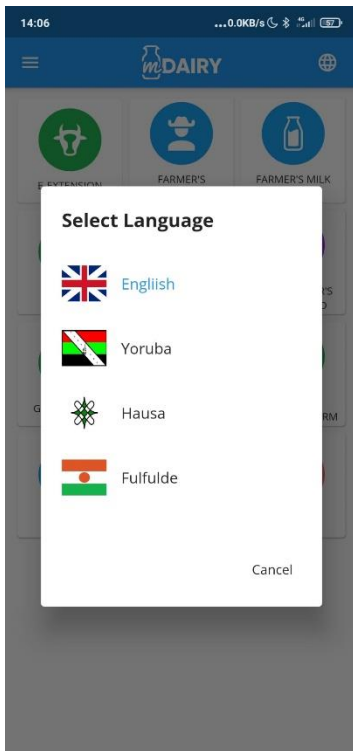


Figure 4: The different languages that mDairy users can choose from



Figure 5: An explanation in Yoruba

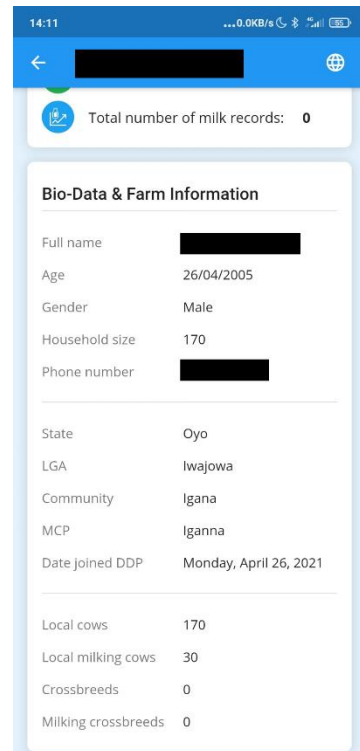


Figure 6: Farmer data that is captured in mDairy

4.3. Data Generation and Ethics

I collected most of my data through interviews. I did nineteen interviews on eleven different stakeholders. Interviews allowed me to ask specific questions as a result of which I could adequately understand mDairy and the detailed context. I interviewed a diverse range of stakeholders because a successfully operating m-Agri service involves input from a diverse range of actors. Table 4 describes the interviews and shows the diversity of interviewees. Additionally, I also extracted information from publications (both publicly available ones and ones that I was granted access to), email contact and personal contact with stakeholders.

Before conducting the interviews, I informed my participants why I wanted to interview them. At the start of the interview, I informed them further on how the information would be used. To safeguard sincere discussions and interviews, I have informed my participants upfront that I would anonymise their identity. I have not used their real names and I have not used their official task description for the sake of anonymity. However, for some people, their identity can still be traced back because of their unique functions. These people aware of this and they still allowed me to conduct my research in this way.

I decided to interview the co-founders, employees at FC and FCW and the mDairy pilot manager because these people are the most involved people at the different organisations that play a role in the mDairy project. The Nigerian farmers, milk transporter, CWL and cooperative leader were elected by Ola Adeyinka, the mDairy pilot manager. I reached out to Adeyinka and asked if he could help me to get in touch with different Nigerian dairy value chain actors. He provided me with the contact details of these people, who he considered to be most eligible to help me. To select Dutch dairy farmers, I looked up the contacts of farmers who participated in the “Campina Boerderijdagen 2022” and who lived close to me. The Campina Boerderijdagen 2022 is an event at which people can visit farms that supply milk to FC. I selected these farmers because I considered them to be open to visitors and because these were farmers of which I knew for sure that they supplied to FC. Additionally, I reached out to Toon van Veenhoven because he is a Dutch farmer who had been sent on mission to Nigeria by FC.

Date	Person(s)	Role	Duration
June 29, 2021	Ola Adeyinka	mDairy Pilot Manager	Unknown
June 30, 2021	Adaku Okeke and Chinaka Aliyu	Co-founders of Tech4Ag	Unknown
July 16, 2021	Joseph Magaji	Dairy Development Manager at FCW	48:45
July 20, 2021	Adaku Okeke and Chinaka Aliyu	Co-founders of Tech4Ag	Unknown
August 3, 2021	Ola Adeyinka	mDairy Pilot Manager	1:04:53
August 11, 2021	Adaku Okeke and Chinaka Aliyu	Co-founders of Tech4Ag	Unknown
August 20, 2021	Ibrahim Musa	Farmer in mDairy pilot and cooperative leader	Unknown
August 28, 2021	Adaku Okeke and Chinaka Aliyu	Co-founders of Tech4Ag	Unknown
May 12, 2022	Adaku Okeke and Chinaka Aliyu	Co-founders of Tech4Ag	Unknown
June 2, 2022	Stijn Markers	Dairy Development Manager at FC	01:06:12

June 7, 2022	Jan Willems	Dutch dairy farmer	40:21
June 9, 2022	Willem Hendriks	Dutch dairy farmer	32:48
June 15, 2022	Samuel Idowu	Nigerian milk transporter	11:44
June 15, 2022	Ahmed Udoh	Nigerian dairy farmer and secretary local dairy council	32:52
June 16, 2022	Adaku Taiwo	Nigerian dairy farmer and CLW	7:29
June 19, 2022	Ibrahim Musa	Farmer in mDairy pilot and cooperative leader	47:45
June 20, 2022	Ibrahim Musa	Farmer in mDairy pilot and cooperative leader	49:40
June 28, 2022	Toon van Veenhoven	Dutch dairy farmer who went on mission to Nigeria	1:06:30
July 7, 2022	Ola Adeyinka	mDairy Pilot Manager	1:24:38

Table 4: Description of interviews conducted for this research

4.4. Analytical Framework

My thesis contains three chapters in which I present and discuss findings. Each of the chapters has a different purpose and for each of the chapter, I conducted a different analysis which required a unique approach.

For the first main chapter, in which I compare Dutch and Nigerian dairy farming, I developed an analytical framework with five analytical concepts. Firstly, I included themes that I regularly encountered during my literature review on dairy farming in Nigeria. Most scholars focussed on factor endowments to explain the productivity of dairy systems, so I categorised these factors into the analytical concepts climate, infrastructure and value chains. I also discussed m-Agri services as a factor endowment because they relate to the core of my research. Lastly, I discussed the profitability of Dutch and Nigerian dairy farming because enhanced profitability and productivity is the purpose with which mDairy has been implemented. With the last concept, I take a bird's eye view. I discuss the first four analytical concepts in relation to factors which are beyond a country's factor endowments. This helps to understand the functioning and the impacts of imports and it helps to develop a complete picture of the profitability and the productivity, i.e. the state, of dairy farming in the Netherlands and Nigeria.

Analytical concept	Guiding question
Climate	What role does the climate play?
Infrastructure	What is the level of infrastructure (transportation, electricity, internet, water, education, legislation) and how does this impact dairy production?
Value chain	What do the value chains look like (input suppliers, buyers and cooperatives) and how do they impact production?
Digital methods	What digital methods are being used and how do they impact production?
Profitability	How profitable is the business and are there factors beyond a country's factor endowments that affect this?

Table 5: Analytical framework for explaining the state of dairy farming

For chapter 6, in which I assess the applicability of mDairy to the Nigerian dairy industry, I based my analytical framework on the Smart Farming Framework developed by Eastwood, Ayre and Dela Rue. Eastwood, Ayra and Dela Rue developed a framework in which 15 aspects were established based on which technological innovations could be assessed. These 15 aspects were allocated to the following factors: (1) characteristics of the target population and the market, (2) technology design and innovation, (3) capability requirements and knowledge exchange. To design this framework, they took into account Roger’s DOI theory.¹¹⁵ I made certain adaptations because there was overlap amongst the aspects and factors. I created three topics for my analytical framework based on the three factors developed by Eastwood et al. However, the focus of these three topics varies somewhat from the focus of the three factors in the Smart Farming Framework. For instance, with the second topic “Technology Development”, I address revenue-making models. This is not done in the Smart Farming Framework. I decided to include a focus on revenue-making models because many m-Agri services in the global south fail to be financially sustainable.¹¹⁶ Because the diffusion of innovation theory is central to my research, I indicated where each of the five aspects of this theory are addressed most strongly.

	Guiding question(s)	Diffusion of Innovation Theory Aspect
Performance	Does it add something to the market? Who benefits? Are there side effects? Is it observable?	Relative advantage Observability
Technology Development	Has it been designed to integrate other technologies and to stay up to date? Is there a revenue-making model? Is it compatible with values amongst the farmers? Can it be tried out?	Compatibility Triability
Target Audience Requirements	What are tools skills required to make use of it and where can these tools and skills be attained?	Complexity

Table 6: Analytical framework for evaluating the applicability of m-Agri services

For chapter 7, where I investigate whether increased north-south farmer connectivity would be value enhancing, I do not have a pre-defined analytical framework. This is the case because what I discuss in this chapter, depends to a large extent on the outcomes of chapter 5 and 6. Chapter 5 and 6 identify potential issues relating to dairy farming in Nigeria and to the design of mDairy. Chapter 7 investigates whether increased north-south farmer connectivity can help in overcoming these issues. I firstly look at frugal innovation, where I ask if implementing simplified functions of m-Agri services in the Netherlands could optimise mDairy. Secondly, I ask if other forms of connectivity, for instance through connecting Nigerian farmers to dairy practices that are used by Dutch dairy farmers, could be value-enhancing.

¹¹⁵ Callum R. Eastwood, Margaret Ayre, and Brian Dela Rue, “Farm advisors need to adapt to provide value to farmers in smart farming future,” *Conference: 13th European IFSA Symposium, Chania, Greece July 1-5, 2018*, 1-3.

¹¹⁶ Emeana, Trenchard and Dehnen-Schmutz, “Revolution,” 2-6.

5: A Comparison of Dutch and Nigerian Dairy Farming

In this chapter, I compare Dutch and Nigeria dairy farming. It is important to do this before assessing the applicability of m-Agri services like mDairy because the successes of m-Agri services depend to a large extent on the contexts in which they are implemented. Based discuss the climate, the infrastructure, the value chain, the use of digital methods and the profitability.

5.1. Climate

The climate is the most clear factor endowment which affects the dairy productivity. North-Western Europe, as well as parts of the United States and New Zealand, have the most desirable climate for dairy production because the most productive cow in the world (Holstein Friesian) is used to temperatures between 5°C and 25°C.¹¹⁷

Because the temperature in Nigeria is often higher than 25°C, Holstein-Frisians experience heat stress as a result of which their health and milk production deteriorates. Therefore, all interviewees urge for an increased use of crossbreeds. They are better able to withstand high temperatures and produce significantly more than local breeds.¹¹⁸

In Nigeria, cows also suffer from ticks, especially Frisian-Holstein and crossbreeds.¹¹⁹ van Veenhoven pointed out that crossbreeds are sensitive to ticks too. Salah et al. also took this into account in their gross margin analysis and found indeed that the costs of removing ticks were approximately two times as high for crossbreeds and three times as high for Friesian-Holsteins compared to local breeds.¹²⁰

5.2. Infrastructure

In Nigeria, the underdeveloped dairy infrastructure poses a big challenge to the productivity. In the Netherlands, the dairy farming infrastructure is of high quality. Firstly, the lacking transportation infrastructure causes transportation to be cumbersome and expensive. In the Netherlands, FC has truck drivers who pick up the milk at farmers. In Nigeria, self-employed milk transporters fulfil this role. How much they charge depends on the distance and the amount of milk. Adeyinka pointed out that they take 25 Naira per litre milk on average, which makes up 10% since the price that FCW pays is 250 Naira.¹²¹

The exploitation of dairy farmers by middlemen or other purchasers is a common theme in dairy value chain literature. For instance, removing the middlemen was one of the most important reasons for the success of Amul, an Indian dairy cooperative. This abolition by Amul led to India's white revolution, with which India turned from a large dairy importer into the largest dairy producing country in the world.¹²² Nevertheless, my interviewees all stated that milk transporters do not exploit

¹¹⁷ Ibid, 29:00.

¹¹⁸ Salah et al., "Improved Dairy Cattle Technologies," 7.

¹¹⁹ Toon van Veenhoven, "Interview with Toon van Veenhoven, Dutch dairy farmer who went on mission to Nigeria," interviewed by Robin van Seumeren, June 28, 2022, 26:00.

¹²⁰ Salah et al., "Improved Dairy Cattle Technologies," 9.

¹²¹ Adeyinka, "Interview 3 with Ola Adeyinka," 44:00.

¹²² Venkatakrisna V. Bellur et al., "The White Revolution – How Amul Brought Milk to India," *Long Range Planning* 23, no. 6 (1990): 78.

farmers and argue that they posit important functions in the value chain. Also, their role could not be taken over by FCW or by farmers.^{123, 124}

Additionally, there is the electricity supply is lacking. The app developers pointed out that most of the participants do not have consistent electricity access.¹²⁵ This also increased the importance of the milk transporters. Because the milk cannot be stored refrigerated, milk has to be transported every day. In the Netherlands, the transportation of milk takes place once every three days.^{126, 127} According to Adeyinka, limited electricity access is more of a restraint to the successful operation of mDairy than limited internet access. He explains that network connection is widespread, but that milk transporters, farmers and CWL often have to charge their phones at milk collection points and centra.¹²⁸

Water access also poses another problem because water is required to grow crops that can be fed to the cows. Musa explained that the building of wells has been effective in reducing the severity of this problem.¹²⁹

The education infrastructure is another issue. Many Nigerian farmers are illiterate and an even larger group is not familiar with digital technologies such as smartphones. Amongst the 500 farmers that participated in the mDairy pilot, the majority did not attend formal education.¹³⁰ FCW obliges farmers to become member of a farmer cooperative when they supply milk to FCW so this enhances knowledge exchange and learning. However, other Nigerian dairy farmers are not always part of cooperatives.¹³¹ Not only the formal education system is more advanced in the Netherlands, but Dutch dairy farmers also have more efficient informal means to learn how to improve their techniques. Dutch dairy farmers frequently make use magazines (also from FC), internet (YouTube) and information events where they exchange information with colleagues.^{132, 133}

Lastly, the legislative infrastructure is important. Here, it is important to compare the Dutch legislative system with the Nigerian legislative system. The Dutch legislative system regarding public spending on agriculture is determined according to the CAP. As Matthews and Soldi explained, the CAP increases productivity in Europe by 5 to 6 percent. Also, productivity significantly increased in the Netherlands as a result of the removal of milk quotas.¹³⁴ Public spending on agriculture is less than 1% in the Netherlands and it is 1.8% in Nigeria.¹³⁵ However, because Dutch farmers are already in a better position to produce dairy products, even without subsidies, this can be seen as unfair. From WST, it can be understood as one of the mechanisms through which the hegemony of

¹²³ Ibrahim Musa, "Interview 3 with Ibrahim Musa, Nigerian dairy farmer and head of cooperative," interviewed by Robin van Seumeren, June 20, 2022, 16:00.

¹²⁴ Adeyinka, "Interview 3 with Ola Adeyinka," 42:00.

¹²⁵ Okeke and Aliyu, "Interview 5 with Adaku Okeke and Chinaka Aliyu," 3:00.

¹²⁶ Jan Willems, personal communication during visit at Willems' farm, June 7, 2020.

¹²⁷ Willem Hendriks, personal communication during visit at Hendriks' farm, June 9, 2020.

¹²⁸ Adeyinka, "Interview 3 with Ola Adeyinka," 13:00.

¹²⁹ Musa, "Interview 3 with Ibrahim Musa," interviewed by Robin van Seumeren, June 19, 2022, 26:00.

¹³⁰ Ibid, 9:00.

¹³¹ Markers, "Interview with Stijn Markers," 42:00.

¹³² Willem Hendriks. "Interview with Willem Hendriks, Dutch dairy farmer," interview by Robin van Seumeren, June 9, 2022, 9:00.

¹³³ Jan Willems, "Interview with Jan Willems, Dutch dairy farmer" interviewed by Robin van Seumeren, June 7, 2022, 34:00.

¹³⁴ Matthews and Soldi, *Evaluation*, 68.

¹³⁵ Mary Izuaka, "Nigeria's agric spending plan highest in four years but still far below AU benchmark," *Premium Times Nigeria*, last modified October 14, 2021, <https://www.premiumtimesng.com/agriculture/agric-news/490001-nigerias-agric-spending-plan-highest-in-four-years-but-still-far-below-au-benchmark.html>.

developed countries is sustained. In 2003, the African Union declared that member states would spend at least 10% of the public spending on agriculture. However, Nigeria has not come close to this number in the past years.¹³⁶ Adeyinka also stated that the Nigerian government does not help dairy farmers in any way, for instance through subsidiaries.¹³⁷ Although policies like foreign exchange controls do not directly benefit the Nigerian farmers, they do benefit the farmers through indirect ways through protectionism. By putting dairy on a forex restriction list, importing milk powder is made more costly for companies like FCW.¹³⁸ Also, the Nigerian government grants licences to operate to the dairy companies. Therefore, it can influence the decisions that business leaders of dairy companies make.¹³⁹ The Nigerian dairy policy draft states that the Nigerian government is planning on requiring dairy companies to source at least 50% of the milk locally in ten years.¹⁴⁰ FC is committed to Nigeria because it is FC's most profitable country, because FC is present for almost 70 years, and because Nigeria's dairy demand is on the rise. Sourcing milk locally may be less profitable and may reduce the profit margins for Nigeria. However, if the quantity of milk consumed and the sales increase, the net profit that FC makes in Nigeria is expected to increase.¹⁴¹ On the other hand, FC knows that Nigeria is dependent on the company for its dairy supply. Markers argued that the demand to source at least 50% in the next 10 years is too big and that it is not feasible.¹⁴²

5.3. Value Chain

I analyse the value chains both vertically and horizontally. With the vertical analysis, I begin with analysing the inputs after which I analyse the output that buyers buy. With the horizontal analysis, I look at the relations that farmers have with fellow farmers, i.e., I look at cooperatives.

Input supplies

To do dairy farming in the best possible way, various supplies are required. These include medicines, veterinary services, semen, milk replacers, agricultural by-products, concentrates, land ownership, stalls, machines, repair services. In the Netherlands, all supplies are present. In Nigeria, input supply systems have started to emerge, but most farmers do not have access yet.^{143, 144}

For instance, Musa explained that during dry season, there is not enough grass available. As a result, significantly more cows die during the dry season (5-10 compared to 1-3 during rainy season). In the Netherlands, farmers cut grasses during summer and store this for the winter when little grass is available (figure 7). Musa explained that some Nigerian farmers use similar techniques where they feed cassava and maize during dry season. He argues that this is too difficult for many farmers because of a limited budget, limited expertise and limited water access.¹⁴⁵ Adeyinka points out that the dairy farmers hardly have machines and that they do not own land. Instead, they borrow land and because they do not own the land, they are reluctant to make investments in the land. Adeyinka

¹³⁶ Ibid.

¹³⁷ Adeyinka, "Interview 1 with Ola Adeyinka,".

¹³⁸ National Daily Newspaper, "CBN restrict forex."

¹³⁹ Markers, "Interview with Stijn Markers," 27:00.

¹⁴⁰ Federal Ministry of Agriculture and Rural Development, *National Dairy Policy*, 40.

¹⁴¹ Markers, "Interview with Stijn Markers," 1:01:00.

¹⁴² Ibid, 29:00.

¹⁴³ van Veenhoven, "Interview with Toon van Veenhoven," 49:00.

¹⁴⁴ Adeyinka, "Interview 2 with Ola Adeyinka," 51:00.

¹⁴⁵ Musa, "Interview 2 with Ahmed Musa," 9:00.

also explains that it is difficult for Fulanis to buy land in South-Western Nigeria. This is one reason why they are reluctant to adopt zero-grazing and continue with pastoralism.¹⁴⁶



Figure 7: Dutch dairy farmers cut and store grass during summer for winter usage

Buyers

A good buyer-supplier relationship is important for a well-functioning value chain. Both in the Netherlands as in Nigeria, farmers are relatively positive about FCW in general. The security of having a buyer is what farmers from both countries value the most. Willem Hendriks, a Dutch dairy farmer, explained that his grandfather had to travel to the market in Rotterdam to sell milk.¹⁴⁷ Ibrahim explains that the presence of FCW enabled the farmers to get a higher income. Before, farmers were using milk for cheese production.¹⁴⁸ The Nigerian farmers also pointed out that FCW's DDP helps farmers improving farming techniques.^{149, 150}

In the Netherlands, there are various other buyers of milk. In Nigeria, the dairy companies are divided amongst the states of Nigeria. FCW sources milk from Oyo state and four other states. Nestle and Arla, two other dairy multinationals, source the milk produces in other states. As there are no other institutionalised buyers of milk that farmers in each state can supply to, the alternative to selling to FCW would be to produce cheese and sell this on local markets. However, this is significantly less profitable.¹⁵¹ Markers explained that this is the case because dairy companies do not want to occupy each other's niches as sourcing milk locally is a harsh and unprofitable business.¹⁵² This does however mean that the Nigerian farmers become dependent to a certain degree on FCW because there are no similar alternatives. Especially when FCW starts to introduce m-Agri services with which FCW starts to become a more central theme in the daily lives of the dairy farmers, path dependency can show up. Because of market entry costs and economies of scale that FCW benefits

¹⁴⁶ Adeyinka, "Interview 2 with Ola Adeyinka," 3:00.

¹⁴⁷ Hendriks, "Interview with Willem Hendriks," 20:00

¹⁴⁸ Musa, "Interview 3 with Ibrahim Musa," 13:00.

¹⁴⁹ Ibid.

¹⁵⁰ Ahmed Udoh, "Interview with Ahmed Udoh, Nigerian dairy farmer and secretary local dairy council" interviewed by Robin van Seumeren, June 15, 2022, 9:00.

¹⁵¹ Ibid, 17:00

¹⁵² Markers, "Interview with Stijn Markers," 28:00.

from, it is unlikely that local start-ups will become competitors of FCW. From WST, this can be interpreted as a development which constitutes to the hegemony of core regions in Western Europe.

Farmer Cooperatives

Apart from being well connected vertically in the value chain with input suppliers and buyers, it is also important to have good horizontal connections. In the Netherlands, farmers are well connected amongst each other through farmer cooperatives. Even FC is a cooperative. FC consists of 15,703 dairy farmers from the Netherlands, Belgium and Germany that pay contribution fees. These make up 30% of FC's capital. The remainder is borrowed.¹⁵³ Farmers form cooperatives like FC for various reasons. Most importantly, this enables them to increase their bargaining power and it reduces transaction costs.^{154, 155}

For Nigerian dairy farmers, FCW is not a cooperative. FCW is owned by FC. This has significant implications. Stakeholder theory explains that companies act in their interest of their stakeholder. The most important stakeholders of FC are the shareholders, who are Dutch, Belgium and German farmers. Thus, FC is significantly less motivated to support Nigerian farmers than to support Dutch farmers.

On the other hand, FCW requires farmers to be part of a cooperative if they want to supply to FCW. This can be interpreted as pro-active and innovative. In most parts of Nigeria, cooperatives are less prevalent. Yet, because the farmers live in many different remote places, there are many small cooperatives. Since they are small, they cannot pose serious threats to FCW.¹⁵⁶

5.4. M-Agri Services

The Nigeria mobile phone penetration rate is 49%. The smartphone penetration rate is 36%.¹⁵⁷ For dairy farmers, who typically live in remote areas and have a lower income, these percentages are lower. With mobile phones they are able to text and call and communicate information. The majority of the mDairy pilot participants do not possess smartphones. Usually, transporters and community livestock workers do have smartphones. With these smartphones, they can find information online about agriculture. They are not familiar with m-Agri services because they did not experienced m-Agri services before.¹⁵⁸

In the Netherlands, using m-Agri services is part of the daily life of a Dutch farmer. According to Markers, one of the main reasons for the top-notch dairy systems in the Netherlands is the large amount of data available and the use of this data to optimise processes.¹⁵⁹ Despite the large amounts of data and the widespread use of m-Agri services, Dutch farmers are not dependent on them. Willem Hendriks, a Dutch dairy farmer, explained that they are useful, but that he can do without.¹⁶⁰

¹⁵³ Royal FrieslandCampina N.V., *2021 Annual Report*, 3.

¹⁵⁴ Willem Hendriks, personal communication during visit at Hendriks' farm, June 9, 2020.

¹⁵⁵ Jos Bijman, "Exploring the Sustainability of the Cooperative Model in Dairy: The Case of the Netherlands," *Sustainability* 10 (2018): 1.

¹⁵⁶ Adeyinka, "Interview 2 with Ola Adeyinka," 58:00.

¹⁵⁷ GSMA, *Spotlight on Nigeria: Delivering a digital future* (London: GSMA, 2018): 1.

¹⁵⁸ Adaku Okeke and Chinaka Aliyu, "Interview 4 with co-founders of Tech4Ag," interview by Robin van Seumeren, August 28, 2021.

¹⁵⁹ Elfers 33:00

¹⁶⁰ Hendriks, "Interview with Willem Hendriks," 25:00.

For Dutch dairy farmers, the m-Agri services fulfil various functions and are provided through apps. Based on the three interviews that I conducted on Dutch dairy farmers, I conclude that there are two most important m-Agri services. The first is an application by FC in which the farmers can keep track of the amount and the quality of the milk supplied. The second is an application provided by CRV (Coöperatie Rundveeverbetering).^{161, 162} CRV is a company which provides information to dairy farmers as well as certain input supplies, most importantly semen. With a mobile phone application called “CRV Dier”, farmers can amongst others find detailed information about cow health, they can make appointments with veterinarians, they can keep track of certain stocks, order supplies and set up arrangements for artificial insemination (figure 7).¹⁶³

There are other m-Agri services, for instance ones that are provided separately by veterinarians. However, they are not as widely used. Also, there are other mobile phone applications which are important for Dutch dairy farmers. They are bank apps for managing financial affairs, weather forecasts and various communication applications. However, these cannot be considered m-Agri services. Table 7 provides a comparison between mDairy and the two m-Agri services commonly used by Dutch dairy farmers.^{164, 165}

	mDairy	CRV Dier	FC app
E-extension	Yes	No	No
Productivity	Yes	No	Yes
Cow health	Hardly (only amount of milk rejected)	Yes (extensively)	No
Cooperation with third parties	Hardly	Yes (extensively)	No

Table 7: Comparison mDairy with m-Agri services used by Dutch dairy farmers

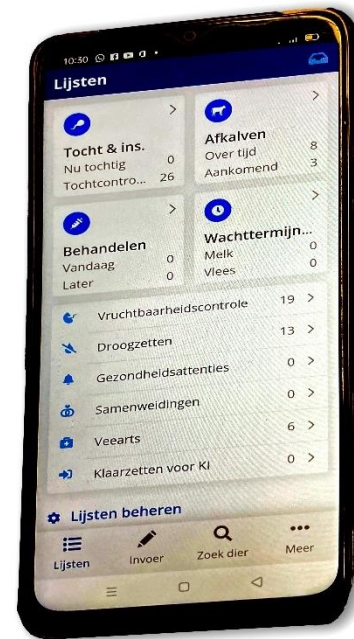


Figure 8: The home screen of CRV Dier, an m-Agri service frequently used by Dutch dairy Farmers

5.5. Profitability

In line with what the literature said, the productivity amongst Nigerian farmers was low. Stijn Markers, dairy development manager at FC, informed me that the average production of farmers participating in the mDairy pilot was between 1 and 2 litres per day per cow. The production is lower in during the dry season (September-January). Other interviewees agreed that production decreases by 25 to 50% during dry season.^{166, 167} Ahmed Udoh, a Nigerian dairy farmer and a secretary of the

¹⁶¹ Hendriks, “Interview with Willem Hendriks,” 10:00.

¹⁶² Willems, “Interview with Jan Willems,” 31:00.

¹⁶³ Coöperatie Rundveeverbetering, “CRV Dier, de nieuwe applicatie voor uw bedrijfsmanagement,” last accessed July 11, 2022, <https://crv4all.nl/nl/service/crv-dier>.

¹⁶⁴ Hendriks, “Interview with Willem Hendriks,” 10:00.

¹⁶⁵ Willems, “Interview with Jan Willems,” 31:00.

¹⁶⁶ Udoh, “Interview with Ahmed Udoh,” 25:00.

¹⁶⁷ Ibrahim Musa, “Interview 2 with Ibrahim Musa, Nigerian dairy farmer and head of cooperative,” interviewed by Robin van Seumeren, June 19, 2022, 06:00.

local dairy council, said that the average production was 3 to 4 litres and that this dropped to 2 to 3 litres during dry season.¹⁶⁸

The 1048 farmers that were registered in mDairy on the 12th of May 2022, had between 35 and 150 cows according to the app developers.¹⁶⁹ Ibrahim Musa, a Nigerian dairy farmer, and the head of a farmer cooperative, estimated the average amount of cows to be 100. Also, they have permanent residences that they live at.¹⁷⁰ With these characteristics, I categorise them as settled peri-urban pastoralists (table 2). Dutch farmers have approximately 100 cows per farmer. The productivity is much higher for Dutch farmers. In the Netherlands, cows give between 25 and 30 litres per day.¹⁷¹

As scholars have previously identified, most Nigerian farmers have local breeds. My interviewees confirmed this and noted that most of the mDairy farmers use local breeds, mainly Bunaji cows.^{172, 173, 174} Another distinction between Dutch and Nigerian productivity is that Dutch productivity is constant year-round whereas Nigerian productivity fluctuates heavily. This affects the profitability since factories need to run on full capacity to be most efficient.¹⁷⁵

So far, I found that dairy production in Nigeria is significantly more difficult because of factors such as an undesirable climate, lacking infrastructure, underdeveloped value chains and the absence of m-Agri-services. This is in accordance with what most scholars have found. Most scholars think in line with the factor endowment theory. Because Dutch farmers have better factor endowments to produce dairy, importing milk from the Netherlands is cheaper than sourcing it locally. In line with this theory, one might expect that the milk price that Nigerian farmers charge is significantly higher than that of Dutch farmers. In fact, the milk price that Dutch and Nigerian farmers receive does not change much. Nigerian farmers receive 250 Naira (€0.57) per litre milk¹⁷⁶ and Dutch farmers receive €0.60.¹⁷⁷ Currently, the global milk price is exceptionally high due to the COVID-19 pandemic and the Russo-Ukrainian War. Before, the milk price used to be €0.40 in the Netherlands¹⁷⁸ and 200 Naira (€0.46) in Nigeria.¹⁷⁹ Even though Dutch milk is generally slightly cheaper, it is unlikely that it is cheaper for FC to import this milk to Nigeria instead of sourcing milk locally because of processing, transportation and transaction costs. This is why I consider the explanation in line with factor endowment theory to be inadequate. Why then, does FCW import milk and why does Markers argue that importing milk is cheaper?¹⁸⁰

This is the case because the imported milk is a different and cheaper dairy product than the locally sourced whole milk. The imported milk is fat-filled milk powder (FFMP), which is made from skimmed-milk to which vegetable oils, usually palm oil, are added. Importantly, skimmed milk powder is a by-product in the Netherlands and other Western countries with highly developed dairy value chains. These countries produce butter from the milk fats because this is a more lucrative business. Skimmed milk is a by-product which the countries seek to sell, or “dump”, at a very low

¹⁶⁸ Udoh, “Interview with Ahmed Udoh,” 25:00.

¹⁶⁹ Okeke and Aliyu, “Interview 5 with Adaku Okeke and Chinaka Aliyu,” 11:00.

¹⁷⁰ Musa, “Interview 2 with Ibrahim Musa,” 2:00.

¹⁷¹ van Veenhoven, “Interview with Toon van Veenhoven,” 2:00.

¹⁷² Markers, “Interview with Stijn Markers,” 09:00.

¹⁷³ Udoh, “Interview with Ahmed Udoh,” 12:00.

¹⁷⁴ Musa, “Interview 2 with Ibrahim Musa,” 04:00.

¹⁷⁵ Markers, “Interview with Stijn Markers,” 20:00.

¹⁷⁶ Musa, “Interview 2 with Ibrahim Musa,” 14:00.

¹⁷⁷ van Veenhoven, “Interview with Toon van Veenhoven,” 2:00.

¹⁷⁸ Ibid.

¹⁷⁹ Musa, “Interview 2 with Ibrahim Musa,” 14:00.

¹⁸⁰ Ibid, 17:00.

price. I verified whether this was the case for FCW by looking at FCW's milk powder products. Indeed, Peak Filled Instant Milk Powder contains 28 grams of vegetable fat (palm oil) and 0.015 grams of milk fat per 100 grams milk powder.¹⁸¹ In the Netherlands, milk powder does not contain vegetable fat. FC only has a brand which sells skimmed milk powder.¹⁸² However, other dairy companies have brands which sell whole milk powder and this contains 28 grams of milk fat per 100 grams of milk powder.¹⁸³ Apart from skimmed milk powder being a by-product in countries with developed dairy value chains, another reason why the price of FFMP is low is because it does not contain milk fat. In the price of milk is determined by the amount of protein and milk fat.¹⁸⁴

FFMP is significantly less nutritious than whole milk or whole milk powder. However, because most Nigerians hardly consume dairy products, the FFMP already brings a relatively large nutritional value. Additionally, Choplin explains that West African people consume FFMP products because they are unaware of the lower nutritional value of FFMP products. He accuses the companies supplying these products of "*deceiving*" the African consumer as they often do not clarify ingredients and nutrients on the packaging.¹⁸⁵

One could wonder why Nigeria does not produce butter from the milk and creates FFMP from the by-product skimmed milk. However, this process required advanced technologies. This process requires milk sprayers to create milk powder out of liquid milk. Markers pointed out that there are currently no milk sprayers in Nigeria.¹⁸⁶

Nigeria finds itself in a difficult position regarding the dairy industry. Local farmers cannot compete with their whole milk against the imported FFMP because FFMP is made from a by-product which can be sold at a very low rate. Also, if one analyses products which can be considered comparable, one finds that sourcing whole milk locally may be cheaper than importing whole milk or whole milk powder. As this is a case of "*selling at an unfairly low price*", it could be considered dumping.¹⁸⁷ One could criticise the World Trade Organisation (WTO), which has the responsibility to safeguard fair trading and to eliminate unfair trading, for not addressing this issue.

The Nigerian government can only apply protectionism to a certain extent because it is highly dependent on FC and other foreign multinationals for dairy supply. FCW dominates 75% of the Nigerian dairy market and the remainder is mostly dominated by other Western multinationals. Stakeholder theory helps explaining that FCW is owned by FC which is again owned by Dutch, Belgium and German dairy farmers. These stakeholders have no interest in developing Nigerian value chains other than through corporate social responsibility (CSR). On the other hand, FCW also has stakes in remaining present in Nigeria. It has been present in Nigeria for almost 70 years, it is FC's most profitable country and Nigeria has a lot of potential. Nevertheless, I expect FC to be able to survive without its operations in Nigeria. From the perspective of the Nigerian government, FCW quitting its operations would have severe implications. These findings support WST as I identify a

¹⁸¹ Oneagrix, "Peak Filled Instant Milk Powder Sachet," last accessed July 26, 2022, <https://www.oneagrix.com/peak-filled-instant-milk-powder-sachet>.

¹⁸² Albert Heijn, "Campina Melkpoeder mager," last accessed 26 July, 2022, <https://www.ah.nl/producten/product/wi108641/campina-melkpoeder-mager>.

¹⁸³ Albert Heijn, "Two cows Melkpoeder," last accessed 26 July, 2022, <https://www.ah.nl/producten/product/wi198385/two-cows-melkpoeder>.

¹⁸⁴ van Veenhoven, "Interview with Toon van Veenhoven," 34:00.

¹⁸⁵ Choplin, *Let's not Export Our Problems*, 4.

¹⁸⁶ Markers, "Interview with Stijn Markers," 13:00.

¹⁸⁷ World Trade Organisation, "Anti-dumping, subsidies, safeguards: contingencies, etc," last accessed 26 July, 2022, https://www.wto.org/english/thewto_e/whatis_e/tif_e/agrm8_e.htm.

system involving companies, farmers and governments which reproduces a form of hegemony and dependency. It seems almost impossible for Nigeria to free itself from this system. One way through which these problems could be alleviated, is by developing the processing of milk locally and to import and promote the use of milk sprayers. With the most recent dairy policy, the Nigerian government has paid increased attention to the processing of milk and it also talks about the use of milk sprayers.¹⁸⁸

¹⁸⁸ Federal Ministry of Agriculture and Rural Development, *National Dairy Policy*, 40.

6: Comparing the Applicability of mDairy with Dutch Digital Agriculture Technologies

In this chapter, I evaluate how value-enhancing mDairy is for the Nigerian dairy farmers. I investigate the potential of mDairy by looking if they add value to Nigerian farmers in similar fashions as to how Dutch farmers receive benefits from m-Agri services. Firstly, I look at the performance by discussing milk tracing, e-extension and side-effects. Next, I look at the technology development where I investigate the integration with other technologies, the financial sustainability and how local values have been taken into account. Lastly, I investigate the target audience requirements.

6.1. Performance

mDairy is ultimately designed to increase the milk yields of the farmers. Unfortunately, no quantitative data exists to give insights as to whether mDairy already fulfils this mission. This is the case because the pilot was about creating farmer profiles and ensuring that stakeholders understood how mDairy works.¹⁸⁹ Nevertheless, it is possible to assess mDairy. For a few of the farmers and transporters, the milk was registered. Also, by interviewing stakeholders, I was able to gain insights into how well the e-extension is working.

Joseph Magajo, dairy development director at FCW, beliefs that mDairy has a relative advantage over previously used methods. He explained that without mDairy, milk recording was done with different methods in each location, ranging from manual methods to digital programs like excel. This undermines unity, clarity and transparency. Also, he explained that the application gives information about the quality of milk by showing the amount of milk rejected. This information can tell FCW which farmers are productive and which ones are not. They can see what methods the productive farmers adopted and they can promote these methods to other farmers through tailored intervention.¹⁹⁰

During the pilot, a few milk transactions have been recorded and this went well. This shows that FCW can use the data from mDairy to see which farmers perform well and which farmers need assistance. Although it brings advantages by making the milk registration process streamlined and efficient, Markers questions whether mDairy can currently bring relevant insights regarding tailored intervention. According to Markers, it is quite clear how farmers can increase their productivity. Markers stated: *“For many of these pastoralists, the steps that they need to take in order to advance, are somewhere else.”*¹⁹¹ He added: *“They are in much more need of semen, good concentrated fodder, stalls, milk replacers, etc.”*¹⁹² Markers used the concept of the Maslow pyramid to explain his point. He explained that Dutch farmers find themselves in the top of the pyramid. Here, complex digital technologies can improve the performance of a system which is already performing well. The average Nigerian farmers finds himself/herself in the bottom of the Maslow pyramid where he/she is in need of water, food shelter, reproduction for the cows. Markers concludes the following: *“It only works in the most professional farms, not yet in mainstream farms. I think it is too early for*

¹⁸⁹ Meeting with Mohammed (don't know time/can't find)

¹⁹⁰ Joseph Magaji, “Interview with Joseph Magaji, dairy development manager at FCW,” interviewed by Robin van Seumeren, July 16, 2021, 5:00.

¹⁹¹ Markers, “Interview with Stijn Markers,” 39:00.

¹⁹² Ibid.

Nigeria.”¹⁹³ He points out that there is “*low-hanging fruit*” that Nigerian farmers can pick first before m-Agri services will be beneficial to them with services like tailored intervention.¹⁹⁴

It should be well understood that e-extension, rather than milk tracing, currently is the most important purpose with which mDairy is designed. Because the Nigerian farmers find themselves in the bottom of the Maslow pyramid and because they are not educated about the most efficient dairy practices, they need to be informed about these practices so they can move up the Maslow pyramid. The e-extension is designed so that CWL can educate farmers (who usually do not have a smartphone) on the best dairy practices. Initially, the opinions on the success of the e-extension component of mDairy seemed highly diverse. Markers and Udoh first comments on mDairy’s e-extension were quite negative whereas those by Udoh and Musa were very positive. However, after discussing different viewpoints with the interviewees, commonalities could be identified.^{195, 196, 197, 198}

Markers said that the e-extension function is “*not effective and that the usage by dairy farmers is moderate to absent*”.¹⁹⁹ On the contrary, Adeyinka stated mDairy pilot participants often used the e-extension. He stated: “*Both the farmers and the community livestock workers are using the e-extension.*”²⁰⁰. Ahmed Udoh called the mDairy pilot “*A nice idea [...] but due to the number of farmers not exposed to certain innovations [...] it will be difficult for them.*” With this he means that because the farmers have not been exposed to the innovations that are presented in mDairy’s e-extension, they have difficulty trusting, understanding and picking up the methods explained in the app.²⁰¹

Udoh also explained that he thinks that increased exposure to innovative dairy methods through physical one-on-one meetings is important. FC currently has extension officers in place but according to Udoh there are too few so they cannot give enough attention to each farmer and explain practices relating to cow health, milk hygiene, cow fodder and sustainability.²⁰² Similar to Adeyinka, Ibrahim Musa’s is very positive about mDairy. However, he understands the concerns raised by Udoh and agrees that many farmers do not understand and take up the advice in the e-extension. He agrees that there should be a closer relationship between farmers and those who possess knowledge about the best dairy practices.²⁰³ Although Adeyinka is positive about mDairy and the e-extension, he also shares these concerns. He concludes that farmers are willing to use the e-extension, and that they do so if they are educated enough to understand it, but that most farmers need to be educated first through one-on-one sessions before e-extension can be most effective.²⁰⁴

Because of this, I believe that dairy does not yet reach its full potential and that a higher degree of relative advantage could be attained once the farmers are more engaged with innovative dairy practices. Also, I believe that mDairy currently only brings relative advantage within the confines of the

¹⁹³ Ibid, 42:00.

¹⁹⁴ Ibid, 44:00.

¹⁹⁵ Stijn Markers, email correspondence, June 2, 2022.

¹⁹⁶ Udoh, “Interview with Ahmed Udoh,” 2:00.

¹⁹⁷ Adeyinka, “Interview 3 with Ola Adeyinka,” 0:00.

¹⁹⁸ Musa, “Interview 2 with Ibrahim Musa,” 33:00.

¹⁹⁹ Stijn Markers, email correspondence, June 2, 2022.

²⁰⁰ Adeyinka, “Interview 3 with Ola Adeyinka,” 0:00.

²⁰¹ Udoh, “Interview with Ahmed Udoh,” 2:00.

²⁰² Ibid, 16:00.

²⁰³ Ibrahim Musa, “Interview 1 with Ibrahim Musa, Nigerian dairy farmer and head of cooperative,” interviewed by Robin van Seumeren, August 3, 2021.

²⁰⁴ Adeyinka, “interview 3 with Ola Adeyinka,” 6:00.

mDairy project. For it to bring relative advantage on a larger scale, to Nigerian farmers or African farmers in general, the issue of importing FFMP needs to be addressed.

Mobile phone applications are typically highly visible because they are often used at any time and at any place.²⁰⁵ However, because the majority of the farmers do not have smartphones, they cannot use the application and the mDairy cannot be observed amongst them. Also, the fact that the e-extension is not as effective and used as much as hoped, makes that the observability of mDairy is lower than the potential observability.

Besides the effect on milk tracing and e-extension, it is also important to take into account side effects of mDairy. In section 5.3, I have already that path dependency could become a threat. However, this is mainly due to FCW being the only institutionalised buyer of milk in Oyo state and only to a lesser degree due to mDairy. The violation of privacy issues, another common theme amongst critics of digital agriculture, is present to some degree with mDairy. As can be seen in figure 6, mDairy contains personal and potentially sensitive information of the Nigerian farmers and transporters. This data is publicly available because anyone can create an account.

Lastly, with mDairy, FCW promotes a zero- or semi-grazing policy. This has significant cultural implications for the large majority of Nigerian dairy farmers, for instance Fulani people, since they typically live a nomadic lifestyle where they even cross-national borders. Primordialists would argue that this represents a loss of culture. On the contrary, constructivists would argue that changing ethnic identities natural.²⁰⁶ Additionally, this changing pattern can also be seen as a solution to the long-standing problem of violent conflicts between herdsmen and farmers in northern and central Nigeria.²⁰⁷

6.2. Technology Development

Tech4Ag is capable of integrating different technologies into the mDairy system. With one of its noncore functions, it has already done so. One of the functions that is under development, is the e-wallet function (figure 1). Here, farmers can receive their income for the milk supplied and they can do financial transactions. With this function, banks are involved.²⁰⁸ Adeyinka, as well as the app developers, explain that it is in the DNA of Tech4Ag to integrate new technologies in mDairy in order to be able to deliver the most adequate service. Currently, it is only the case for the e-wallet, but other examples could include weather forecasts or input supplies.^{209, 210}

The revenue-making model is a concern for Tech4Ag. Currently, mDairy is still financed by FCW (42%), Tech4Ag (41%) and 2SCALE, (17%). 2SCALE stands for “Toward Sustainable Clusters in Agribusiness through Learning in Entrepreneurship” and it is a Dutch start-up incubator that is primarily financed by the Dutch Ministry of Foreign Affairs. 2SCALE has facilitated the relationship and cooperation between FCW and Tech4Ag.²¹¹

²⁰⁵ Rogers, *Diffusion of Innovations*, 246.

²⁰⁶ Pierre Engelbert and Kevin C. Dunn, *Inside African Politics* (Boulder: Lynne Rienner Publishers, 2013):68-71.

²⁰⁷ Markers, “Interview with Stijn Markers,” 45’00.

²⁰⁸ Okeke and Aliyu, “Interview 2 with Adaku Okeke and Chinaka Aliyu.”

²⁰⁹ Adeyinka, “Interview 2 with Ola Adeyinka,” 36:00.

²¹⁰ Okeke and Aliyu, “Interview 2 with Adaku Okeke and Chinaka Aliyu.”

²¹¹ 2SCALE, *Supportive Partnership Agreement By and between Tech4Ag LTD and International Fertilizer Development Center, (on behalf of the 2SCALE program consortium)* (Utrecht: 2SCALE, 2020): 21.

Emeana, Trenchard and Dehnen-Schmutz pointed out that many m-Agri services fail to survive in the long run because they are too dependent on donor funding.²¹² mDairy is currently also financed with donor funding and Tech4Ag has identified various revenue-making models to make the m-Agri service self-sustaining. Firstly, Tech4Ag considers charging a maintenance fee for agricultural companies like FCW that use their services. In addition, Tech4Ag can sell data analysis infographics to these organisations. A second option is charging a fee on transactions which take place in the mDairy system. However, FCW and the farmers would have to agree with this first. Thirdly, mDairy can serve as a tool for communication or research. If the Nigerian government or other parties want to convey messages to the farmers who live remotely, they can use the mDairy system against a usage fee. The same can be arranged for research institutions which would want to conduct surveys or get in touch with farmers. Lastly, Tech4Ag has considered developing a function where users can make investments in the Nigerian dairy farmers. Anyone can create a profile on mDairy, look at farmer profiles and choose a farmer to extend a loan to which will be paid back with an interest after a certain amount of time.²¹³

Enabling farmers to make use of a free trial is something that Tech4Ag takes into account to attract customers. This means that the innovation is triable. The problem the third and fourth model is that they rely on parties that are currently not cooperating with Tech4Ag. With the first two models, Tech4Ag makes FCW and the farmers pay. FCW is willing to pay for the service, but there is uncertainty whether FCW is willing to pay the full sum. Markers and Adeyinka both expect that farmers are not willing to pay for mDairy because it is not what the farmers need most urgently.^{214,}
²¹⁵

According to Rogers, a successful innovation must be compatible with local norms and values.²¹⁶ Agyekumhene et al. explain that co-designing m-Agri services significantly enhances the likelihood of being successful.²¹⁷ Because most Nigerian dairy farmers are unfamiliar with digital technologies, mDairy has by definition a low compatibility with existing norms and values. However, to make the app compatible with the farmers' lifestyles, the app-developers provided the e-extension in four different languages (English, Yoruba, Hausa and Fulfulde) (figure 4). Although the app-developers collected feedback from farmers, they did not include them actively in the designing phase.²¹⁸ Adeyinka also stated that he believes that the e-extension in mDairy contains too much text and too little images and videos.²¹⁹ Agyekumhene et al. also strongly emphasised the use communication methods that stand close to methods that farmers traditionally use such as storytelling, visuals, narratives and games instead of texts.²²⁰ Thus, increased focus on HCI4D, for instance by including farmers in future design processes could be one way to reduce the complexity for farmers and to increase their engagement with the app.

²¹² Emeana, Trenchard and Dehnen-Schmutz, "Revolution," 2-6.

²¹³ Okeke and Aliyu, "Interview 2 with Adaku Okeke and Chinaka Aliyu."

²¹⁴ Markers, "Interview with Stijn Markers," 39:00.

²¹⁵ Adeyinka, "Interview 3 with Ola Adeyinka," 18:00.

²¹⁶ Rogers, *Diffusion of Innovations*, 211.

²¹⁷ Agyekumhene et al, "Making Smallholder Value Chain Partnerships Inclusive," 1.

²¹⁸ Okeke and Aliyu, "Interview 4 with Adaku Okeke and Chinaka Aliyu."

²¹⁹ Adeyinka, "Interview 3 with Ola Adeyinka," 43:00.

²²⁰ Agyekumhene et al, "Making Smallholder Value Chain Partnerships Inclusive," 5.

6.3. Target Audience Requirements

For mDairy to be a success, there are certain requirements that mDairy users have to comply to. Firstly, they need to possess a smartphone. Secondly, they need to be able to understand the information that is provided through mDairy. In this section, I investigate whether or not the users comply with these requirements.

Currently, the app is meant to be used by community livestock workers who educate farmers with the e-extension, for extension officers who create profiles and by milk collection officers who insert the amount of milk supplied. As explained in section 6.1, the milk tracing works well. The milk collection officers possess smartphones and know how to make use of mDairy.

However, for the e-extension, the target audience requirements pose a challenge. Because most Nigerian dairy farmers do not possess phones, mDairy has been designed for CWLs to educate farmers. Ideally, the app is directly used by farmers. Tech4Ag hopes that the smartphone penetration rate amongst Nigerian dairy farmers will increase so that mDairy can be more effective.²²¹ Musa and Adeyinka pointed out that farmers can buy smartphone, although some farmers would need to sell one or multiple cows to do so.^{222, 223}

As I explained in section 6.1, the performance of the e-extension is suboptimal because are not familiar enough with the practices outline in mDairy. In fact, they are highly unaware of these practices. Markers explains that it is “*too early*” for mDairy and that farmers first have to focus on “*low-hanging fruit*”.²²⁴ Udoh stated that the farmers do not yet have received enough “*exposure*” to these practices.²²⁵ Adeyinka argued that a “*behavioural change*” is required before mDairy’s e-extension can be value-enhancing.²²⁶ Lastly, van Veenhoven explains that the farmers do not understand “*the why*” of the practices. He criticises the farmers for being naïve and for underestimating what work is required to execute a zero-grazing policy.²²⁷

Based on these comments, I conclude that the Nigerian farmers first need to be taught how to think of a zero-grazing policy and other innovative dairy practices. Only once the farmers have a basic understanding and are willing to undergo a behavioural and ideological change, mDairy’s e-extension, where these practices are explained in more detail, can benefit the farmers. This is in line with scholars promoting the term HCI4D. They argue that ICT4D can be established, but that human-computer interactions (HCI) need to be in place first.²²⁸

²²¹ Adaku Okeke and Chinaka Aliyu, “Interview 3 with Adaku Okeke and Chinaka Aliyu, co-founders of Tech4Aag,” interview by Robin van Seumeren, August 11, 2021.

²²² Musa, “Interview 3 with Ibrahim Musa,” 32:00.

²²³ Adeyinka, “Interview 3 with Ola Adeyinka,” 17:00.

²²⁴ Markers, “Interview with Stijn Markers,” 44:00.

²²⁵ Udoh, “Interview with Ahmed Udoh,” 16:00.

²²⁶ Adeyinka, “Interview 3 with Ola Adeyinka,” 28:00.

²²⁷ van Veenhoven, “Interview with Toon van Veenhoven,” 25:00.

²²⁸ Emeana, Trenchard, and Dehnen-Schmutz, “Revolution,” 1-2.

7: Dutch-Nigerian Farmer Connectivity

In this chapter, I investigate whether Dutch-Nigerian farmer connectivity would be value-enhancing for Nigerian farmers and I explore ways through which this could be achieved. Because this thesis focusses specifically on m-Agri services, I firstly look at knowledge exchange regarding m-Agri services, captured by the notion frugal innovation. Secondly, I look whether connectivity unrelated to m-Agri services can be value-enhancing. When I do this analysis, I ask what knowledge is missing and how it can be made available.

7.1. Frugal Innovation

Currently, mDairy is not performing optimally. Most importantly, milk tracing is not what the farmers need most urgently and the effectiveness of the e-extension is low. There is low-hanging fruit which can be picked first before mDairy can add significant value. Farmers first need to be familiar with digital tools and they need to understand the basics of zero-grazing farming before mDairy can be value-enhancing. Nevertheless, this does not mean that mDairy can be abandoned. Although it may be too early, mDairy still has potential for the future.

What farmers need instead of milk tracing and e-extension is first and foremost one-on-one education and secondly, input supplies. Looking into frugal innovation does not provide insights into one-on-one education because Dutch farmers do not use m-Agri services for education purposes. However, frugal innovation can assist in increasing the accessibility of input supplies.

When comparing functions of Dutch m-Agri services and mDairy, a big difference is that Dutch m-Agri services allow farmers to get in touch with inputs suppliers and to make appointments with veterinarians, semen providers and other important actors. With mDairy this function is not present. This is partly the case because most farmers do not use a wide range of inputs and because these inputs are not widely available. Nevertheless, partnering up with input suppliers and ensuring that inputs are available, would benefit farmers much. In the academic literature, scholars also argue that linking m-Agri services with information providers, for instance regarding the weather or market prices, is beneficiary.²²⁹ Doing so would also improve the usefulness of mDairy for farmers.

Additionally, this could also provide a solution to the revenue-making model issue. In the Netherlands, farmers pay for CRV Dier. In Nigeria, farmers are not willing to do so. However, if farmers can get input supplies through mDairy, their willingness to pay is likely to increase.²³⁰

7.2. Dutch Dairy Practices in Nigeria

There is a wide range of tools and practices that Dutch farmers effectively use that Nigerian farmers do not use. They include making use of milk replacers, semen, medicines, concentrates, machines and agricultural by-products. Dutch dairy farmers also participate in cooperatives and are active in harvesting grasses. Some practices cost money, such as using milking systems. However, other practices are not expensive, for instance equalizing the land. Because Nigerian farmers are heavily used to their type of farming, and because they are not aware of innovative methods, they have hardly implemented any of these practices. Therefore, much can be achieved by increasing Dutch-Nigerian farmer connectivity. Importantly, interviewees pointed out that farmers need to be made

²²⁹ Ibid, "Revolution," 2.

²³⁰ Adeyinka, "Interview 3 with Ola Adeyinka," 18:00.

aware, convinced or activated to change their behaviour through personal one-on-one meetings.²³¹
232, 233

FCW is aware of this and has made use of both Nigerian and Dutch specialists to educate Nigerian dairy farmers. FCW currently employs 15 extension officers who are divided over the five states that FCW is active in. Because FCW sources milk from approximately 2,000 farmers per state, the average extension officer to farmer ratio is 1:733. Because high number makes it difficult for extension officers to provide high-quality extension services to the farmers. Adeyinka explained that increasing this number is difficult because extension officers are expensive for FCW due to their wages and the travel costs that they have to be compensated for. Also, the Nigerian government has many extension officers employed under the UAES (unified agricultural extension services) scheme who are supposed to provide extension to dairy farmers. However, their services are of poor quality. Adeyinka explains that their commitment is low, most importantly because they are not well taken care of by the Nigerian government. For instance, they are not begin provided with transportation or all the necessary materials.²³⁴ He explains that FCW's extension services should be seen as pro-active:

"FrieslandCampina is not willing to wait for their delays. So that's why FrieslandCampina, they are proactive in hiring extension officers. They employ extension officers as staff, which is not supposed to be so because FrieslandCampina is a processing company. So, if the government or public institutions are doing the right thing, FrieslandCampina, they don't need to have extension officers because the government extension officer is supposed to do that job. Because they are not doing it, that is why FrieslandCampina went ahead and started their own extension service department in the company."²³⁵

The question then arises who is best equipped to fill up this gap. According to Adeyinka and 2SCALE, private extension officers are best placed to do this. Veterinarians and other specialists in dairy farming can organise themselves as private extension officers and can provide assistance to farmers against a fee. To institutionalise this, mDairy could be of use to ensure that farmers and these private extension officers can get in touch with each other.²³⁶

Next to connecting Nigerian farmers with Nigerian specialists, FCW could also connect Nigerian farmers with Dutch farmers. This is something that the company has already done. Firstly, the Center for Nigerian Dutch Dairy Development (CNDDD), which is an initiative by FCW, creates publishes videos for Nigerian farmers in which Dutch farmers explain about the most important dairy farming practices. Secondly, FC has sent Dutch farmers on mission to Nigeria. With these farmer2farmer programs, Dutch farmers can show Nigerian farmers many effective dairy farming practices. van Veenhoven explains that Nigerian farmers, appreciate education from a fellow farmer. He states: *"When they see your hands, you have already won their trust."*²³⁷ However, these missions only last for a few weeks and because they do not happen regularly, they are unlikely to have long-term impact.

Therefore, I investigated whether Dutch farmers would be interested in participating in a program in which they start a mentor relationship with one or multiple Nigerian dairy farmers. If FC would make

²³¹ Udoh, "Interview with Ahmed Udoh," 16:00.

²³² Musa, "Interview 2 with Ibrahim Musa," 33:00.

²³³ Adeyinka, "Interview 3 with Ola Adeyinka," 0:00.

²³⁴ Ibid, " 46:00.

²³⁵ Ibid.

²³⁶ Ibid, 1:18:00.

²³⁷ van Veenhoven, "Interview with Toon van Veenhoven," 37:00.

the right arrangements, which includes a small sign of recognition and gratitude, all three of the Dutch farmers that I interviewed would be interested starting such a relationship.^{238, 239, 240}

Additionally, I researched whether the Dutch farmers would be interested in investing in a Nigerian dairy farm or setting up a farm in Nigeria in cooperation with Nigerian farmers. This would be an even more intense form of Dutch-Nigerian farmer connectivity where Nigerian farmers are likely to pick up innovative dairy techniques most quickly. The opinions of the Dutch farmers were mixed regarding this proposal. Hendriks acknowledged that long-distance farming is becoming more prevalent and that this can also be done in dairy farming. He answered that he was “*interested*”.²⁴¹ van Veenhoven would not want to start a business partnership with Nigerian farmers. He explained that he is very sceptical about this. He would not trust people in Nigeria to run his business and he would want to be present at a farm fulltime if he would make an investment in a farm.²⁴² Jan Willems explains that Dutch-Nigerian business partnerships could be a possibility for certain Dutch farmers. He explains that there have been various cases of Dutch farmers that invest in farms in Eastern Europe where they can do large-scale farming. However, he questions whether it would be profitable in the Nigerian context. If FC could provide assistance, he envisions that there is potential.²⁴³

²³⁸ Willems, “Interview with Jan Willems,” 36:00.

²³⁹ Hendriks, “Interview with Willem Hendriks,” 23:00.

²⁴⁰ van Veenhoven, “Interview with Toon van Veenhoven,” 47:00.

²⁴¹ Hendriks, “Interview with Willem Hendriks,” 23:00.

²⁴² van Veenhoven, “Interview with Toon van Veenhoven,” 42:00.

²⁴³ Willems, “Interview with Jan Willems,” 37:00.

8: Conclusion

Since the turn of the century, Africa started experiencing a food trade deficit which has increased ever since. One of the industries in which this trend is highly present, is the Nigerian dairy industry. 64% of the dairy products that Nigerians consume, are produced by imported milk powder. As the Nigerian population is expected to be doubled by 2050, and because the demand for dairy products is rising, this topic is increasing in relevance.

FCW is the market leader and imports between 85% and 98% of the dairy that it sells in Nigeria. As the Nigerian government recognises the urge of changing this development, it urges the dairy companies like FCW to increase the percentage of locally sourced milk. To do so, FCW initiated the mDairy project. mDairy, a digital platform with a smartphone application, is designed by Tech4Ag to facilitate milk tracing and to provide e-extension to Nigerian dairy farmers. Most Nigerian farmers practice pastoralism where they cross long distances in search of water and pasture. Because this is inefficient, both the Nigerian government and FCW promote innovative methods such as zero-grazing. With mDairy's e-extension, farmers are informed about these. Also, they can get in touch with FCW's extension officers if they are in need of assistance. Because most farmers do not have smartphones, this happens through CLWs who have been taught how to inform the farmers about the functions of mDairy and the practices that are explained in the app.

Some scholars argue that m-Agri services have a lot of potential for Africa and that they can significantly reduce Africa's food security problems. Other scholars are sceptical and show that the rate of success is lower in the global south compared to the global north. To better understand which factors determine the success of m-Agri services in Africa, and to better understand the potential of m-Agri services for Africa, I employed a case study on mDairy. Because m-Agri services are generally successful in the global north, I compared the mDairy case with cases of m-Agri services amongst Dutch farmers that supply milk to FC. Because Dutch farmers are using the practices that the Nigerian government and FCW want Nigerian farmers to use, I also investigated possibilities of increased Dutch-Nigerian farmer connectivity.

To assess the applicability of mDairy and to assess the potentiality of increased Dutch-Nigerian farmer connectivity, I conducted nineteen interviews eleven diverse stakeholders. Amongst others, I interviewed the app developers, personal at FC and FCW, Nigerian farmers and Dutch farmers.

There are several limitations to my research. Because I chose to do a qualitative case study, my position as a researcher has been less distant than what is the case with some other study designs. This could have resulted in bias and reduced the objectivity of the researchers. Secondly, case studies have limited generalisability. There are certain unique characteristics which reduce the representatives of mDairy for m-Agri services in Africa. Firstly, mDairy is introduced by a Western multinational, which serves different interests than local companies. Secondly, FC is a cooperative which is owned by mostly Dutch farmers. Also, the 500 farmers that participated in the mDairy pilot, are farmers that have settled whereas most Nigerian farmers live nomadic lifestyles.

Because of the COVID-19 pandemic, I could not visit Nigeria and I could not do on site field work to collect data. This made it more difficult for me to understand the lifestyles of the farmers and other stakeholders, to assess the effectiveness of mDairy and to communicate with different stakeholders. Communication with various Nigerian stakeholders was difficult because of network connectivity issues and because of the level of English that they spoke. Because I could only interview Nigerian farmers that could speak English, some degree of selection bias may be present. On a positive note, not being able to visit Nigeria forced me to think creatively and as a result, I decided to focus on comparing Dutch and Nigerian dairy farming.

Because successful m-Agri services require input from a wide range of origins, it can be best studied with an interdisciplinary approach. My expertise lies in the fields of African studies and business administration, which are highly relevant for this research. However, I have limited expertise in agricultural science and computer science, which are also important for evaluating m-Agri services. Lastly, it is important to point out that I narrowed development down to income even though development involves more than just economic welfare.

My research concludes that it is too early for mDairy for two reasons. mDairy is relatively well designed but before it can be value-enhancing for Nigerian dairy farmers, farmers first have to be more aware of what innovative dairy practices entail and require. My interviewees agreed that the farmers have to undergo a behavioural change, that they require more exposure and that they need to understand “the why” before they will, by themselves, buy smartphones and actively use mDairy. They also agree that one-on-one assistance is what farmers need to be informed and convinced about the added value of the innovative methods. Thus, for FCW to increase the amount of locally sourced milk, it needs to increase the level of Dutch-Nigerian farmers connectivity. This is somewhat complicated as the Nigerian government currently fulfils the role of providing extension services on the most effective farming practices through the UAES, but it fails to do so adequately. FCW has replied to this by employed a number of extension officers by itself, but it cannot completely take up this task. Alternatively, it can facilitate sustainable partnerships between Dutch and Nigerian farmers. Dutch and Nigerian farmers are quite positive about establishing relationships involving regular online meetings where Dutch farmers assist and advice Nigerian farmers. FC is advised to facilitate these relationships and possibly, they could evolve in Dutch-Nigerian business partnerships.

The second reason why I believe that mDairy cannot reach its full potential currently is because there is a structural problem where Nigerian farmers have to compete with their whole fresh milk against FFMP, which is imported and can be sold at a cheap price because it is primarily made from a by-product. The cheap-by product, rather than factor endowments, explain why milk is imported instead of sourced locally. The imports could be considered dumping, especially given that FFMP is less nutritious than whole milk and because it may even be cheaper to source whole milk locally than to import whole milk or whole milk powder. Because Nigeria is dependent on dairy multinationals like FCW for the nation’s dairy supply, it is difficult for Nigeria to escape from this system as the government has limited power to demand the dairy multinationals to substitute imports with locally sourced milk. I suspect that escaping this structure is a timely process. Nevertheless, steps can be made to advance in this process by importing and promoting the use of milk sprayers so that Nigerian milk can also be processed and so that it can become more globally competitive.

I believe that my research has identified various interesting and relevant future research topics. Most importantly, I urge researchers to investigate in more detail the role of imports and FFMP, and to investigate how improved milk processing could help in making Nigerian milk more globally competitive. It would also be relevant to investigate what would be the most efficient ways of informing and convincing Nigerian farmers zero-grazing policies and other innovative dairy farming methods. Possibilities for increased Dutch-Nigerian farmer cooperation would also be an interesting research topic. Also, I believe that more country-comparisons are insightful, especially when this is done with a successful dairy country that shares more similarities to Nigeria, for instance Uganda. Lastly, it would be useful to do similar research on farmers who are more representative of the average Nigerian dairy farmer and it would be highly interesting if quantitative research could be done on the effects of m-Agri services on the productivity of dairy Nigerian farmers. Hopefully, more research on this topic will help to further enable m-Agri services to reach their potential to develop Africa’s food value chains and alleviate Africa’s food security issues.

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