Egg value chain analysis in Zambia

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The information and knowledge produced through the value chain studies are intended to support the Delegations of the European Union and their partners in improving policy dialogue, investing in value chains and better understanding the changes linked to their actions

VCA4D uses a systematic methodological framework for analysing value chains in agriculture, livestock, fishery, aquaculture and agroforestry. More information including reports and communication material can be found at: https://europa.eu/capacity4dev/value-chain-analysis-for-development-vca4d-

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Notwithstanding the above, we state that the conclusions, views and recommendations stated in this report are those of the authors and do not necessarily represent the views of EC DEVCO or the EU Delegation in Zambia.

ACRONYMS

AAF: African Agriculture Fund
AFA: Agri-Food Chain Analysis
AMG: At market gate
AFG: At farm gate
BOP: Bottom of the pyramid (distribution system adopted by GLL)
BOZ: Bank of Zambia
CH4: Methane
C: Completeness
CIRAD: Centre de coopération internationale en recherche agronomique pour le développement
CO2: Carbon Dioxide
DEVCO: EC Directorate-General for International Cooperation and Development
DR Congo: Democratic Republic of Congo
DRC: Domestic Resource Cost
DOC: Day Old Chicks
DQL: Data Quality Level
DQR: Data Quality Rating
E-VCA: Egg Value Chain Analysis
EC: European Commission
EU: European Union
EUD: European Union Delegation
eq.: Equivalents
FAO: Food and Agriculture Organization of the United Nations
FISP: Farmers Inputs Support Programme
FRA: Food Reserve Agency
FU: Functional Unit
GDP: Gross Domestic Product
GMO: Genetically Modified Organism
GLL: Golden Lay Limited
GR: Geographical representativeness
GRZ: Government of Republic of Zambia
IAPRI: Indaba Agricultural Policy Research Institute
ICCPR: International Covenant on Civil and Political Rights
ICESCR: International Covenant on Economic, Social and Cultural Rights
ILCD: International Reference Life Cycle Data System
ILO: International Labour Organisation
IFC: International Finance Corporation
IGS: Intermediate goods and services
IPCC: Intergovernmental Panel on Climate Change
ISO: International Organization for Standardization
JSE: Johannesburg Stock Exchange

Kg.: Kilogram = 1,000 grams (g)
Km. Kilometer = 1,000 meters (m)
kg CO2-eq: Kilograms of carbon dioxide equivalents
kWh: Kilowatt-hour=3,600,000 joules (j)
LCA: Life Cycle Assessment
LCI: Life Cycle Inventory
LCIA: Life Cycle Impact Assessment
LUC: Land Use Change
M: Methodological consistency
m3: Cubic meter
MCTI: Ministry of Commerce, Trade and Industry
MJ: Megajoule = 1,000,000 joules, (948 Btu)
NGO: Non-governmental Organisation
NGHL: NWK Grain Handlers Limited
NH3: Ammonia
NIRSAL: Nigeria Incentive-based Risk Sharing System for Agricultural Lending
N20: Dinitrogen monoxide
NOx: Nitrogen oxides
P: Precision
PAZ: Poultry Association of Zambia
POL: Point of Lay Pullets
Pop.: Population
PM: Particulate Matter
PMU: Project Management Unit
POL: Point of Lay
PO4 3: Phosphate
RF: Reference flows
SAPA: South Africa Poultry Association
SCLCI: Swiss Center for Life Cycle Inventories
SETAC: Society of Environmental Toxicology and Chemistry
SHF: Smallholder farmers
SI: Statutory instrument
SO2: Sulfur dioxide
SOC: Soil Organic Carbon
SPSS: Statistical Package for Social Sciences
7NDP: Seventh National Development Plan
TAF: Technical Assistance Facility
TOR: Terms of Reference
UNESCO: United Nations Educational, Scientific and Cultural Organization
USAID: United States Agency for International Development
VAT: Value Added Tax
VC: Value Chain
TeR: Technological Representativeness
TiR: Time related Representativeness

VCA4D: Value Chain Analysis for Development
VGGT: Voluntary Guidelines of the Governance of Tenure
ZAMACE: Zambia Agricultural Commodity Exchange
ZANACO: Zambia National Commercial Bank
ZARI: Zambia Agricultural Research Institute
ZDA: Zambia Development Agency
ZEMA: Zambia Environmental Management Agency
ZMW: Zambia Kwacha
ZNFU: Zambia National Farmers Union

EXECUTIVE SUMMARY

Background: Consistent with similar studies commissioned under this project, the study of the egg value chain (egg VC) responds to four framing questions:

1) What is the contribution of the egg VC to economic growth in Zambia?
2) To what extent is this growth inclusive?
3) Is the egg VC socially sustainable; and
4) Is the egg VC environmentally sustainable?

The egg VC in Zambia is under-researched. Previous studies on the poultry sector have focused on the broiler VC. This study aims to provide a robust analysis of quantitative and qualitative data, based on relevant indicators, which will support evidence-based decision making on the formulation of investment strategies and policy dialogue to promote sustained and inclusive growth in the egg VC. It is also anticipated that the study will contribute to cross-cutting conclusions and lessons relating to the Value Chain Analysis for Development (VCA4D) methodology.

Scope: The main boundary for the analysis of quantitative data relating to the egg VC is egg production – from day old chicks (DOC) to table eggs. In particular, financial and economic analysis undertaken as part of the study focused on the egg producers as well as those who rear point of lay (POL) hens and sell to small and medium-scale egg producers. Also included in the analysis are the table eggs traders and consumers. In addition, relevant background information is collected and discussed in relation to other players connected to the basic chain. These include key inputs suppliers such as farmers growing soya beans which are a vital ingredient in commercial layer feed formulation. Small-scale soya producers who are participating in contract farming are of interest, partly because of opportunity provided to learn from experiences under the Technical Assistance Facility (TAF) support in Zambia. TAF funded a pilot a distribution system with a major egg producer to improve supply of table eggs to retailers in "high-density" (relatively poorer) urban communities and an out-grower scheme involving the production and supply of soya beans by small-scale farmers to the market leader in egg production in the country. As far as egg producers are concerned, the focus of the study is on "table eggs" produced from hybrid layers primarily for the market. Eggs produced in rural areas from "village chickens" are therefore not covered in this study as evidence available suggests these eggs are not marketed but are consumed by households or hatched for raising chicken.

Methodology: The team used the generic methodology developed for the VCA4D Project. Specific methods used included literature review, analysis of existing databases, semi-structured interviews of key actors, a structured questionnaire, statistical analysis underpinning the functional and economic analysis, involving mainly spreadsheet calculations. The social analysis framework and spreadsheet tool was applied, as was the Life Cycle Analysis (LCA) and a software platform (SimaPro) for analysis of environmental sustainability and impact assessment. Regular consultations between team members were used to confirm the study scope, agree the base year for analysis and agree on categories of egg producers. A validation workshop enabled stakeholders to engage with the emerging conclusions and also assist in filling data gaps.

Main Findings

Functional analysis

Based on the boundaries set for the study, the main actors consulted were the different categories of egg producers (large-scale, medium scale, small and micro-scale), POL suppliers and table egg traders and consumers. Other stakeholders consulted included small-scale producers of soya, various inputs suppliers including hatcheries, agro-dealers/vets, grain producers, feed millers/manufacturers, grain traders, importers of pre-mix and veterinary products, agricultural and livestock research and extension services, producer organisations, veterinary and financial service providers. The latter were not included in the detailed analysis but the information obtained was relevant to the study.

The different categories of egg producers have varying capacity to address the common constraints and risks which exist in the value chain and which exert significant impact on the margins and competitiveness of the producers. Wholesale/retail prices of table eggs have remained rather flat in Zambia for over two years. In comparison the price of a close substitute in terms of cheap protein source (*Kapenta* – local dried fish) has been consistently higher but also more volatile. The fact that table eggs prices remained virtually flat and relatively cheaper than other major protein sources contributed to the rising demand among poor households. However, this same situation implies that price competitiveness in the chain is critically dependent on the capacity of producers to minimise cost, especially of the major cost drivers such as feed, which constitutes about 70% of the production cost for layers.

Another source of competitiveness for large-scale producers is their capacity to minimise labour costs and optimise efficiency through investing in modern production technology and employing highly skilled technical and administrative personnel. This is sometimes because they are able to access relatively cheaper offshore finance and/or are able to negotiate highly attractive trade credits from inputs suppliers. For most medium and small-scale producers, the main strategy for coping high cost build-ups in the chain is a temporary shift into broiler production.

Local hatcheries are commercially viable, but face some constraints to further expansion due mainly to volatility in demand for day old chicks (DOCs), when producers cutback production in response to sharp increases in inputs costs, especially for grains. Consequently, the market leader in table egg production relies imports of DOCs from Europe for about 55% of its requirements. Importation of DOCs is, however, tightly controlled by government for biosafety reasons. The rest of the market depends on the local hatcheries for the supply of DOCs, with the exception of some micro-scale producers who use mini-incubators for on-farm hatching.

Producers of point-of-lay (POL) hens, rely on local hatcheries for DOCs, and supply mainly small-scale and a few medium scale egg producers, mostly around Lusaka. The main advantage for producers sourcing POL hens, is that the specialised producers have requisite skills and technical capacity to limit mortality to the industry average of 3-5%. In addition, these producers also provide technical advice and veterinary support to their customers, thereby enabling them to achieve industry average production efficiency of about 95% (calculated on the basis of eggs produced per week and the population of in-lay hens).

Most of the large-scale producers and some medium-scale producers source grains (maize and soya) from either their own farms or from large-scale farmers and grain traders. A window of opportunity has emerged for small-scale farmers to supply soya to the market leader in egg production through a shortened supply chain through an out-grower scheme (Box 1). This scheme has been piloted under TAF and has the potential increase smallholder share of supply of soya beans and maize to commercial egg producers. The out-grower scheme also has the potential to stabilise grain prices for off-takers in and/or linked to egg producers, contributing a more stable growth trajectory for the industry. However, this will require re-visiting the terms under which participating farmers repay inputs loans in order to minimise side-selling which can undermine the out-grower scheme.

Grain traders, who supply maize and soya to some egg producers as well as the feedstock producers, usually face challenges in terms of price and supply uncertainty, especially during seasons of significant dip in output. Both the smaller-scale so-called “brief-case” traders and large agribusinesses, face this risk. The better-capitalised large agribusinesses, which also have greater access to commercial finance, tend to pursue an inter-temporal arbitrage strategy of buying at low prices from small-scale farmers shortly after harvest, storing and re-selling at higher prices. Heavy government intervention in the form of a maize price support policy (pegging prices at harvest above market price) tends to crowd the private traders out of the market. Structured trading systems which are emerging around the Zambia Agricultural Commodity Exchange (ZAMACE) have the potential to enable the grain traders manage marketing in a more efficient manner but that will also require scaling back the presence of government in the grain market.

Some layer feedstock manufacturers are vertically integrated to egg production though others are independent. A notable example of the former is the holding company Zambeef which has a feed-producing unit linked to Zamchick (for egg production) and a network of retail units for marketing a range of products including eggs. Lusaka-based Tiger Feeds is an example of an independent feedstock producer. Diversification is a key strategy for such enterprises in managing volatility in demand for layer feed. Most feed enterprises source grains for feed manufacture through forward contracts with large-scale grain trading companies such as Afgri and CHC Commodities. The feedstock manufacturers and egg producers rely on imports of pre-mix for feed. Veterinary products are also, generally, imported from South Africa and Europe and distributed through a network of small agro-vet retail outlets which bring services closer to the small and medium-scale egg producers.

Access to finance, especially from the local financial institutions, is rather limited especially for medium and small-scale egg producers. High interest rates of over 30% per annum create difficulties in servicing loans especially when producers face uncertainties such as the grain price shocks in 2016, which also coincided with a severe dip in demand as a result of developments in the major export destination, which is the Democratic Republic of Congo (DR Congo). Some medium-scale producers had to scale down production by over 50% or go out of business as a result of this development. Hence, there is increased aversion among the medium/small-scale egg producers to borrowing from local banks, especially to finance capital investments.

Governance of the egg VC involves minimal coordination and information sharing between key players, particularly the egg producers. It is apparent that the large-scale producers set the benchmark wholesale prices around which all other prices are set, including retail prices by informal community-based retailers. Government agencies do effectively regulate issues relating to animal health and human health, mainly at the level of the large-scale producers. There is less tight influence and regulation of issues relating to environmental management and labour conditions, even for the large-scale producers. Public research and extension services are also provided but does not really target egg producers. The main beneficiaries of extension and inputs support are small-scale grain farmers. The role of government in the regulation of grain prices (maize in particular) is much debated, with different viewpoints prevailing among key actors in the egg VC. Many of the large-scale producers and some medium-scale producers prefer less intervention by government in the form of setting floor prices through purchases by the Food Reserve Agency (FRA) and restrictions on grain exports because of the instability these actions create.

The main producer organisation, the Poultry Association of Zambia (PAZ), operating under the umbrella of the Zambia National Farmers Union (ZNFU) provides a potentially influential platform for policy engagement, communication and service provision to poultry producers. However, many producers (particularly smaller scale ones) are not aware of PAZ and/or not actively engaged with it.

Q1. What is the contribution of the egg VC to economic growth in Zambia?

The economic analysis to address this question consisted of the following: financial analysis, assessing contribution to the national economy, assessing the viability of the chain within the global economy and its integration into the local economy. The outcome of the analysis reported in detail in Chapter 3 is summarised below.

Financial analysis

It emerged from the financial analysis that all categories of egg producers are profitable, though margins are pretty tight at the lower end of the production scale. The lowest return on turnover is 5.23% for the small-scale producers, whilst at the top end of the scale, returns range between 24.13% and 31.38% for large-scale producers. At the small-scale end, the average annual earnings of ZMW 4,662.01 (or €416.33) tends to be seen as supplementary household income as it is well below the average annualised minimum wage of €714.16[1] and even further lower than the annualised living wage in Zambia, which is estimated at €3,403.20 (or €283.60 per month[2]). Even at the lower end of medium-scale egg production, the net annual income of €2,577.86 for egg

1 Source: Government of republic of Zambia Statutory Instrument no. 46 of 2012.
2 Source: Wage Indicator Foundation, 2016.

production is 24.2% below the annual living wage. Hence, it is only when producers reach the scale of production of about 1,750 in-lay birds and are able to invest in on-farm formulation of feed that the net income from the operation is able to support the average family. However, that requires investing in the battery cage production system and access to finance for such investment was reported by most of the actors to be very difficult and also very expensive (with interest rates of 30% and above per annum).

Four categories of egg traders are covered in the analysis. Egg trading is a profitable operation for all traders, the margins exceeding 11% for supermarkets and community-based wholesalers and retailers. Margins are very tight for wholesalers based in the urban markets – estimated at 6.85%. However, net income generated by these operators is more than double the annualised living wage in Zambia (€3,403.20) implying that households who are dependent on this trade can sustain their livelihood.

The net earnings generated for community-based retailers is estimated at €242.24 per annum. This is despite the rather high return on turnover of 12.5%, the highest within the egg trade. To put this figure in context, it can actually make a difference in terms of household income in poor urban households. In Zambia an estimated 60.5% of the population is below the national poverty line estimated in 2011 by the World Bank at US $1.90 a day or €581.30 per annum. The contribution from retailing eggs therefore constitutes about 42% of the income threshold. This is important, considering that the households involved in the trade often sell other essential food items, including especially nutrient-rich vegetables.

Contribution to GDP

Total value added in the egg value chain in Zambia in 2015 is about ZMW 1.71 billion (equivalent to €151.7 million). The direct value added is estimated at ZMW 1.54 billion (equivalent to €137.0 million) and indirect value added (contribution from suppliers) is estimated at ZMW 165.45 million (€14.7 million). The total value added in the egg value chain constituted 13.6% of agricultural GDP in Zambia in 2015. This figure is almost double the contribution of fisheries and aquaculture and 1.2 times the contribution of forestry and logging.

The bulk of the value added, about 60%, is generated by large-scale egg producers. Together the medium-scale and small-scale egg producers contributed about 6.1% of overall value added in the chain. The contribution by the egg trade to value added in the trade is quite sizeable. It is estimated at 22.1% and is exceeded only by the contribution by the large-scale egg producers. This segment of the chain is also dominated by informal wholesalers and community-based retailers as the share of formal traders, including the supermarkets, is limited to about 10-15% of the domestic trade in eggs. The aggregate contribution of maize and soya suppliers in the form of the grains utilised in formulating feed for the birds is about 5%. The other players in the chain make up the remaining 6.5% of value added.

Net profit or income to players in the chain is by far the largest proportion of the value added, about 69%. Financial charges and depreciation together represent 18% of the value added, whilst taxes and council levies account for 6%. Only 7% of the value added is allocated to hired labour. This is an indication of rather low labour-intensity of the chain. This is in contrast with the agriculture sector in the country in general, which despite contributing only 8.1% of GDP employs over 70% of the labour force – a situation which, as argued by (Mulungu and Ngombe 2017) makes the sector "a repository to which labour goes when it cannot find income elsewhere". Furthermore, growth, in the chain places it in a strategic position drive sustained economic growth, in especially the grains subsectors as it absorbs about 35% of soya produced in the country (about 87,300 tonnes).

The distribution of net profit or players' income is skewed in favour of the predominant egg producers, the large-scale producers as depicted in Figure 3.7. The share of net profit received by this category of producers about 66%. The egg trade has a rather large share of the income generated but, it has to be noted that this share is distributed among a large number of players, including over 18,000 micro-retailers in especially the low-income, high-density communities in urban areas. The share received by medium-scale egg producers is about 4%, whilst small-scale producers obtain only 1% of the net profit generated in the chain. DOC and POL producers as well as feedstock manufacturer and other suppliers/service providers together share the remaining 4% of the net profit generated.

Contribution to public finances and balance of trade

The egg value chain contributed an estimated ZMW 102.4 million (approximately €9.1 million) to Zambia's public finances in 2015. No subsidies are provided directly to any of the egg producers as well as suppliers and traders. This contribution is relatively low, only 0.3% of overall domestic revenue generated by GRZ in 2015, which is estimated at ZMW 34.2 billion by Bank of Zambia (BOZ)[3]. The contribution of players in the egg value chain to the finances of local government authorities may be rather more significant. In 2015 players in the chain paid a total of ZMW 13.9 million (€1.24 million) as council levies. We demonstrate the importance of this contribution citing the case of the Lusaka City Council. According to a report of Zambia's Auditor General, in 2015 the City Council (LCC) mobilised a total of ZMW 18.0 million (€1.59 million) in levies. Taking into account the concentration of the egg value chain in the Lusaka and Copperbelt Provinces, we estimate that egg value chain actors will be contributing close to 30% of levies generated by, for example, the LCC and could be critical to the operations of the councils.

From available data, foreign exchange generated from export of table eggs from Zambia in 2015 is estimated at ZMW 205.1 million (€18.2 million), which is higher than inflows to other more recognised non-traditional agricultural export products such as horticultural products. The total value of imported intermediate goods used in the value chain is estimated at ZMW 171.4 million (i.e. €15.2 million), meaning net foreign exchange proceeds of ZMW 38.0 million (i.e. €3.0 million).

Chain sustainability in global economy and integration in national economy

3 Source: Bank of Zambia Annual Report, 2016.

The DRC for the egg value chain in Zambia is 0.17, which is well below unity (i.e. <1), and indicates that the value chain is viable within the global economy and Zambia has comparative advantage in the production of table eggs. Evidence on the extent to which the egg value chain in Zambia is integrated into the local economy is assessed by computing a coefficient which involves dividing total value added in the chain by the value of total production. The result, which is 0.67, indicates that the chain is well integrated.

	At production						Others		TOTAL
Item	Small-scale	Medium (deep litter)	Medium (deep litter with DOC)	Medium (battery)	Large-scale (10-100,000 birds	Large-scale (200,000 plus)	Point of lay producers	Traders	
Total production	66,841,000	60,515,000	48,253,000	44,334,000	521,553,000	773,618,000	59,797,000	817,622,000	2,392,533,000
Imported IGS	3,887,700	3,382,400	2,658,300	2,446,000	20,779,000	26,816,000	14,357,000	7,263,000	81,589,400
Remaining IGS	44,875,300	29,656,600	15,999,700	13,336,000	102,712,000	113,352,000	17,251,000	429,350,000	766,532,600
Hired Labour	7,295,500	9,345,900	6,746,900	3,806,000	11,374,000	10,076,000	1,253,000	18,345,000	68,242,300
Financial charges	0.00	0.00	7,939,000	6,884,000	46,655,000	39,007,000	8,775,800	15,212,000	124,472,800
Depreciation	0.00	2,377,800	2,060,000	2,675,000	46,655,000	58,510,000	2,551,200	10,628,000	125,457,000
Taxes	29,000	25,300	20,100	822,000	20,408,000	25,875,000	660,000	38,804,000	86,643,400
Net profit	10,753,500	15,727,000	12,829,000	14,365,000	272,970,000	499,982,000	14,949,000	298,020,000	1,139,595,500
Value added	**18,078,000**	**27,476,000**	**29,595,000**	**28,552,000**	**398,062,000**	**633,450,000**	**28,189,000**	**381,009,000**	**1,544,411,000**

Table 1-1: Summary of values of production and value addition by eggs/POL producers and traders in Zambia in 2015 (in ZMW)

Item	DOC producers	Feedstock producers	Veterinary products suppliers	Transporters	Maize suppliers	Soya suppliers	TOTAL
Total production	27,012,000	66,000,000	15,253,000	35,900,000	91,392,000	80,160,000	315,717,000
Imported IGS	8,103,000	13,200,000	3,589,000	10,770,000	33,320,000	20,875,000	89,857,000
Remaining IGS	4,821,000	19,618,000	2,801,000	1,770,000	16,730,000	14,671,000	60,411,000
Hired Labour	1,891,000	6,600,000	1,794,000	8,975,000	19,040,000	20,875,000	59,175,000
Financial charges	4,052,000	9,900,000	3,589,000	5,385,000	9,520,000	12,525,000	44,971,000
Depreciation	1,750,000	3,300,000	762,000	1,795,000	2,284,000	2,004,000	11,895,000
Taxes	2,343,000	3,482,000	922,000	3,615,000	2,881,000	2,530,000	15,773,000
Net profit	4,052,000	9,900,000.00	1,796,000	3,590,000	7,617,000	6,680,000	33,635,000
Value added	**14,088,000**	**33,182,000**	**8,863,000**	**23,360,000**	**41,342,000**	**44,614,000**	**165,449,000**

Table 1-2: Summary of values of production and value addition by suppliers to eggs producers in Zambia in 2015 (in ZMW)

Item	Direct value added for VC actors	Indirect value added for VC actors	Consolidated value added for VC actors
Total production	2,392,533,000	315,717,000	**2,708,250,000**
Imported IGS	81,589,400	89,857,000	**171,446,400**
Remaining IGS	766,532,600	60,411,000	**826,943,600**
Hired Labour	68,242,300	59,175,000	**127,417,300**
Financial charges	124,472,800	44,971,000	**169,443,800**
Depreciation	125,457,000	11,895,000	**137,352,000**
Taxes	86,643,400	15,773,000	**102,416,400**
Net profit	1,139,595,500	33,635,000	**1,173,230,500**
Value added	**1,544,411,000**	**165,449,000**	**1,709,860,000**

Table 1-3: Consolidated direct and indirect value added for actors/suppliers in eggs value chain in Zambia in 2015 (in ZMW)

<table>
<tr><th colspan="2">Analysis</th><th rowspan="2">Key Issues/observations/conclusions</th></tr>
<tr><th>Framing Question</th><th>Core Questions</th></tr>
<tr><td rowspan="7">1. What is the contribution to economic growth?

(Required indicators: profitability, value added, public funds balance, balance of trade, nominal protection coefficient, domestic resource cost ratio)</td><td>How sustainable are the VC activities for the entities involved?</td><td rowspan="7">
The activities players in the egg value chain in Zambia are financially sustainable. From the top-end of medium-scale producers to the large-scale producers, the rate of return on turnover ranges from 24.13% to 31.38%. At the lower end, especially at the level of small-scale producers, the margins are pretty tight with return on turnover of 5.23% but average annual earnings of ZMW 4,662.01 (or €416.33) at this level represents close to 60% of the annual minimum wage of €714.16[4] and is therefore seen as critical supplementary household income. Households can subsist on income from egg production when scale reaches over 1,700 in-lay hens and there is on-farm feed formulation.
Total value added in the egg value chain in Zambia in 2015 is about ZMW 1.71 billion (equivalent to €151.7 million). The total value added in the egg value chain constituted 13.6% of agricultural GDP in Zambia in 2015. This figure is almost double the contribution of fisheries and aquaculture and 1.2 times the contribution of forestry and logging.
The egg value chain contributed an estimated ZMW 102.4 million (approximately €9.1 million) to Zambia's public finances in 2015. No subsidies are provided directly to any of the egg producers as well as suppliers and traders. This contribution is relatively low, only 0.3% of overall domestic revenue generated by GRZ in 2015, but levies paid to local councils may be more significant in relative terms.
Foreign exchange generated from export of table eggs from Zambia in 2015 is estimated at ZMW 205.1 million (€18.2 million), which is higher than inflows to other more recognized non-traditional agricultural export products such as horticultural products..
The egg value chain of Zambia is well integrated into the local economy, which is reflected by a coefficient of 0.67.
The chain has domestic resource cost (DRC) ratio of 0.17, which shows that it is viable within the global economy.
</td></tr>
<tr><td>What is the contribution of the VC to GDP?</td></tr>
<tr><td>What is the contribution of the VC to agriculture sector GDP?</td></tr>
<tr><td>What is the contribution to public funds?</td></tr>
<tr><td>What is the contribution of the VC to the balance of trade and balance of payments?</td></tr>
<tr><td>Is the VC economically sustainable at the international level?</td></tr>
<tr><td>What are the risks of growth sustainability at each level of the VC?</td></tr>
</table>

4 Source: Government of republic of Zambia Statutory Instrument no. 46 of 2012.

Analysis		Key Issues/observations/conclusions
Framing Question	*Core Questions*	
		• The main risks to sustainable growth in the value chain, especially at the production level, include major price hikes for feed ingredients (maize and soya) as well as instability in regional export markets.

Table 1-4: Economic analysis – summary of responses to framing questions

2.Is this economic growth inclusive? (*Required indicators: total farm income, total wages, income distribution, number of jobs*)	*How is income distributed through the VC levels and actors?*	• Hired labour represents only 7% of value addition, compared to profits of operators (69%), the bulk of which accrues to large-scale egg producers (66%). This is an indication of the low labour-intensity of the chain, which is also a growing trend with investment in battery cage and more fully automated production systems.
	How is employment distribution in the value chain?	• Labour income per unit is highest at the small-scale production level, which tends to have the lowest in-lay hens to labour ratio.
	How are marginalised groups involved in the VC?	• The chain is dominated by men at the egg production end, in terms of the labour force as well as ownership, though there is a high representation of women at the level of ownership among medium-scale producers. Trading is dominated by informal traders who are not in formal employment, including wholesalers who require low equity investment (ZMW 7,500 to 11,250 or €660 to 1,000) who are mainly older males and some females, and egg micro-enterprise retailers who are both male and female.
	Impact of the organization /governance on income distribution?	• The governance of the chain involves very minimal coordination by the large-scale egg producers, who in the main determine market prices. All prices within the chain are benchmarked against the wholesale prices they set. Egg traders in the main markets also have a governance influence, informally regulating which egg producers can deliver to particular markets, and who can engage in egg wholesale and retail activities in these markets.

Q2 .To what extent is this growth inclusive?

The detailed response to this question is addressed in the economic analysis in Chapter 3. The question is also addressed in the Social Analysis in Chapter 4.

Inclusiveness of egg value chain

The bulk of income generated in the egg value chain in Zambia, which is estimated at 46.5%, accrues to egg producers. Income distribution among egg producers is substantially skewed in favour of the large-scale producers, who together earn 87.7% of the income generated by this segment of the chain. This just about matches the share of productive capacity, in terms of population of in-lay hens kept by these farmers. The medium-scale producers earn 10.45% of the income earned in aggregate by producers, slightly above their share of productive capacity of 8.7%. Though small-scale producers keep close to 5% of the in-lay hens population, their share of income generated is only about 1.85%. Employment generation is, however, higher at the lower levels of the scale of production, especially among small-scale producers.

The above may suggest that the chain is not inclusive, favouring principally the large-scale producers, who also exercise substantial influence in determining wholesale prices of table eggs – which has been stable for over three years at ZMW 23 per tray. It is at the table egg trading level that the value chain becomes most inclusive. Income generated at this level is well-spread among over 600 wholesalers and an estimated 18,500 micro-retailers. The wholesalers are not the typical relatively well-capitalised traders found in other commodity and consumer items trade. Start-up capital for these range from ZMW 7,500 (€665.00) to ZMW 11,250 (close to €1,000.00). This is often generated through micro-retailing of various produce in the main urban markets. The wholesale trade is dominated by men but retail and, especially retailing eggs in the communities, is often undertaken by women as part of their micro-enterprise.

Within its wider context, the economic growth of the egg VC has provided increased livelihood opportunities and benefits for a wide range of actors in various segments of the VC.

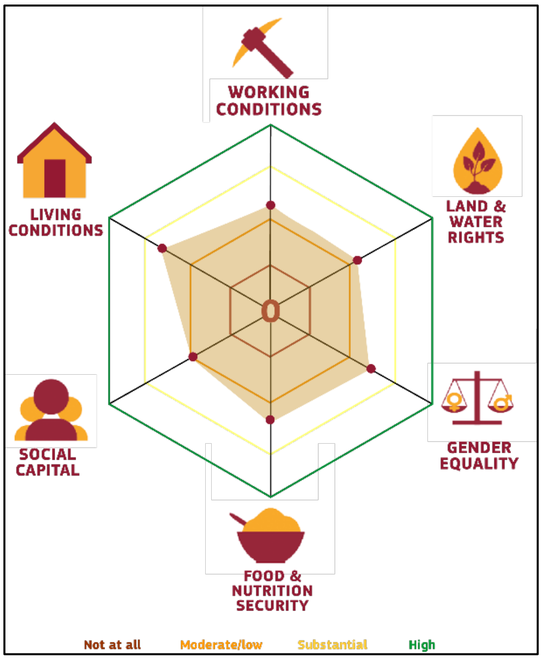
In the grain production and processing segment, increasing numbers of small-scale farmers, both male and female are now producing soya for sale, nearly 40% of which is absorbed into the egg VC. Innovations in input supply and marketing arrangements for these small-scale grain farmers, through local "aggregators" is provides increased opportunities for enterprising rural people, who are frequently trusted older women in communities. Soya is a labour demanding crop under smalls-scale production conditions, hence the increased production of small-scale soya has also provided casual employment opportunities for rural youth in rural areas for land preparation, planting, crop spraying, harvesting, threshing, bagging and transport to sale points. Poultry feed production and distribution has provided more limited opportunities for youth employment, as casual workers during peak periods, and also as store assistants in the rapidly expanding number of distribution points for feed.

In the egg production segment of the VC, opportunities for employment are more limited due to the dominance of large scale operations which are designed to operate with minimal labour requirements, and requiring more skilled labour. In the smaller egg production operations younger men with basic levels of numeracy and literacy have been able to gain employment and skills because of the importance of accurate record keeping. Some senior technical positions in large egg production enterprises (e.g. vets) are occupied by expatriates, perhaps indicative of a skills shortage at this level due to rapid expansion or because the poultry industry is not attractive to local veterinary graduates. The dominant system for distributing eggs through informal markets which are increasing more distant from the egg farms provides increasing employment opportunities for drivers, vehicle mechanics and sales auditors.

The trading, processing and consumption segment of the egg value chain is the segment which has provided the most space for inclusive growth and value added benefits. The dominance of informal sector trading has provided increasing opportunities for self-employment, without the usual barriers to entry of educational qualification requirements for the formal employment sector. Significant increases in the supply of table eggs at affordable prices throughout Zambia have enabled increased household consumption of eggs as a protein and vitamin rich food source with nutritional benefits for all family members. A survey undertaken as part of the study, indicated that it has become increasingly common in the lower income urban areas for eggs to be included in the diet for young children under 5, along with soya products, due to their affordability, availability and ease of preparation with compared with alternatives. In terms of "knock on" benefits, the increase in egg supply at low prices has also benefited the confectionary and hotel industries which are increasingly important as sources of employment.

Q3 Is the Egg VC socially sustainable?

Application of the social profile tool to the Egg VC provides scores in the medium range in each of the six domains of the social analysis.



Social capital was the domain with the lowest score. Weaknesses in social capital development apply to all three segments of the value chain, as defined in the social analysis section, and to the different scales of egg production enterprises. In the grain production segment, trust-based longer term business relations required for sustainable production of soya are largely lacking, and need to be nurtured. The relations between small-scale producers of soya and the providers of inputs and marketing are largely short-term and opportunistic. Egg producers, of all scales, operate largely in isolation from each other with very limited sharing of information, expertise and cooperation. The largest-scale egg producers are in communication with each other and contribute to lobbying through PAZ and NFU, but are very guarded in terms of information sharing and collaboration with each other. Medium and small scale egg producers have very limited communication with each other and virtually no collaboration or engagement with lobbying. A similar picture applies to the individuals and organisations that supply inputs and services to small-scale grain producers and to egg producers of all scales. While there are some examples of longer term business relations developed between individual egg producers and other players in the VC, the culture of competition and careful guarding of information which makes it hard to promote the development of trust and cooperation between the main players in the Egg VC. On the positive side, a low score in this domain indicates significant scope for improving levels of trust and social capital through well designed policies and other interventions.

Working conditions did not register a “substantial” score mainly because of uncertainties, labour demands and potential risks relating to small-scale soya production, and also because of the relatively weak enforcement of Zambian labour laws in companies involved in egg production and the allied industry actors (e.g. stock feed companies, agro-dealers and grain traders). As the policies and legal framework relating to working conditions are very clear in Zambia, being broadly supportive of worker’s rights and gender equality at work, the scope for specific interventions to improve working conditions is relatively limited. The improvement of contract farming agreements is one area, related to the area of building trust/social capital, is worthy of deeper exploration.

Gender equality was assessed as substantial, with the second highest score. As with employment conditions, this was partly a result of the positive impact of national legislation, policies and programmes to promote gender equality over the past 3 decades, including promotion of access to agricultural services and credit for women farmers. A further contributing factor is the legal and social status of women in many of Zambia’s various ethnic groups, which allow women to own and inherit rights to land and other valuable assets such as livestock. In addition newer initiatives within the Egg VC, such as the promotion of rural aggregators and small-scale enterprise opportunities in agro-veterinary products have provided further opportunities for enterprising women.

The food and nutritional status of low income urban households was substantially and positively impacted by the Egg VC providing improved and more affordable access to both eggs and soya products. Using the questions in the social analysis methodology, this domain did not register a “substantial” score overall due to the potential, rather than the fully known, risks of seasonal rural food insecurity associated with out-grower cash cropping arrangements[5]. This score was also

5 If the soya production segment of the Egg VC had not been excluded the score for food security and nutrition would definitely have been higher. It should be emphasised that the risk to rural food security and nutrition was limited, being

lower due to anecdotal evidence on the negative effect of household decision making norms relating to gender on the utilisation of soya to improve nutrition at household level, when soya is seen by husbands mainly as a cash crop for sale, rather than as a food crop.

Land and water rights are not currently a significant risk area in relation to egg production, as the operations are largely on state land, rather than on customary land. This is a future potential risk area for some areas of small-holder production as pressure on farm land increases through conversion of customary to state land.

In relation to social inclusion, youth unemployment is a key national issue impacting on social sustainability. Opportunities for younger men in all segments of the Egg VC are potentially available, Egg trading is an example where the barriers have been relatively low enabling younger men without formal employment to benefit and earn a reliable income. Egg production provides opportunities mainly for younger men and women with a level of education and skills required for more complex management tasks. Smallholder soya production provides useful earning opportunities for younger men, either directly as farmers or by providing services to farmers, such as crop spraying, land preparation and transportation from the field.

Q4 Is the Egg VC Environmentally sustainable?

Environmental LCA TOR regarding the sustainability of the egg value chain in Zambia addresses three core impact questions: human health, ecosystems quality and resources depletion. The answer to these questions are summarised below:

What is the potential impact of the value chain on human health?

The evidence obtained indicates a very low environmental impact but there are risks which need to be minimised. The risks are related to pesticides application on crops (required to feed the birds) and chemicals present in feed formulations that are excreted after intake by chicken population. In general, the impacts of these on human health are not significant, tend to be localised and may be reversible. Moreover, feasible mitigation measures are available, including health standards, environmental regulations, and best practices/environmental management systems. These measures are either mandatory in the food industry and agriculture practices and require effective enforcement. For instance, adoption of relevant environmental management systems needs to be encouraged in Zambia. Additionally, awareness campaigns (through local leadership) and advisory services provided through public extension services and by agri-businesses may contribute to effectiveness.

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based on anecdotal evidence on the negative impact of herbicide use on planting of traditional food crops and on very rapid assessment of the risks to food security from indebtedness arising from disadvantageous contract farming arrangements for cash crops in Mpongwe. Literature on the effects of cash cropping on food security and nutrition which indicates that the effects can be either positive or negative, depending on the context. There was insufficient time within this study to look in detail into the actual impact of increased small-holder participation in soya production on the food security and nutrition of these households. It is also noted that with the right type of advisory services and improved contracts, the positive impact of soya production on rural household food security and nutrition could also be substantial.

What is the potential impact of the value chain on ecosystem quality?

There is a medium environmental impact, in particular regarding chicken manure disposal and potential groundwater contamination and emission of nitrous oxides into the air emissions (when manure is stocked or there is overloading of manure disposal on land). These problems occur more at the level of large-scale egg producers. The impacts may be significant but usually local in scale and may be reversible. Mitigation measures are available in the environmental protection technology market and are already mainstreamed in many countries. However, environmental technologies may require significant investments and skilled operation. Manure treatment-valorisation processes is linked to core question number 3 considering energy (biogas) recovery and/or organic compost production (please see below).

What is the potential impact of the value chain on resources depletion?

There is a very low environmental impact, namely in non-renewable resources consumption required for fertilizers/pesticides production and energy carriers in feed production, egg production facilities and transportation (transports at regional and trans-boundary scale). The impacts are not significant, but may have a diffuse regional scale. If organic loads provided by manure disposal in land are higher than crop requirements, or if the water table is high, soil and groundwater quality may be jeopardized. Nitrogen emissions from manure bio-denitrification processes may be significant too, but can be minimised if properly managed, an issue already mentioned above.

Additional but minor mitigation measures are possible regarding energy and materials conservation, although they are rather difficult to apply in practice. An exception may be adjustments in transportation paths of fertilizers/pesticides, aiming at minimisation fuel/oil consumption and vehicle conservation (e.g. to increase the use of Beira Port in Mozambique as an optional gate).

In addition, the following points should be highlighted. Most of these points are related to the aforementioned core questions:

- Manure disposal is the most significant issue in large-scale egg production in Zambia. It should be perceived as an opportunity not as a problem. Bioenergy (biogas) production derived from anaerobic treatment of manure is a potential process with the benefits of reducing external dependence on fuel, capturing emissions and improved treatment of manure. The financial feasibility of bioenergy recovery from manure deserves assessment, particularly for corporate egg producers.
- Composting is a suitable technology for medium and small-scale egg producers, and also for large-scale producers if biogas projects are not applied. Compost application in land will minimise macronutrients requirements by crops, saving mineral resources and will restore organic soil structure and properties. A large-scale egg producer in Zambia that is currently producing compost from chicken manure provides a good example of this option. Because manure composting is a low cost technology for soil conservation and resources recovery, other egg producers should follow the concept.

- It should be noted that the current LCA study didn't assess the presence of heavy metals or endocrine disruptors in manure.
- Groundwater contamination in the vicinity of mining industries (Copperbelt region) is an emerging problem in some locations and may negatively affect the quality of groundwater used in egg production facilities, especially in the Copperbelt.
- Efforts to increase food production by smallholder farmers should encompass the water and energy nexus in order to reinforce positive social and environmental impacts in rural areas. This strategy will require appropriate but simple onsite sanitation technologies connected to small-scale biogas or composting facilities (e.g. urine diversion toilets, biogas digesters and composting reactors). This issue was not covered in the LCA study but deserves mention.

Recommendations

This study has provides ample evidence to justify inclusion of the egg value chain in areas to be prioritised by GRZ in its efforts to promote export-oriented agricultural sector development which is also inclusive and sustainable. Growth dynamics within the value chain make it a good candidate to sustain its contribution to sector and overall GDP growth in the medium-term. This is driven by rising domestic demand as well as potential growth in the regional export market. Growth in the chain will increase its capacity to absorb surplus soya and therefore ensure sustained growth in soya production. Furthermore, the positive impact of growth in egg production on household nutrition security, especially in urban poor households has been demonstrated. It is also evident that most producers, especially those in the medium-scale and large-scale categories are well aware of prospects in the value chain and anticipate investment in capacity expansion in the short to medium term. To realise the growth prospects and, especially, to ensure that it is inclusive not only at the domestic trading level but also at the level of production, the recommendations below are outlined.

Recommendations emerging from functional, financial and economic analysis

Exchange rate risks, in particular as regards volatility and appreciation of the local currency, are unlikely to impact very much on the overall viability of egg production in the country. This is principally because of the low level of utilisation of imported intermediate goods. However, appreciation of the local currency can impact negatively on foreign exchange inflows generated by the chain and adversely affect the capacity of players who have used competitively-priced offshore financing to scale up production and/or improve production technology. A notable example is the market leader, GLL. Hence, macroeconomic stability and effective exchange rate management to avoid sharp currency appreciation should be seen as part of the required enabling environment for sustained growth in the egg value chain.

Severe spikes in the price of feed ingredients, mainly maize and soya, has been shown (in Section 2.2 of this report) to exert significant growth-reducing effects on the chain. Some large-scale producers are attempting to mitigate this risk by means of backward integration involving cultivation of maize and soya. This may lead to exclusion of smallholder soya producers. However, GLL (Golden Lay) has been part of a pilot outgrower scheme under which it can procure soya produced by smallholder farmers. The main drawback of the scheme are the delivery terms for the participating smallholder farmers, who are required to fully repay inputs credit immediately after harvest when output prices have bottomed out.

To address this we propose inventory collateralisation under ZAMACE in a system which allows soya marketing to be better managed to the benefit of producers and without putting the interests of inputs credit providers and soya users at risk. The case of the harvest 2017 harvest season is cited to demonstrate that such a system can produce tangible income benefits to producers (close to 30% income gain for producers). Further evaluation of this system involving ZAMACE and exploring the potential to significantly scale up and also service medium-scale egg producers should be undertaken. Active involvement of local financial intermediaries in providing inventory finance can catalyse uptake of the system by both grain producers and buyers. However, anecdotal evidence from managers of ZAMACE suggests limited internal capacity within the banks in terms of providing such facilities. Hence, collaboration with ZAMACE to provide training in inventory finance for banks and other non-bank financial intermediaries needs to be explored, especially for the benefit of medium-scale egg producers.

One of the main challenges facing producers is how to reach retailers in the communities on a cost-efficient basis. The outcome of the BOP model piloted by GLL has been successful as proof of concept and can be taken up by other large-scale producers. However, replication does not need to be subsidised as viability has already been demonstrated. Furthermore, subsidising large-scale producers to undertake this will undermine competition between them and medium/small-scale producers whose main competitive advantage lies in the proximity to buyers in high density urban communities.

Access to finance for capital investments in improved housing and cost-efficient production technology as well as working capital is a challenge for most players in the egg value chain. Not only are interest rates high in the domestic money market and the existing capital market is too thin to become a major vehicle for mobilising equity capital. Banks are also averse lending to players in agriculture because of risk perceptions which are borne out by evidence on the quality of loans advance by banks in the country. The ability of GLL to secure financing the AAF has proved critical in expansion programme but also demonstrated that chain plyers have the potential to effectively manage such resources. It can therefore open up opportunities for other large-scale, well-run egg producers.

However, for most medium-scale producers, who need to be prioritised in order to ensure inclusiveness at the level of production this does appear to be a viable option. It is for this reason that we stress the need to develop and inventory credit scheme which will ensure that they can access feed ingredients on a cost-effective basis. Furthermore, for capital investment by these players, BOZ and GRZ may explore the possibility of replicating the innovative financing package piloted by the government of Nigeria – that is the Nigeria Incentive-based Risk Sharing System for Agricultural Lending (NIRSAL). Under that scheme government offers loan guarantees to encourage lending but is tied to appropriate insurance and provision of interest rebates which kick-in only when borrowers repay loans. To improve prospects for effective access to cost-effective finance by medium-scale egg producers we further recommend improved availability of quality business advisory services. It is apparent that the support provided under TAF proved pivotal in the ability of GLL to secure finance from AAF. Consideration may be given to the development of the business advisory services within PAZ.

Recommendations to enhancing social sustainability and inclusion

The following interventions are suggested in order to improve social inclusion and sustainability of the egg value chain in Zambia:

- Improve the support to small-scale farmers either growing soya or in locations suited to soya production. The improved support should be channelled through the relevant agencies, with the aim of improving levels of mutual trust and building sustainable business relations between these agencies and participating farmers. The services (technical advice, supply of inoculum and seed, credit packages as part of contract arrangements, marketing support) need to be more carefully tailored, taking account of the variation[6] within the small-scale farming sector. The aim should be to reduce the current risks faced by small-scale farmers growing soya, and improve the opportunities (including value addition at village level) for sustained small-scale production of soya which is profitable and also improves household food security and nutrition.
- Increased focus on interventions to promote appropriate and more widespread use of both soya products and eggs (as more affordable sources of high quality protein and key vitamins and minerals) in the diet of infants and vulnerable adults, to improve human nutrition both in rural and urban areas,
- Specific initiatives targeting the youth, to improve their inclusion in the Egg VC, including vocational training in rural areas for employment in egg farms and the agencies servicing these farms, and setting up viable small-scale enterprises in rural areas to add value to the soya produced, and to increase the local production of eggs from chickens reared by households.
- Strengthening of egg producer organisation/s, with a specific focus on supporting the medium scale egg farmers and new entrants, so that this sector is not further marginalised and squeezed out of production by the large players, with the attendant negative consequences for employment (not only on smaller egg farms but also the enterprises servicing them).
- Interventions to improve the participation of the medium and smaller egg farmers in PAZ, and in particular to improve key services for new entrants, such as business advice and technical advice on DOC rearing, vaccination, feed formulation, and egg production and marketing, should reduce barriers to entry for this category.
- There is potential for production by small and micro-scale egg producers to be boosted if per capita demand in rural poor households rise. This may not impact significantly on overall production in the chain but can produce major positive nutrition benefits. Considering that eggs are the cheapest animal protein source in the country, there is need for research to understand the socio-cultural as well as economic factors which discourage consumption in poor rural households. The outcome of such studies can guide actions to promote rural egg consumption just as was done in the case growing “village chicken” for urban markets.

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6 This includes variation between farmers in terms of levels of resource ownership and access, current levels of indebtedness, health situation, knowledge and capability to manage risks.

Recommendations to improve environmental sustainability of egg value chain

To support the environmental sustainability of table egg production, the following “mitigating measures" are proposed:

Policy perspective: In order to promote LCA as a decision-making tool, both for industry and for government policy, more robustness, reliability and representativeness are needed. Thus, because identical methods are being used, it is strongly recommended that this project be benchmarked with similar LCA studies being undertaken by the VCA4D project and, if possible, with additional egg value chain studies in other regions. Voluntary labeling can definitely promote the adoption of best (and sustainable) management practices. However, again, it is important to consider the diversity of conditions within the industry in Zambia when identifying and promoting activities towards increasing environmental performance (e.g. GMO free soya is a known product in Zambia). Governmental and non-governmental institutions have a role to play in order to advance with labeling. Promoting practices that will contribute to reduce environmental (and social) impacts, while improving farmers/co productivity or income (value-added), is the most important path in order to reduce environmental impacts either in maize, soya and wheat on-farm activities in egg producing facilities.

Technological perspective:

- To promote better manure management: In order to guarantee public health, as well as soils and ecosystems protection, water monitoring programmes should be reinforced, including appropriate chemical analysis. Monitoring is a priority where medium-large scale facilities dispose off manure and where groundwater abstractions may exist for drinking water supply. As a side effect, industry-level initiatives focused on optimizing feed composition and nutrient cycling that minimizing losses of nitrogen and phosphorus may potentially induce significant improvements in the overall environmental profile of Zambia egg industry.
- In addition, monitoring programs are mandatory also to obtain further knowledge on possible presence of priority/dangerous substances, namely in soils and water bodies. Investments in supplemental manure drying and pelletization may be profitable given the growing recognition of the value of manure in increasing soil organic matter, capacity to retain water and slow release of nutrients. An adjacent benefit of manure pelletization is fertilizer import reduction, thus inducing lower manufacturing and transport impacts. However, when manure production is very significant (e.g. Golden Lay, Quantum, Zamchick) and the applied load in soil is being higher than plant nutrient requirements, biogas production (methane) will be a profitable option for producing electricity in corporate livestock industries (allowing co-digestion of animal excreta with crop wastes also). It should be highlighted that biogas operation is simple but requires skills that are not available now: an appropriate training process should be in place. Biogas processing or pelletization has another positive side effect: manure transport is minimised and fuel consumption and other negative impacts (e.g.: air emissions, noise, dust and general traffic risks) are cut down. Availability of capital to provide proper investments can pose barriers that may need to be overcome to allow the implementation of the aforementioned technologies.

- To reduce logistics impacts: Time and proper roads should be improved in order to reduce environmental constraints (emissions, vehicles maintenance). Transit between South Africa and Lusaka may be have an option if Beira harbour (Mozambique), which was recently upgraded and is able to handle bulk ships. Anyhow, local/regional fertilizers/pesticides manufacturers, as well as other service providers, should be preferred when price is competitive.
- To foster technical capacitation at local level: Farmers training and education on best practices and innovations is required in Zambia. Among the topics it is suggested farm management and control (including machinery maintenance), manure management regarding nitrogen management and odour control techniques regarding facilities near peri-urban areas, fertilization and pesticide application, general waste management and recycling, transport logistics. In Copperbelt region, technical support to local egg producers may be advisable in order to protect water sources and to prevent possible contamination by mine operation if necessary. Capacitation on water treatment processes may be required also. Stronger relations between farmers and egg producers associations with research centres and universities of Zambia are highly advisable to foster innovation and competitiveness of the egg value chain.

At last, if a more in-depth LCA on crop production of maize, wheat and soybean is aimed, a specific study with a more extensive, as well as intensive, field work period will have to be developed for achieving this goal.

1. INTRODUCTION

1.1 Background to study:

This Egg Value Chain Analysis (E-VCA) in Zambia forms one of a number of studies commissioned under the Value Chain for Development (VCA4D) Project on which DEVCO and Agrinatura are collaborating. The four-year VCA4D Project aims to generate evidence-based, largely quantitative, analytical information on selected value chains in developing countries. The project involves application of a holistic and multi-disciplinary methodology to generate evidence which can inform decisions as well as policy dialogue. The adoption of the same methodology across countries and different value chains is also intended to allow for learning relevant lessons.

Two focal value chains were selected from Zambia, including the E-VCA on which we report. The study, as is the case with similar studies, aims to respond to four key issues: the contribution of the egg VC to economic growth in the country; whether the economic growth associated with the value chain is inclusive; and is socially sustainable; as well as VC environmentally sustainable. The egg VC in Zambia appears to be under-researched as most studies on the poultry industry in the country, as is the case in most African countries, focus on the broiler value chain. Therefore, selection of the egg VC in Zambia may fill some knowledge gaps. However, one of the considerations for selection of the egg VC is related to opportunities to learn from the support provided under the Technical Assistance Facility (TAF), which eased access to investment finance from the African Agriculture Fund (AAF). The AAF is private equity fund, which has been created to foster investment in agriculture and agribusiness in Africa. TechnoServe serves as the implementing agency of TAF, collaborated with a market leader in the chain in piloting a distribution system which improved supply of eggs to retailers in “high-density” (relatively poorer) urban communities. In addition, an out-grower scheme involving the production of soya beans supplied to a major egg producers was also piloted.

Though lessons from the pilots in the egg VC mentioned above can be relevant, it was decided upfront that the study would not in way involve an evaluation of their performance. The specific objectives of this study therefore focus on generating information which will contribute to the formulation of investment strategies and to support policy dialogue in a manner which will drive sustained and inclusive growth in the egg VC. It is also anticipated that the study result in some important cross-cutting conclusions and lessons.

1.2 Study methodology:

The team used the generic methodology developed for the VCA4D Project. The specific methodology adopted for this study included the following (boundary of analysis):

a. Literature review, including desk review of relevant publications as well as grey literature including unpublished reports on poultry and soya beans value chains. Also reviewed were publications and reports on rural livelihoods studies and consumer surveys. Some of the publications were obtained from the European Union Delegation (EUD) in Lusaka and IAPRI. Other literature were obtained via wed searches.
b. Field data collection involved the following:

- Semi-structured interviews of key actors in the egg VC, including sessions where the whole team had consultations with key informants and others where sub-teams or individual members of the team met with particular respondents.
- Use of structured questionnaire in carrying out a survey of consumers in "high-density" communal areas in Lusaka as well as with groups of farmers engaged in soya production in the Copperbelt.

c. Analysis of data involved the use of the following:
   - Basic statistical analysis to underpin the functional analysis;
   - Mainly using spreadsheet calculations and applying indicators set in the standard methodology for the study;
   - Use of the standardised framework developed for social analysis; and
   - Application of the Life Cycle Analysis (LCA) methodology and a proprietary software platform (SimaPro) in carrying out analysis of environmental sustainability and impact assessment.

d. Other activities:
   - Regular consultations between team members on issues for which convergence is required, including for example categorisation of egg producers as the industry-based classification of producers adopted by the Poultry Association of Zambia (PAZ) seemed to favour the large-scale producers and also made it difficult to undertake cross-industry comparison of producers. The consultations also agreed on the base year for analysis – 2015 – partly because of availability of data from a rural livelihoods survey. However, trend analysis was also undertaken, data-permitting.
   - Validation workshop in order to allow for stakeholders to express views on emerging conclusions and also assist in filling data gaps.

1.3 Activities undertaken:

The study consisted of the following phases:

- Montpellier, CIRAD: Training of economists in AFA (Agri-Food chain Analysis) software to be used for economic analysis, 8 – 9 February 2017.
- Brussels: Briefing at VCA4D PMU, 18 – 19 April 2017.
- First fieldwork mission: 14-26th May 2017.
- Second fieldwork mission: 22nd July to 28th August 2017.
- Stakeholder validation workshop in Lusaka on 2nd August 2017.
- Analysis and report writing: July and August 2017.

1.4 Geographic focus of egg value chain study

The field missions were mainly in two main geographic areas where egg production is concentrated: the Copperbelt and Lusaka Provinces (see Figure 1.1). Most of the large-scale egg producers are in the Copperbelt largely to ensure proximity to the big export markets in the Democratic Republic of Congo (DR Congo). However they also have major supply networks into the urban markets in Lusaka and Northern Zambia. Producers of varying sizes, including especially medium-scale egg producers, are located in and around Lusaka, which has a large market for table eggs. Also found in the Lusaka Province are service providers such as hatcheries supplying day old chicks (DOC), farms selling point of lay (POL) pullets, feedstock manufacturers and stockists of poultry equipment and vaccines as well as egg traders.

FIGURE 1.1: MAP OF ZAMBIA (PROVINCES AND KEY TOWNS/CITIES)

<u>Value chain actors consulted:</u>

During the missions the team interviewed and/or consulted the following stakeholders:

- Representative organisations of producers – the Poultry Association of Zambia (PAZ) and Zambia National Farmers Union (ZNFU).
- Officials of the Ministry of Agriculture and Ministry of Fisheries and Livestock.
- Egg producers of various sizes including large and medium-scale producer who mainly use battery cages for egg production as well as smaller-scale producers using deep litter and cage systems.
- Suppliers of DOCs and POL pullets.
- Egg traders, especially those in the large informal markets, including the Soweto Market in Lusaka and egg traders in the border town of Kasumbalesa (a major transit point for supplies into DRC).
- Promoters of out-grower schemes involving farmers producing soya and maize which is supplied to egg producers – Musika in Lusaka and NKW in Kanyenda in the Copperbelt – as well as an "aggregator" located near Mpongwe which services out-growers.
- Feed producers and suppliers.
- A public research institution which also supplies inoculum to soya farmers.
- Formal grain trade facilitating entity, the Zambia Agricultural Commodity Exchange (ZAMACE) and financial institutions.
- Extension and veterinary service providers as well as suppliers of poultry equipment, including small-scale incubators as well as egg trays; egg retailers and consumers.

The study team consisted of the following team members:

- Gideon Onumah, team leader and economist, NRI;

- Alistair Sutherland, social analysis expert, associate of NRI;
- António Guerreiro de Brito, environmental/lifecycle analysis expert, University of Lisbon;
- Antony Chapoto, economist and national resource person, Indaba Agricultural Policy Research Institute (IAPRI), Lusaka.

2. THE FUNCTIONAL ANALYSIS

2.1 Strategic importance of Zambia's agricultural sector

The contribution of agriculture to overall GDP in Zambia is rather modest, projected at 8.1% in 2016 (Table 2-1), compared to an average of 15% for the African continent (OECD/FAO 2016). The share of industry is about 31.9% and the dominant sector is the services sector which accounts for about 60% of the country's GDP. The agricultural sector is, however, of strategic importance in Zambia's economy. It accounts for over 70% of the labour force but its share of value added is rather low implying, as noted by (Mulungu and Ngombe 2017), that it "is a repository to which labour goes when it cannot find income elsewhere". Agriculture is also important in poverty reduction, improved rural livelihoods and enhanced food security in most African countries (OECD/FAO 2016).

The growth performance of the sector in Zambia has been rather erratic. Data reported by Chapoto and Chisanga (2016) indicates that whilst sector growth was a high 7.0% in 2011, this dipped to -4.1% in 2013. The sector recovered and posted positive growth of 1.1% in 2014 but in 2015 growth was a severely negative 7.7%. This erratic performance limits the potential contribution of the sector to overall economic growth and poverty reduction in the country (Mulungu and Ngombe 2017). A major contributory factor to this situation is the dominance of the crop subsectors which are generally weather-dependent. Domination of production by resource-constrained smallholder farmers (SHFs) of the low-input, low productivity crop production systems is another factor stymieing overall economic growth.

Under Zambia's Seventh National Development Plan (7NDP), the Government of the Republic of Zambia stated its committed to the development of a diversified, export-oriented agriculture sector. It also intends to pursue an inclusive growth strategy which reduces poverty and vulnerability as well as inequalities and enhances human development. Hence, growth in the non-crop subsectors such as poultry and livestock have the potential to trigger sustained economic growth, especially where such growth is accompanied by rising demand for crops and other agricultural produce. This potential is demonstrated in this chapter.

Indicator	2015*
Population	15.9 million
Population growth rate (annual %)	2.9
Land area (sq. km)	752,618
Agricultural land (% of land area)	31.7
Population density (persons sq. km)	21.2
Population living in rural areas (%)	58.2
GDP Growth (%)	2.9
Contribution of agriculture sector to GDP (%) in 2016	8.1
Agriculture sector growth (%)	-7.1
Inflation (%)	10.1
Unemployment rate (%)	17.5

Table 2-1: Zambia macroeconomic and other indicators (2015)
Source: Bank of Zambia/Central Statistics Office.
*Unless otherwise stated against indicator.

2.2 Recent developments in the egg value chain in Zambia

As stated above, the poultry industry in Zambia has out-performed the agricultural sector in general in terms of output growth. Whilst overall growth in the sector shrunk by about 0.4% between 2011 and 2015, the egg value chain expanded nearly four times over that same period. Growth in the chain over a five-year period including 2015 was estimated at 15-20% per annum. The population of in-lay hens peaked in 2015 at an estimated 3.5 million, producing about 1.2 billion eggs during that year[7]. However, as depicted in Figure 2.1 below, a steep decline in production occurred in 2016, with the population of in-lay birds dropping sharply by about 30% to an estimated 2.5 million birds. The decline was due mainly to a steep increase in the cost of key feed ingredients – maize and soya. As shown in Table 2-2, maize production fell sharply in 2015, triggering steep price increase which impacted on the chain in 2016. Furthermore, in both 2014 and 2015, soya output fell below estimated domestic requirement of 230,000 tonnes, thereby driving prices up.

Year/Crop	Maize output (tonnes)	Soya bean output (tonnes)
2012	2,852,687	203,038
2013	2,532,800	261,063
2014	3,350,671	214,179
2015	2,618,221	226,323
2016	2,873,052	267,490

Table 2-2: Maize and soya bean production in Zambia (2012-16)
Source: Chapoto and Chisanga (2016)

An additional source of pressure for chain actors was closure of the border between Zambia and the Democratic Republic of Congo (DR Congo) as a result of political instability in that country. This situation disrupted egg exports and created a glut in the domestic egg market. Most of large-scale egg producers responded to these developments by cutting-back production. Many small to medium-scale producers were also squeezed out, driving down demand for DOCs. In response,

7 Source: PAZ (*pers. comm.* Dominic Chanda, Executive Manager of PAZ, 15/05/17)

breeders/hatcheries reduced the production and supply of DOCs total egg output fell by 25.9% between 2015 and 2016.

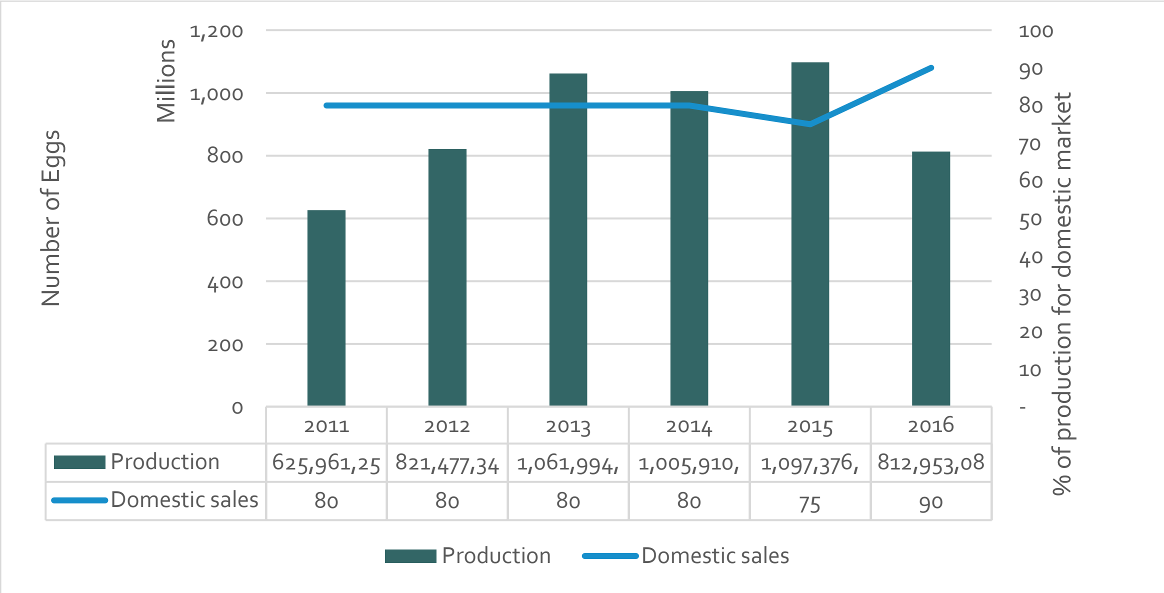

FIGURE 2.1: EGG PRODUCTION AND DOMESTIC SALES IN ZAMBIA (2011-16)

Source: Authors based on data collected during the field study.

2.2.1 Recovery in egg production in 2017

A recovery is widely reported to be underway in 2017[8]. It is reported that this is due to resumption in egg exports to DR Congo following the opening of the border. In addition, the prices of maize and soya are trending downwards due to a bumper harvest of both crops in 2017 as elaborated below:

- Maize output during the 2017[9] harvest is projected at about 3.5 million tonnes. Carry-over stocks from the previous season was substantial, estimated at over 650,000 tonnes. This is partly because of restrictions on maize exports into regional markets during 2016. Hence, the country had a substantial surplus as domestic demand is estimated at about 2 million tonnes per annum. As a result of the apparent glut government reduced the producer price paid by the Food Reserve Agency (FRA) – from ZMW 85 to ZMW 60 per 50kg bag (i.e. from US$170 to US$ 120 per tonne) – a reduction of 29.4%. Crop farmers' representatives protested this development[10] and it is uncertain how this will affect their planting decisions during the next season, even if the weather is favourable.
- A surplus of over 150,000 tonnes of soya was also forecast for the 2017 harvest[11]. Again this is putting downward pressure on producer prices, as regional exports have been hampered as a result restrictive trade policies imposed by GRZ in 2016.

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8 Source: PAZ (*pers. comm.* Dominic Chanda, Executive Manager of PAZ, 15/05/17) and other producers.

9 Source: Crop Forecast Survey by Ministry of Agriculture and Central Statistics Office (MOA/CSO).

10 Source: https://www.lusakatimes.com/2017/08/11/fra-sticks-k60-maize-price-market-price-farmers-appeal-agric-minister/

11 Source: Crop Forecast Survey by MOA/CSO.

As a result of the fall in maize and soya prices many egg producers consulted during the study were quite bullish about prospects in the value chain. With recovery in the industry underway, total egg production in 2017 is expected to reach 1.1 billion[12]. Domestic consumption is estimated at about 865 million eggs per year, implying availability of about 235 million eggs for export to the main regional markets, thereby generating close US$20 million. Anecdotal evidence obtained during the study indicates that most large-scale egg producers intend to scale up production within the medium term (5-10 years) if conditions remain stable and favourable. Many medium-scale producers consulted have similar intentions but cite access to cost-effective finance as their main obstacle. Interest rates in the local banking industry are excessively high (35-40%)[13].

2.2.2 Concentration of egg production in Zambia

Crop and livestock production in Zambia is generally influenced by agro-climatic conditions, but that is not the case with egg production. Proximity to markets appears to be a primary consideration in determining the location of production units. Concentration of farms is therefore around Lusaka and the Copperbelt, in towns such as Ndola, Kitwe, Luanshya and Chingola. Other major producing regions are the Eastern and Southern Provinces.

The large-scale farms tend to be located on sizeable estates well out of town but close to well-maintained access roads to ease marketing, especially as cracks which reduce the value of eggs tend to rise when transported over rough terrain. The large-scale egg producers with significant arable land are using the manure to also fertilise maize and soya crops from which they obtain critical ingredients for their own poultry feed. In cases where large-scale egg producers don't have significant crop production operations, the manure is given to other farmers at zero or very low cost.

Most of the medium-scale producers are in peri-urban areas where land is allocated for dual residential and farming purposes. Small and micro-scale producers raise the birds in homes in both urban and rural areas. One of the main challenges faced by producers in peri-urban and urban areas close to residential facilities is Local Government Regulations dating back to 1941 which prohibit farming, especially keeping of poultry and livestock in urban residential areas. If effectively enforced, this regulation can significantly impact on a large number of medium/small-scale egg producers. There have been reports of complaints by neighbours of such producers about air pollution from the farms.

The supply of the other main inputs required by producers, listed in the first column of Figure 2.2, are generally clustered around the major egg producing regions. These include manufacturers of feedstock and suppliers of DOCs as well as POL hens. Industry representatives indicated that liberalisation of the economy contributed to the opening up of the value chain, attracting externally funded investment into hatcheries and more advanced production units (among large-

12 Source: PAZ (*pers. comm.* Dominic Chanda, Executive Manager of PAZ, 15/05/17).

13 A local development bank which has a package to support medium-scale producers is reported to be charging interest of 33% per annum.

scale producers), and easing importation of key inputs such as vaccines, drugs, feed pre-mix and quality day old chicks (where necessary).

Availability of skilled and unskilled labour does not appear to be a constraint for most producers. Per capita labour demand is lowest at the level of the large-scale producers who have access to modern labour-saving facilities. The ratio of staff to in-lay birds, including management and support staff, tends to be much lower for these producers who, on the average have a ratio of about 1:3,500 as against 1:1500-2,000 for medium-scale producers and 1:500-1,000 for small-scale producers (especially those using the deep litter system). Hence, labour productivity tends to be higher among the fast-growing large-scale producers, a factor which can potentially increase the contribution of the value chain to overall growth in the economy as argued by (Mulungu and Ngombe 2017).

2.2.3 Table eggs market in Zambia

Domestic demand takes up between 75% and 80% of total table egg production in Zambia, depending on developments in the main export market (i.e. DR Congo). According to PAZ officials[14] domestic demand is driven by two main factors: income-effects linked to rising living standards, particularly in the urban areas; and price effects. Per capita egg consumption is by far higher in Lusaka and the Copperbelt than in other towns and rural communities However, it is evident also, as validated during this study, that egg consumption is quite steep in the low-income, high-density communities in the urban areas largely because table eggs are highly price-competitive in comparison with other protein sources. For instance, since 2015, eggs have been much cheaper on a price per kilogramme basis than "Kapenta" (a cheap local dried fish) as illustrated in Figure 2.3. At its lowest margin, eggs retail at about 35% cheaper than "Kapenta". As also evident from Figure 2.3 is the fact that the price of table eggs has been very stable. Households surveyed in the course of this study reported that preparation of eggs was less energy-intensive and therefore cheaper than cooking beans, the most common traditional plant protein source. Egg consumption in poorer households is therefore critical in assuring household food and nutrition security. Furthermore, it emerged from the survey that as living standards in poorer households improve, egg consumption tends to shift from being part of the dinner menu to breakfast, implying that domestic demand is unlikely to be adversely affected by rising incomes in urban communities.

The structure of domestic demand has clearly influenced the marketing strategies of most egg producers, including the large-scale producers. They all tend to concentrate sales through "wholesalers" in the big informal markets (e.g. Soweto Market in Lusaka) and also target retailers in the high-density communities.

14 Source: PAZ (*pers. comm.* Dominic Chanda, Executive Manager of PAZ, 15/05/17).

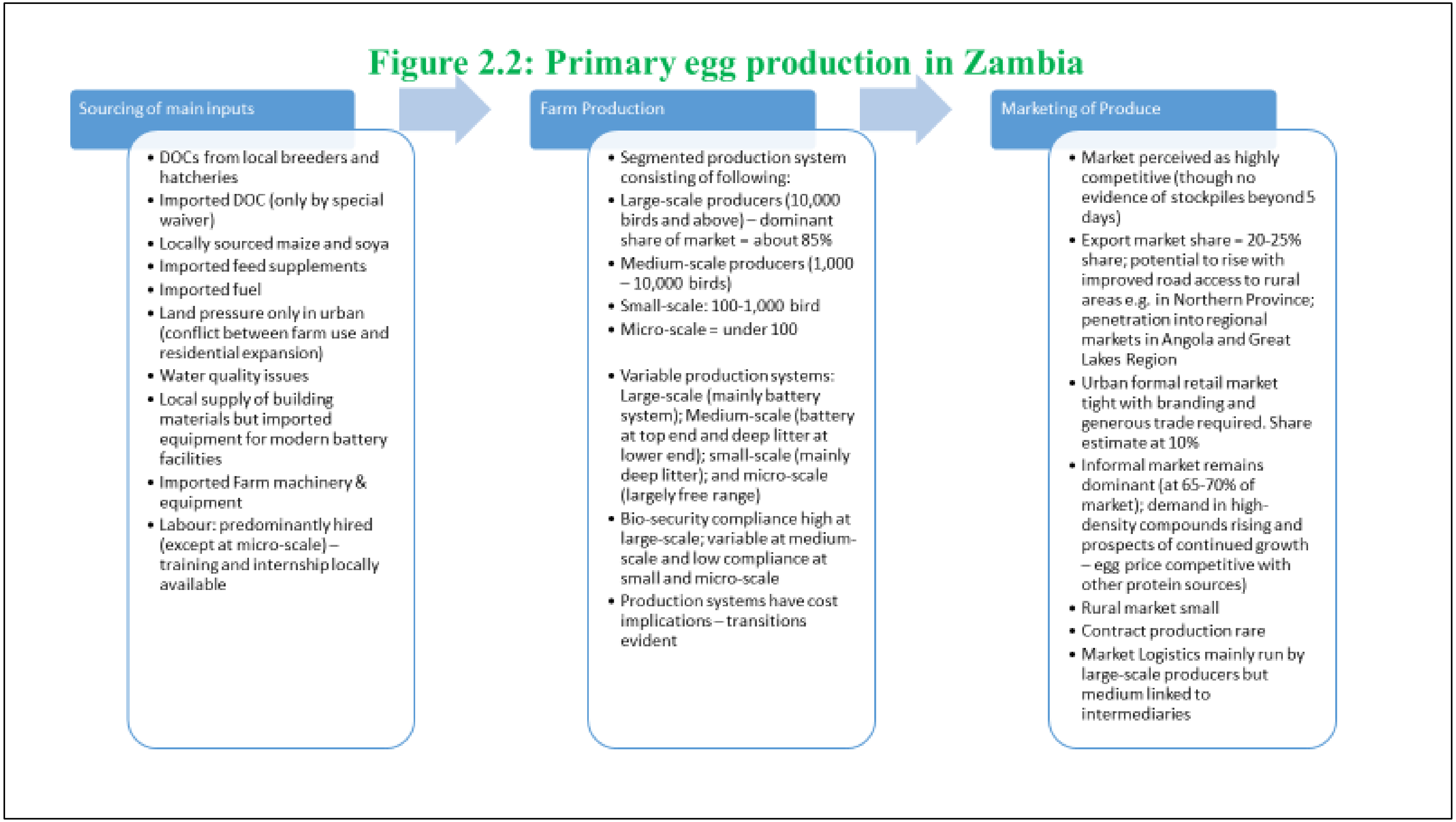

Figure 2.2. Primary egg production in Zambia

The large-scale producers are also pursuing a strategy of penetrating markets in the rural areas, especially in Northern Zambia, a strategy which will be helped in no small way by public investment in rural roads as distribution costs per unit on poor roads tend to be about three times higher than when well-surfaced roads are accessible. As a result of relative stability in DR Congo chain actors see conditions for expansion of exports as favourable. Some producers, especially the large-scale producers are also targeting markets in neighbouring Tanzania, Angola, Burundi and Rwanda.

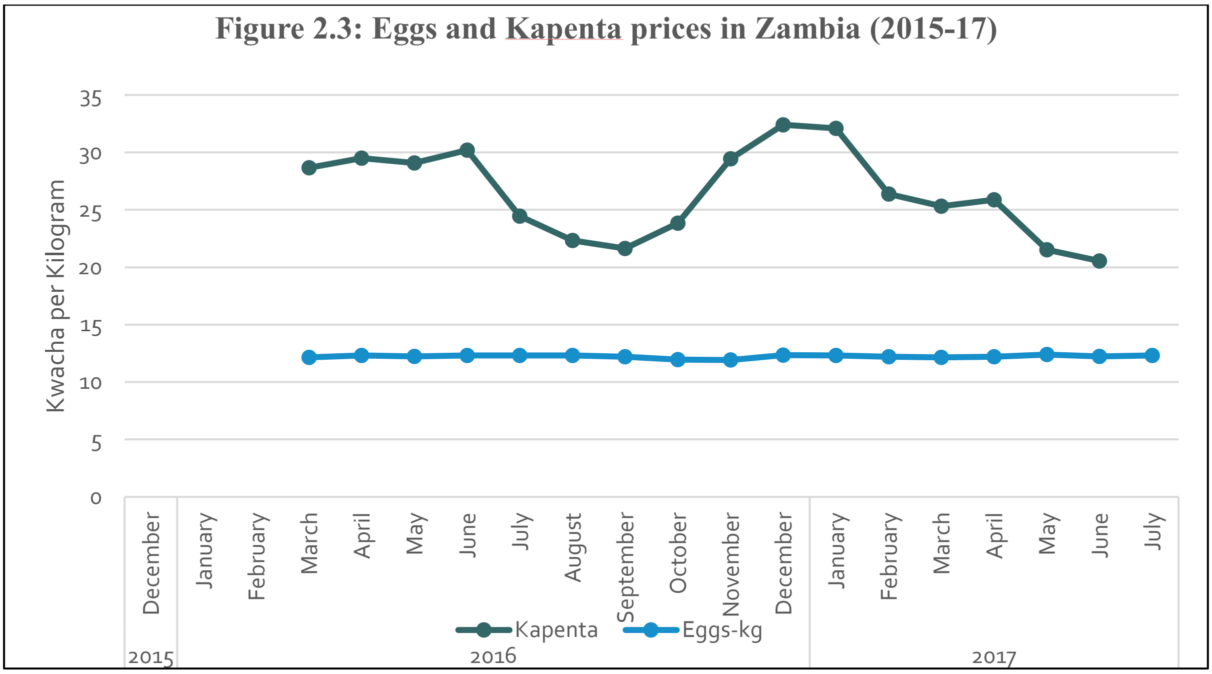

FIGURE 2.3. EGGS AND KAPENTA PRICES IN ZAMBIA (2015-17)

2.3 Typology of egg producers in Zambia

Figure 2.5 depicts the range of players in the egg value chain in Zambia. This section describes the main types of producers, including the different categories of producers and services providers. The activities of the main inputs suppliers are discussed in Section 2.4, followed by a brief overview of the table eggs traders and consumers in Section 2.5. The main risks and constraints the value chain actors face are also discussed in Section 2.6 followed by a brief review of value chain governance, including coordination, information flow, power relations, regulation and policy in Section 2.7.

Data available suggests a skewed distribution of egg producers with a small number, the large-scale egg producers. The classification adopted in this study, which is based on the population of in-lay birds, is modified from the one used by the Poultry Association of Zambia (PAZ). In this study, the main categories of producers are as below:

- Large-scale producers: 10,000 to 200,000 and above;
- Medium-scale: 1,000 – just under 10,000;
- Small-scale: 100 – under 1,000; and

- Micro-scale: below 100.

This differs from the PAZ approach which disaggregates the large-scale producers into "large-scale", "commercial" and corporate producers. Under the PAZ system all other producers are categorised as small-scale producers though as is evident, especially in Chapter 3 of this report, the differences in this broad group can be significant. The particular classification adopted also allows for cross-sector consistency in terminology applied in other allied value chains such as the maize and soya value chains which are important inputs suppliers to the egg producers.

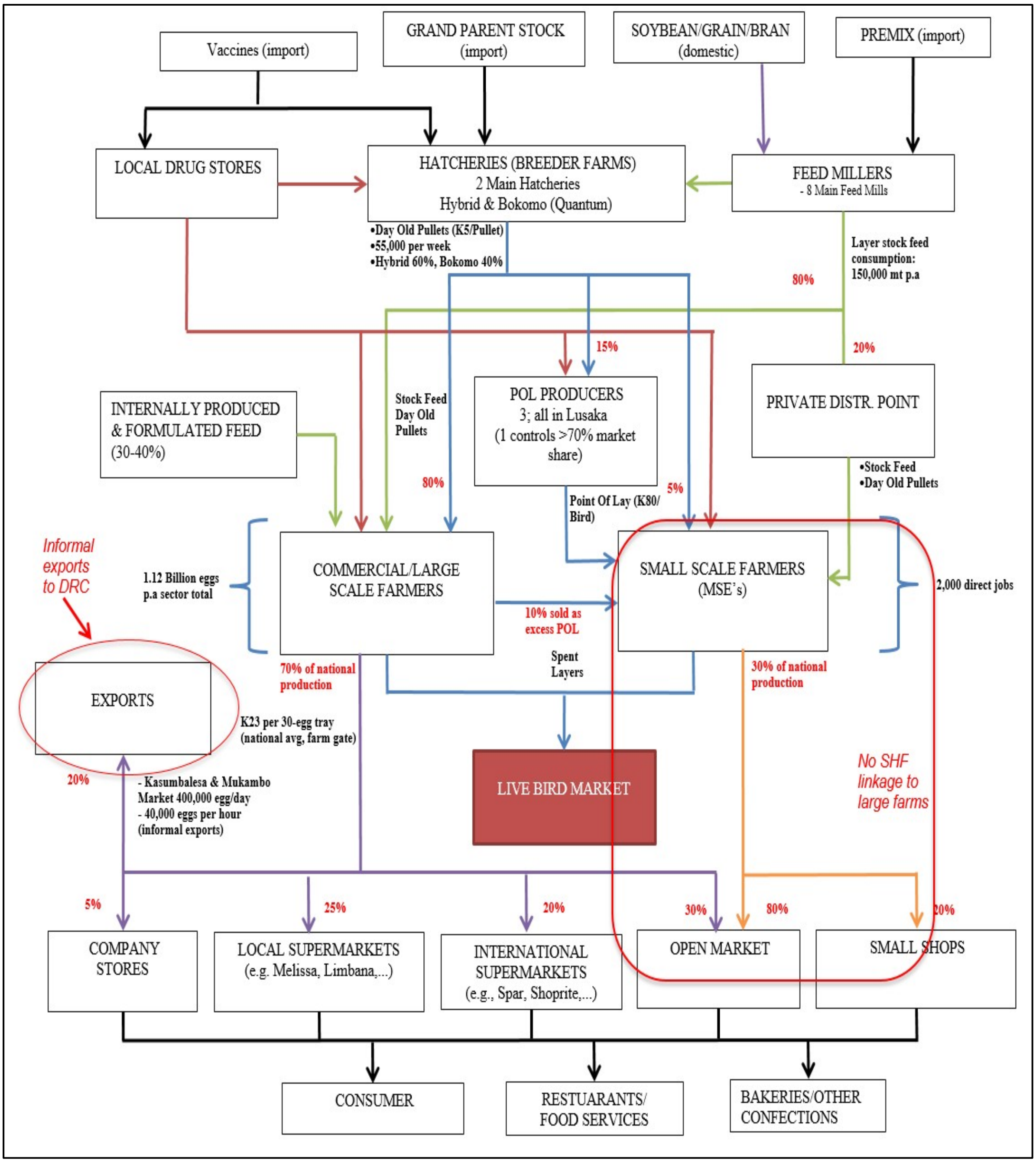

Figure 2.4: The egg value chain in Zambia
Soure: Adapted from World Bank (2017)

2.3.1 Predominant market leader: Golden Lay Limited

The large-scale producers together account for about 87% share of the market but the scale of production differs significantly. The market leader by far, in terms of scale of production, which is Golden Lay Limited has over 750,000 layers and accounts for about 21% of total table eggs produced in Zambia (Figure 2.5). The company has very modern highly efficient production units. For instance, the layers are housed in modern, environment-controlled units with automated feeding and watering facilities which minimise human intervention. These units are not only highly efficient units but also optimise enforcement of biosafety standards. It is apparent as shown in Box 2.1 that the operations of Golden Lay have impacted on the activities of producers as well as the egg market in Zambia.

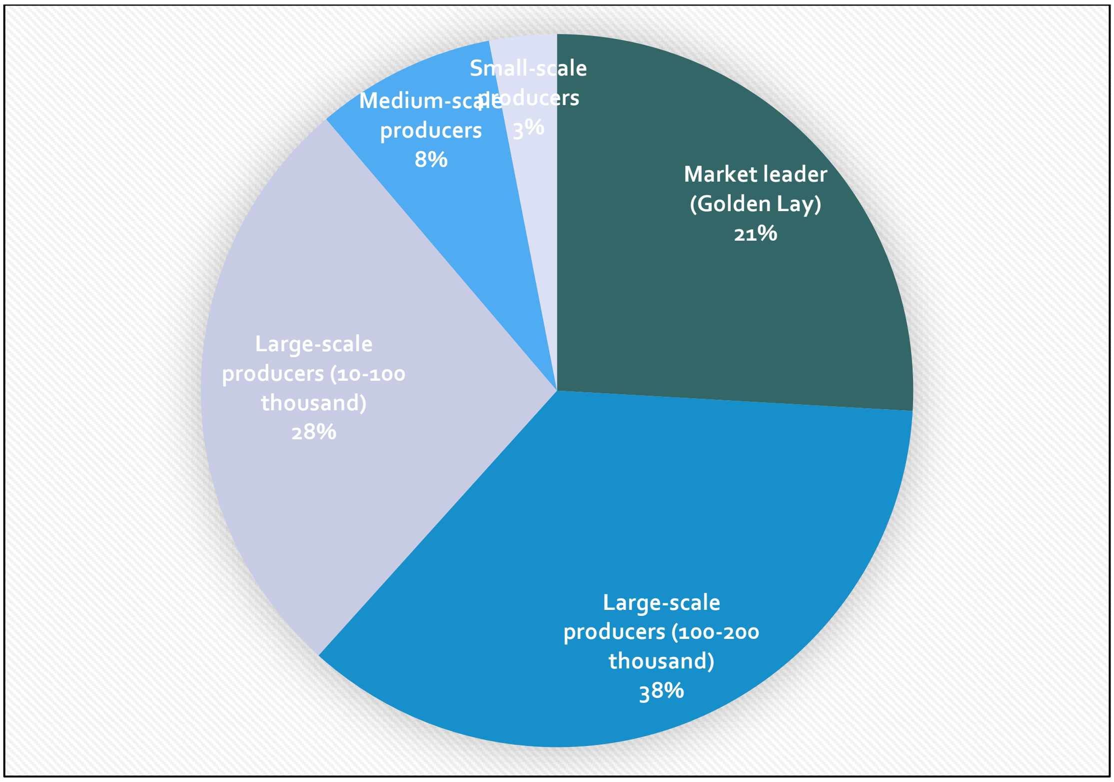

Figure 2.5 Zambia egg market share for different producers

Box 2.1: Golden Lay Limited (GLL) – market leader in egg production in Zambia

GLL was established in 2005 and secured equity investment from the African Agriculture Fund (AAF) in 2012. The funding enabled GLL to invest in highly efficient, environment-controlled production technology and double production capacity to 750,000 in-lay hens. Its strategy location close to the border with copper-rich Katanga Province of the Democratic Republic of Congo (DRC), means that it can sell into the lucrative export market and the major domestic markets in Lusaka and the Copperbelt.

Reports reviewed during this study indicate that the operations of GLL are not only efficient but also profitable. The company therefore appears keen to further scale up production capacity to 1 million in-lay hens. From consultations with stakeholders, it is apparent that GLL's growth is encouraging other producers to invest in increased production capacity. In particular, most of the large-scale egg producers indicated that they intend to increase production in the medium term (over the next five years).

It is evident that GLL is the price setter in Zambia's table eggs market, largely because of its dominant position. Producer prices are benchmarked against the GLL price per tray whilst wholesale and retail prices, especially in the urban markets, tend to reflect rather distribution margins between producers and consumers. Partly due to this situation, wholesale/retail prices of eggs have been very stable, as shown in Figure 2.4. This creates immense competitive pressures on producers, making cost-efficiency of production more critical than wide producer margins in ensuring commercial sustainability. The low, stable prices have, however, spurred increased egg consumption especially in urban poor households.

GLL also received support under the Technical Assistance Facility (TAF) to successfully pilot a bottom-of-the-pyramid distribution (BOP) system. Under this system GLL has recruited bicycle riders to who distribute eggs to small-scale retailers with shops (*Ntembas*) in the relatively poor urban communities (elaborated in Section 2.5). Also with TAF support, GLL has been participating in a soya outgrower scheme, which improves assures supply of this critical feed ingredient.

Sources: *pers. comm*. (with reps with representatives of GLL) and secondary sources e.g. Africa Global Funds, vol. 2/Issue 03 (March 2016); and AndisaAgri/Technoserve (2013).

2.3.2 Other large-scale egg producers

The other large-scale egg producers can be further categorised into two groups on the basis of the scale of production. At the top end of the scale are those with in-lay hen population of between 100,000 to 200,000. Together these producers account for about 36% of the table egg market in Zambia. Among these producers Zamchick, which is part of Zambeef, a holding company with investments in livestock and manufacture of livestock products, leads with over 200,000 in-lay birds. Chico Estates Ltd., which is located close to Lusaka and has about 100,000 in-lay birds is another example of the producers in this category. It is a pioneer in the production of pelletised chicken manure fertiliser. Other large-scale egg producers include Mega Eggs, Egg Mania Ltd., Cedric Farms, Wadi Farida, Frios Eggs and Collets Farms. Most of these producers have large tracts of arable land which they use for growing crops such as maize and soya to feed the birds. All of them formulate chicken feed on farm.

The other group of large-scale producers have in-lay bird population of between 10,000 and 100,000 birds. This group accounts for an estimated market share of 27%. All the large-scale egg producers use the battery system of production.

2.3.3 Medium-scale egg producers

Medium-scale producers, including some who were interviewed during this study account for an estimated at 8% of the table egg market. Most of these are middle class professionals who invest in poultry as an additional source of income. Many start with broiler production using the deep litter production system because the initial capital investment required is relatively low. They transition into egg production as the business grows and ultimately scale up to adopt the battery system. There is, however, flexibility in their production system as they tend to switch back to broiler production when rising costs squeeze egg production margins. Though some, especially the relatively bigger ones, raise DOCs, most of them buy POL hens. Only a few formulate feed on-farm and these are usually those at the upper end. It is a segment with high growth potential if capital constraints can be addressed.

2.3.4 Small/micro-scale egg producers

Small-scale producers with in-lay bird population of up to 1,000 have an estimated 4% share of the table eggs market. Most of them are households in urban and peri-urban areas with small-sized deep litter farms. They employ family labour and/or deploy house-helps. They predominantly buy POL hens and depend on commercial feedstock producers for feed. Micro-scale producers keep small numbers of hybrid layers, usually less than 100, on a "backyard" basis. They either buy POL hens or hatch DOCs from own eggs. They may provide supplementary feed purchased from agro-dealers. They rarely sell eggs and if they do it is to neighbours and work-mates. Their main aim appears to produce "village chicken" (free range broilers), which have a niche premium market in urban areas.

2.4 Inputs suppliers in Zambia's egg value chain

2.4.1 Chicken breeder farms and hatcheries

Two major commercial hatcheries which produce layers are both based in Lusaka. These are Hybrid Poultry (established in 1961) and Quantum Foods a relatively new player (since 1997). They both breed parent stock from imported grand-parent stock. Usually they supply day-old chicks (DOC) to egg farmers directly and/or to producers of point-of-lay (POL) hens, who rear pullets for about 16 weeks. The hatcheries also provide training and advisory services to their customers, particularly the newer entrants. Quantum Foods also provides veterinary support services. It is estimated that currently Hybrid Poultry supply approximately 30% of the locally produced DOCs and Quantum Foods the remaining 70%. The two hatcheries companies are not able to meet the total demand for DOCs, for which reason Golden Lay for example is allowed to import approximately 675,000 DOCs per year from Europe.

2.4.2 Producers of POL pullets

These specialise in growing DOCs until 16 weeks and sell them onto egg producers, especially at the lower end of the medium-scale producers and the small-scale producers. They rely on the two main hatcheries for supply of DOC and their specialised role enables them to produce and market POL which are fairly robust, thereby minimising mortality during egg production. The large-scale POL producers include Yielding Tree Ltd. and Crawain Ltd. The market leader in this market segment sells about 270,000 POLs per year and currently accounts for close to 10% of in-lay birds in the country and an estimated 70% of point of lay sales[15]. The largest supplier of POL hens provides training, advice and veterinary support services to their customers. There also a number of out-growers of POL pullets linked directly to the breeders/hatcheries. Some of the large-scale egg producers sometimes sell surplus pullets – up to 10% of the birds reared from day-old – to smaller-scale producers.

2.4.3 Agro-dealers and vets

In addition to retail outlets run by the feed companies, there has in recent years been a proliferation of small retail outlets called "agro-vets" which stock a range of agricultural inputs. Some of the agro-vets sell day-old chicks, POL pullets, feed for rearing point of lay pullets, feed for layers, poultry medicines, vitamins and vaccines and relevant equipment (feeders, drinkers, egg trays). They are particularly useful for the small and medium scale egg farmers operating outside of peri-urban areas around Lusaka and the Copperbelt i.e. in communities in the Eastern and Southern Province as well as rural parts of Lusaka, Central and Copperbelt Provinces).

2.4.4 Grain producers

Whilst maize used by the poultry industry is mainly produced by small-scale farmers in Zambia, production of soya is dominated by large commercial farms. Maize production by commercial (or large-scale) farmers has dipped in recent years as smallholder production has risen partly due to the combined effects of two government interventions. These are the Farmers Inputs Support Programme (FISP) and the grain price support programme by the Government of the Republic of Zambia (GRZ). Under FISP smallholder producers access heavily subsidised inputs originally targeting mainly maize production. The level of the subsidy provided is close to 80%. In addition, smallholder maize farmers were offered producer prices by the Food Reserve Agency (FRA) which are well in excess of market prices (Kuteya and Chapoto 2017). These two policies made maize production very attractive to smallholder producers, leading to increased output which has made Zambia a net surplus producer in most years – as shown in Table 2-2. Despite this, production of maize by commercial farmers remains significant and is concentrated in areas along the "line of rail" from Choma District in Southern Province to Mkushi District in Northern Province and

15 Based on an estimate from World Bank (2017).

Mpongwe District in the Copperbelt. Maize grown on commercial farms tends to be sold to major grain trading companies (see Section 2.4.5) and/or millers producing "mealie meal" for human consumption or feedstock manufacturers. Large-scale maize producers are, in principle, excluded from selling directly to FRA.

During the 2016/17 season GRZ initiated a process to extend coverage of FISP to include crops such as soya cultivated by smallholder farmers. Prior to that both FISP and the price support programme did not include soya. Despite this soya production increased substantially by an average annual rate of 14% between 1999 and 2010 (Technoserve 2011). As shown in Table 2-2, Zambia is self-sufficient in soya production and the contribution from small-scale farmers has been rising, reaching about 25% of national output in 2014/15 (Sitko and Chisanga 2016). Figure 2.6 below shows that virtually all regions in Zambia are suitable for soya cultivation but production is concentrated in the Central, Copperbelt and Eastern Provinces. This eases geographical access to soya for egg producers.

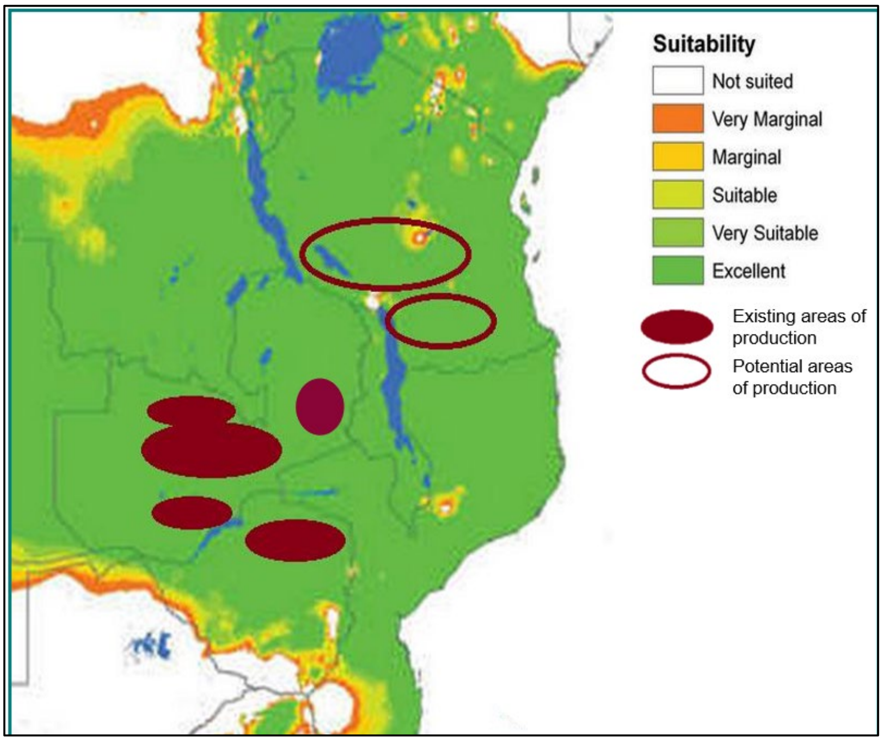

FIGURE 2.6: AREAS SUITABLE FOR SOYA PRODUCTION IN EAST/SOUTHERN AFRICA
SOURCE: TECHNOSERVE (2105)

Most large-scale soya producers sell on contract to oil crushers and feedstock manufacturers or through the large-scale grain trading companies. Smallholder producers, however, sell into the informal chain through aggregators. As is common with trade of this type, informal soya marketing does not entail enforcement of commodity standards pertaining to measures and quality standards. Formal standards apply only in cases where outgrower schemes are being implemented (see Box 2.2).

Box 2.2: Promoting soya production in Zambia through an outgrower scheme

NWK (a major cotton/grain trading company) and Golden Lay (the leading egg producer in Zambia) are collaborating to promote soya production by smallholder farmers through a joint venture company called NWK Grain Handling Company (NGHL). Under the scheme launched in October 2015 and supported under TAF, NGHL supplies inputs such as improved seed, inoculum, herbicide and fertiliser for production of both cotton and soya. The 1,940 participating farmers also receive free extension advice from NGHL field staff. They repay inputs credit by selling equivalent volume of soya to NGHL through aggregators who are lead farmers. The NGHL buying centres where deliveries are made are equipped with suitable weighing, grading and storage facilities. NGHL offers competitive producer prices during the harvest season in order to attract more crop than is required to repay inputs credit. During the 2016 harvest season, most of the participating farmers were able to fully repay inputs credit for both cotton and soya through the delivery of soya only because of high soya prices. Loan recovery was reported to be 87% and soya yields obtained by the participating farmers had increased by about 45%. Though soya prices fell steeply during the 2017 harvest, the expectation was that farmers will cover revenue shortfalls from better cotton prices and be able to repay inputs credit provided. NGHL sells the soya directly to Golden Lay on contract basis and has been assisted with training and capacity building by Musika (a local NGO involved in output market development). A credit guarantee scheme covering 25% of the value of inputs delivered was also provided under TAF.

Source*: pers. Comm.* (with reps of NGHL on 18th May 2017).

2.4.5 Grain traders

The bulk feed ingredients are supplied to millers producing poultry feed producers by large-scale traders such as NWK, Afgri and CHC Commodities. These traders usually own or lease modern warehouses and silos and stock grains supplied by both commercial farmers and aggregators. They tend to sell to feedstock producers and large-scale egg producers on forward contracts. Grain aggregators also buy maize, especially, and soya from smallholder producers and sell either to stockfeed manufacturers or directly to large-scale egg producers. Usually trade at this level is not based on contracts – they bulk grains of 5 to 30 tonnes and transport to warehouses, mills or poultry farms and negotiate sale based on the prevailing prices. During years of substantial surplus, the grain traders are allowed to export into regional markets including Zimbabwe, DRC and Tanzania. However, sustainable development of this trade tends to be hampered by ad hoc imposition of restrictions on exports by the GRZ.

A new more formal grain marketing system is expected to emerge in Zambia after GRZ enacted a Statutory Instrument (SI) authorising the Zambia Agricultural Commodity Exchange (ZAMACE) to operate. Under the SI, ZAMACE is authorised to certify and oversee the operations of warehouses and silos holding stocks which can be traded on the exchange floor. As at August 2017, ZAMACE had certified five operators with total certified storage capacity of over 400,000 tonnes. The certified storage facilities are concentrated in the Central, Copperbelt and Southern Provinces, coinciding with the area where egg production is also concentrated. Most of these operators are linked to grain aggregators which also distribute farm inputs sourced from major suppliers such Seedco Zambia.

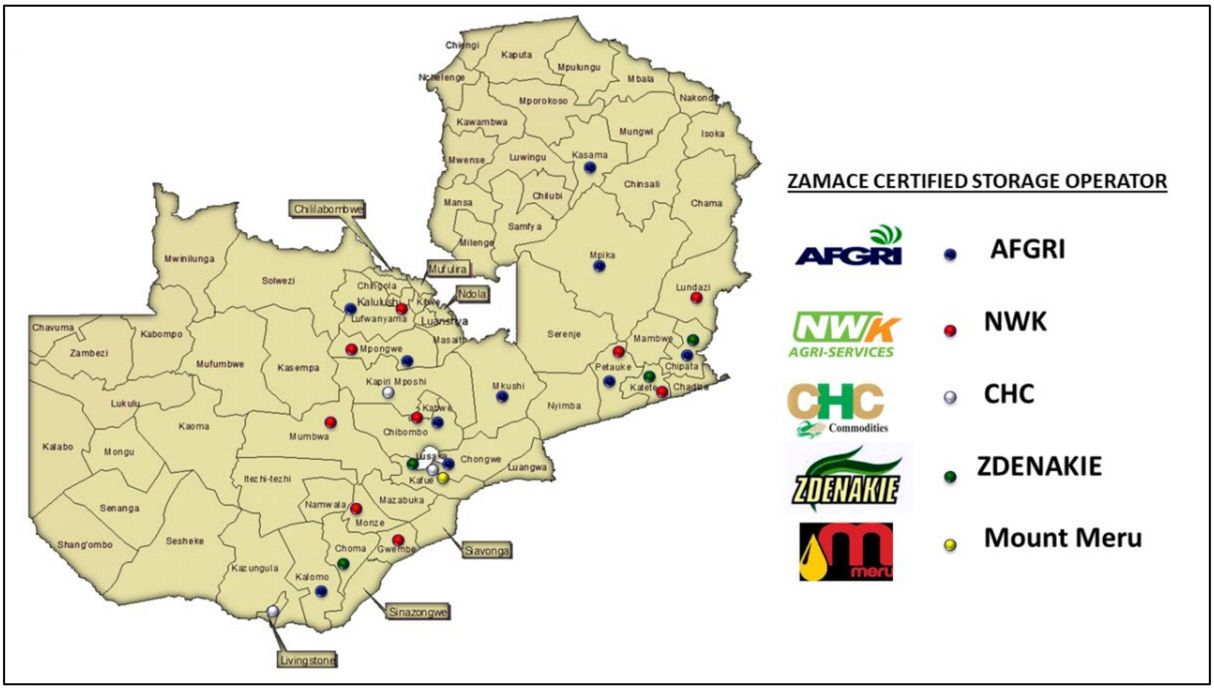

FIGURE 2.7: ZAMACE-CERTIFIED STORAGE OPERATORS AND SITES IN ZAMBIA

SOURCE: ZAMACE WEBSITE

ZAMACE has developed an electronic warehouse receipting system, which is similar to the one used by the Johannesburg Stock Exchange (JSE). According to a recent report (NRI 2017), during the 2016/17 marketing season, a total of 10,000 tonnes of maize was deposited by a commercial farmer and warehouse receipts issued. The deposited stock was used as collateral to secure inputs supplied on credit by a major inputs distributor, enabling the farmer to plant on time whilst waiting for prices to 'peak' before sale of the crop and settlement of the credit. The value of inputs supplied was US$ 2.6 million and it allowed the depositor to obtain significant discount for bulk procurement as well as an interest-free trade credit for about 90 days. This financing model is attracting both farmers and inputs suppliers and represents an interesting competition with bank finance for farmers. The suppliers are able to offer this facility as they enjoy back-to-back trade credit from their offshore suppliers. Though active trading of commodities by ZAMACE is yet to begin, the following financial institutions have committed to provide inventory finance against stocks in warehouses/silos certified by ZAMACE: AgDevCo Ltd., FNB, the Zambia National Commercial Bank (ZANACO) and Pangaea Securities, which has developed a special Grain Fund in collaboration with Musika (a local NGO which promotes market access for smallholders).

2.4.6 Layer Feedmillers/manufacturers

The main poultry feed producers are millers located in Lusaka and Copperbelt. They include National Milling, Tiger Feeds, Novateck, Nutrifeeds, Pembe Milling, Choma Milling and Olympic Milling. These companies supply mainly to medium and small-scale egg producers, either through their own retail outlets or via agro-dealers acting as agents. Most large-scale egg producers and some of the relatively bigger medium-scale producers formulate feed on-farm. Micro-scale egg producers generally use household scraps and/or limited free ranging to complement feed bought from agents/agro-dealers supplied by the major feedstock producers. Total poultry feed produced by these players is estimated at about 300,000 tonnes per year, out of which approximately 26,000 tons goes into the egg value chain[16]. This is much smaller than the volume produced on-farm, which is estimated at between 120,000 and 168,000 tonnes of feed per year[17]. Pre-mix feed concentrates used in Zambia is mainly imported from South Africa[18].

2.4.7 Importers of pre-mix feed concentrates and veterinary products

Egg production in Zambia depends on three key imports: Vaccines, pre-mix feed concentrates and grand-parent breeding stock for the hatcheries. Vaccines (Gumboro and Newcastle Disease) are imported by local companies based in Lusaka (e.g. Livestock Services a cooperative, and Vet 24 a Zambian owned private company) and either sold direct or distributed for resale through local agro-veterinary stores. Large-scale egg producers usually import their vaccines and poultry vitamins directly. Pre-mix concentrates for layer feed is imported by locally-based companies (e.g. Livestock Services), from a range of international sources, mostly from South Africa, and sold to feed manufacturers as well as egg producers and hatcheries. Grandparent stock for layers are imported by the two main hatcheries from sources in Europe, the USA or South Africa, depending on the prevailing animal health situation which may restrict movement of poultry across borders. The quantity of grandparents imported also depends on anticipated future demand for day old chicks.

2.4.8 Other service providers

These include veterinary and extension service providers as well as providers of finance. Providers of veterinary services mainly target small and medium-scale egg producers because the large-scale egg producers tend to have in-house skilled personnel who can administer vaccines. The veterinary and extension service providers are mainly located in the peri-urban areas of Lusaka and the Copperbelt towns, though some may be found in some district centres.

Zambia has quite a diverse financial sector. In terms of volume of transactions and branch network, the banks dominate. There 19 commercial banks licensed by the Bank of Zambia (BOZ), which is the central bank. The leading banks include international banks such as Barclays and Standard Chartered Bank, South Africa-headquartered Standard Bank (known more commonly as

16 Actual sales figures of layer feed are difficult to acquire due to the number of feed producers and competitive nature of the feed market, which also includes production of feed that is exported into neighbouring countries, including DRC, Malawi and Tanzania. The above figure is based on the estimated population of layers kept by medium and small scale producers (15% of a total laying hen population of 3.5 million=525,000), each consuming 45kg of layers feed per year, giving 23,625 tons, rounded up to 24,000 tons.

17 This is based on an assumed laying hen population of 3 million, each consuming 42.5kg of feed per day (a lower figure due to higher levels of productivity in large sem-automated layer houses resulting in generally more efficient feed to egg conversion ratios).

Stanbic Bank), First National Bank (also South Africa-owned) and the Zambia National Commercial Bank (ZANACO), which is owned jointly by GRZ and Rabobank of the Netherlands. BOZ has also licensed and regulates three (3) building societies, one (1) development finance institution, eight (8) leasing companies and 34 microfinance institutions (MFIs). Despite this, financial services appear to be more readily available only to the large-scale egg producers. They are able not only to access finance from local banking institutions but also to obtain equity finance and working capital for scaling up operations from international sources. The interest rates they obtain from international financial institutions tend to be much lower than rates in the domestic market. Large-scale egg producers are also able to negotiate favourable (often zero-cost) trade credit, depending on their size and length of trade relations with suppliers. As far as most small and medium-scale producers are concerned, the main source of fixed and/or working capital finance is capital saved from other enterprises as well as pension benefits and/or support from family members such as spouses. Most of them reported significant difficulties in obtaining bank loans due partly to lack of suitable collateral. They also complained about the "prohibitive" cost of borrowing.

2.5 Egg traders and consumers/users

2.5.1 Domestic table eggs trading system in Zambia

The table eggs distribution system in Zambia is aligned to the structure of the market. About 60-70% of table eggs produced the country is sold through the domestic informal markets. Formal retail distributors such as supermarkets account for 10-15% of total egg production, with the remaining 20-25% being exported into regional markets such as the DRC. Figure 2.8 illustrates the distribution system which GLL and most large-scale egg producers deploy in marketing their output.

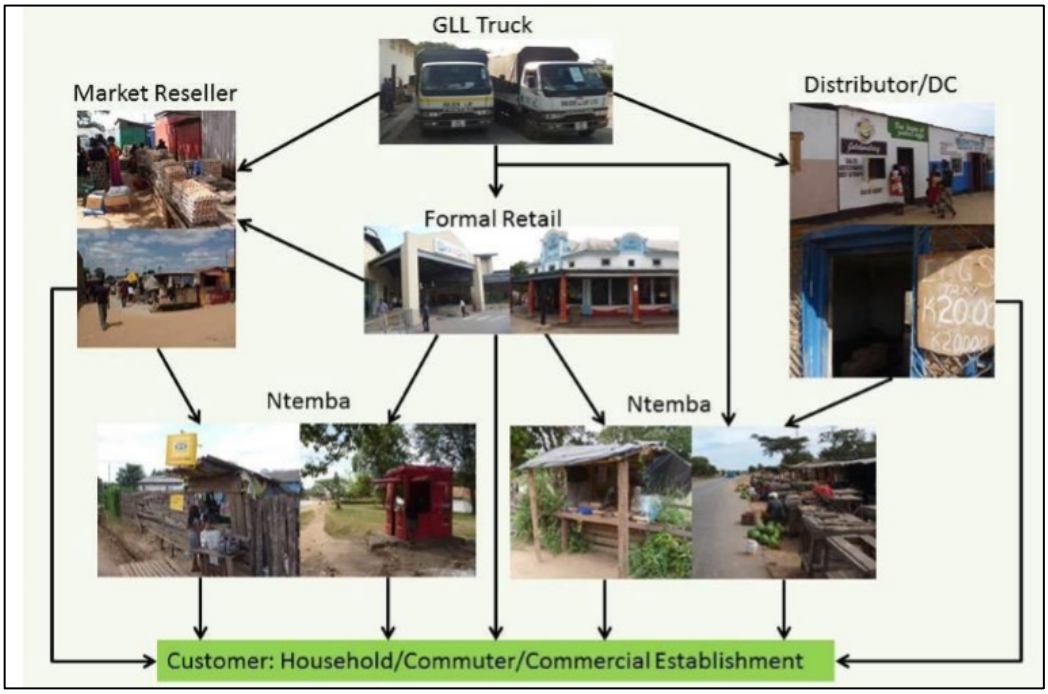

Figure 2.8: Illustrative table eggs distribution system in Zambia
Source: AndisaAgri/Technoserve (2013).

Most large-scale egg producers such as GLL sell eggs in the main urban markets such as the Soweto Market in Lusaka through middlemen traders (referred to in Figure 2.8 as "market resellers). These traders operate as small-scale "wholesalers", stocking between 100 to 1000 trays of eggs per delivery, which is often sold within 1-2 days. They usually sell to mainly retailers (the ntembas) who buy between 1-10 trays of eggs and retail in the low-income, high-density urban communities. The middlemen or "wholesalers" also sell to hotels, restaurants and confectioners who tend to supplement by buying from the supermarkets. These traders are well-organised and operate under associations which regulate access to the market by egg producers, in part to downside price risk due to oversupply. Their associations collaborate with local councils in the collection of market levies and in basic maintenance of the trading areas allocated to them. They therefore appear to have semblance of government recognition, which empowers them in enforcing their regulations in the market. Some egg producers, including large-scale producers, complained about this type of "control of the market".

The smaller urban markets appear to be less "organised" and it is possible for producers, especially the large-scale producers to sell directly from their trucks in such markets to the micro-retailers (ntembas) as well as household consumers. Some of them have also set up distribution agencies close to the markets (depicted of the top right of Figure 2.8), from which retailers and household consumers can buy eggs in trays. Interestingly, none of the medium-scale egg producers consulted sell through the main urban markets, either directly or through the middlemen/wholesalers. They tend to distribute directly to ntembas in the communities near their farms. Some of the large-scale producers as well as many medium-scale producers also sell to middlemen (wholesalers) directly from the farmgate and distribute mainly to ntembas, though they also retail to some "better-off" households.

The formal distribution channel consists of supermarkets/retail chains such as Shoprite, Food Lovers, Pick n Pay and Spar as well as locally-owned shops such as Melissa. Also emerging are producer-owned retail channels, the main example being Zambeef outlets which sell eggs from its subsidiary (Zamchick). Their model appears to work partly because the outlets sell a wide range of products from the holding company (Zambeef). Some producers have direct supply arrangements with local institutions such as schools, hospitals, prisons as well as hotels, restaurants and confectioners.

FIGURE 2.9: URBAN EGG MICRO-RETAILER IN ZAMBIA
SOURCE: ANDISAAGRI AND TECHNOSERVE (2013).

The ntembas at the bottom of the table eggs distribution pyramid (see Figure 2.8) are, essentially, micro-retailing operations. Most of the traders are women who sell all types food and other consumer items. Figure 2.9 illustrates the range of products which they sell. Their key competitive advantage is that they are able to sell all items in very small units as are affordable to their core clientele. The bottom-of-the-pyramid (BOP) distribution system which GLL piloted and is briefly described in Box 2.3 aims to shorten the distribution, principally, by excluding the middlemen.

In general throughout the egg trade, we found no evidence of producers selling eggs on credit into the informal markets, though they are required to offer trade credit of up to 30 days to formal retailers. There were reports indicating that in times of scarcity, traders may pay farmers in advance for eggs to secure their supply. Except in the supermarkets, eggs are sold undifferentiated with no branding. Some of the "wholesalers" sell eggs by size with larger sizes attracting premiums which range from ZMW 2-3 per tray. It is, however, common to find eggs of different sizes mixed and sold either per tray or in packs of 6-10 eggs. There appear to no loyalty to specific egg producers in the informal market. However, in the major supermarkets eggs are not only branded but may be sold from shelves dedicated to particular producers who have to pay for the allocated space.

Box 2.3: Bottom of pyramid (BOP) egg distribution system in Zambia

Under the Technical Assistance Facility (TAF), Golden Lay Limited (GLL) was assisted in developing an egg distribution system targeting egg micro-retailers (referred to as ntemba in the local language). TAF funding was used in assessing the market and providing technical advice on a sustainable, cost-effective distribution system. Under the pilot initiated in 2016, GLL invested in expanding its network of distribution centres (DCs), which serve as nodes receiving supplies from GLL trucks. Bike/pushcart pedlars (figure embedded) pick up stocks and deliver to the ntembas.

Each pedlar is assigned a network of up to 100 ntembas and their bikes have capacity of 40 trays per trip. On the average they undertake two trips per day. The specially-designed bicycles are owned by GLL and the riders are paid on commission basis – earning about ZMW 1,140 to ZMW 1,425 (equivalent to between €100 and €125) per month. There is a mark-up of between ZMW 3-5 per tray for direct delivery to ntembas to cover staff and other related distribution costs. However, this still keeps the cost per tray for ntembas at the same levels as would be the case if they had to buy from "wholesalers" in the markets or from the DCs, mainly because they avoid transport costs associated with obtaining eggs from these sources. Further features of the system include of point-of-sale equipment which makes it possible to track sales and availability of SMS hotline to ntemba operators to place orders and also to lodge complains.

Usually the ntembas buy one or two trays per day and sell either single eggs or in packs of 6-10 eggs. A report by AAF/TAF (2017) shows that within six months of its launch, over 2,000 trays of eggs was being distributed daily through this system – 10 times the target of 200 trays of eggs per day. They also reported over 60% increase in egg sales by ntembas.

Source*: pers. comm.* (with rep of GLL on 18th May 2017)/Phatisa (2015).

2.5.2 Export of table eggs: dominated by informal trading system

Export of eggs into regional markets, especially in the DRC is dominated by the large-scale egg producers. It is not only those who are located in the Copperbelt who sell into the DRC market but others in Lusaka are involved. There were reports that some aggregators buy eggs, mainly from medium-scale producers in and around Lusaka and export to DRC but it was not possible for this to be confirmed. Zambian exporters are reported to be in competition with suppliers from South Africa. However, there appears to be a preference for Zambia-produced eggs because of "freshness". Zambia producers are also price competitive.

Though the export trade is dominated by large-scale producers, it is largely informal. Deliveries are not made by exporters directly into DRC but the sales occur at border towns, the largest close to DRC being Kasumbalesa, visited by the team during the study. This situation has been attributed to challenges such as informal non-tariff barriers originating from DRC. Many of the exporters also reported payments challenges when they supply buyers in DRC on credit. They also expressed concerns about security, especially with physical transfer of sales proceeds from DRC.

As a result egg exports into DRC from Zambia occur mainly in Kasumbalesa. Some of the large-scale producers, including Zamchick trade from distribution outlets they run from the town. Many, however, send out distribution trucks which sell directly to buyers from DRC, as depicted in Figure 2.9 below. There was no evidence of pre-arranged sales and the trade is strictly on cash basis and is dollarized. The buyers from DRC are fully responsible for compliance with customs procedures and the bulk of the eggs is transported either by head porterage or heavily overloaded bicycles, evidently increasing the cost of delivery into the DRC market.

FIGURE 2.10: EGGS "EXPORT" TRADE IN KASUMBALESA BORDER TOWN IN ZAMBIA SOURCE: AGRIPROFOCUS ZAMBIA (2015).

2.5.3 Table eggs consumers in Zambia

Households in urban and peri-urban communities are the main consumers of table eggs in the country. Other users include hotels, restaurants, confectioners and "roadside eateries" which sell fried or boiled eggs. PAZ estimates national per capita egg consumption at 66 eggs per person, which is less than half the per capita consumption in South Africa[19]. There is ample anecdotal evidence showing that egg consumption is much higher in urban areas than rural areas. Domestic consumption is therefore highest in Lusaka, with a population estimated at 1.5 million; and the

19 The South Africa Poultry Association (SAPA) estimates that per capita egg consumption in 2016 was about 140 per annum.

Copperbelt where total population of the main towns is estimated at about 1.2 million. Hence, per capita consumption is likely to far exceed the national estimate, especially in low-income, high-density urban and peri-urban communities, where there is a trend of rising levels of egg consumption. For example, from a rapid survey of 150 members of the public in low-income communities in Lusaka, which was undertaken as part of this study, it emerged that about 90% of the respondents eat eggs. Over 75% of the respondents had eaten an egg within two days prior to the survey, and 60% of them said they eat eggs on most days or at least 2-3 times per week. Taking this as a proxy for an average of 2-3 eggs per person per week, consumption would be between 100 and 150 eggs per person per annum in these communities. It is therefore not surprising that the marketing strategies of most egg producers in the country target consumers in the low-income communities. According to some of the respondents, *"you eat more eggs at dinner when times are dense (or financially difficult)"* mainly because eggs provide a rich but relatively cheap source of protein when used in preparing tomato gravy or relish (*"with the egg yolk being used as a sort of thickener"*). This is used in eating *Nshima* (local maize meal). On the other hand, when household incomes rise (in local parlance – *"when ma-level change"*), then eggs are substituted with fish and meat for preparing the relish but consumed more during breakfast. The indication therefore is that egg consumption will grow whether there is economic stress or boom.

Evidence that rural consumption of table eggs is low is corroborated by a recent study undertaken in Zambia and Tanzania by De Bruyn (2017). The study shows that in rural households eggs account for less than 5% of total protein intake from fish and meat sources. This happens even in households which participate in projects to promote rearing of chicken rearing. In such households the preference is for eggs to be hatched to produce pullets which are reared for the premium "village chicken" market (mainly in urban areas). Anecdotes from respondents, including some consulted during this study, suggest that in rural poor households *"chicken is slaughtered for food when there is a visitor and during major festivals". "Why eat the eggs which produce chicken which can be sold to buy main ingredients for preparing relish for the main meal – nshima with tomato gravy prepared with dried fish (kapenta)"*. The puzzle is that in urban areas poor households prefer eggs because it is cheaper than kapenta but this is not the case in rural poor households.

The strategic importance of the export market to egg producers is illustrated the case of DRC market. The main area of DRC which shares a common border with Zambia is what was until 2015 known as the Katanga Province[20]. Katanga is geographically a big area. Its total land size is equivalent to about 65% of Zambia's entire land area. The population of the province is estimated at 10.6 million (2015), compared to Zambia's population of about 16 million. The economy of Katanga is substantially mining-based with copper and cobalt as its main exports with other minerals such as diamonds also being produced. Over-reliance on the mining industry as well as long-standing political instability and civil strife has made it difficult for the province to fully exploit its very high agricultural production potential. It therefore relies on imports of food and other consumer goods. With total egg production in the province estimated 85 million by Agriprofocus (2015), we project that it can absorb over 340 million eggs per year – assuming per capita consumption is about 60% of the level in Zambia. The importance of the trade with DR Congo,

[20] Since 2015 Katanga Province has been subdivided into four provinces.

which is estimated to have generated over €700 million in export earnings for Zambia in 2014[21], is being acknowledged by GRZ. However, food security policy often hampers its sustainable development as export restrictions tend to be imposed on ad hoc basis whenever a supply deficit is anticipated in Zambia.

2.6 Technical Diagnosis; production and service provider typologies, constraints and risks

In this subsection we discuss the main features of the different categories of players in the egg value chain and the constraints and risks they face which were identified during the study.

2.6.1 Typology, constraints and risks facing large-scale egg producers

Most large-scale producers have automated poultry housing units, either fully or partially. Those interviewed have plans for further investment in automation, including more advanced systems for water quality management, disposal of dead birds, the removal and disposal of manure and the processing and sale of spent hens. Priority is given to very strict bio-control systems, employment of managers with higher levels of technical qualification to supervise production and animal health practices, on-site housing for managers with other staff staying off the farm if possible to minimise health risks to the laying flock. As part of bio-control, day old chicks are reared in nursery facilities located away from the main flock in locations where risk of contact with other hens and wild birds is minimised. Capacity for purchase and storage of grain, processing and mixing of feed is developed as part of cost-saving and quality control of feed regimes. Systems for the storage, quality control, distribution and sale of eggs produced are in the process of development, with a view to minimising risk of storing eggs past their shelf life and securing the best possible price at any point in time. The owners/senior managers have access to high quality technical advice on all aspects of their operations from international sources.

Constraints and Risks: This category of egg producers is aware of the main constraints and risks involved, and have strategies in place to manage these risks. Animal health risks (disease outbreak, poor nutrition when birds are approaching point of lay) are potential high, and managed through employment of qualified staff, strict regimes for bio-control applied to all categories of the workforce and all operations, attention to detail in feed mixing and vaccination. The productive quality of laying hens is important, given tight margins, and is managed through high standards of management when rearing day old chicks to point of lay, and sourcing quality chicks from the best available source. Cost risks relating to fluctuating grain prices are managed through purchase of large quantities grain (e.g. one year's supply) for feed when prices are lowest and careful storage of this. Responding to sudden changes in demand remains a risk, for example when the DRC border closed for several months in 2016. The largest players were in a stronger position to "weather this storm" and absorb the shock by expanding their distribution networks into local markets and being able to absorb the impact of lower prices through the benefit of economies of scale and low levels of debt servicing. Theft of eggs (by employees) was reported as a significant issue by two company managers interviewed. The strategy of one of the companies

21 Source: http://www.zda.org.zm/content/congo-dr-strategic-market-zambia

was to provide a financial reward to other employees providing information leading to identification of the culprits.

2.6.2 Typology, constraints and risks facing medium-scale egg producers

This category is mostly comprised of what in Zambia is termed "emergent" farmers[22], most of whom have transitioned or diversified from broiler production into egg production. There is a mix of deep litter and cage based production systems, with automated lighting to optimise egg production and in some cases automated water supply systems to the laying sheds. Deep litter systems provide a low-risk strategy of transitioning from broiler to layer production, with limited additional extra capital outlay required, although productivity is usually somewhat lower due to increased stress in deep litter systems. There is awareness of benefits of the battery case system, and a number of small-scale producers start with this system, or transition to it, as part of their growth and investment strategy, but this is expensive. Some producers prefer deep litter systems for animal welfare reasons.

Many producers in this category purchase of point of lay hens rather than rearing of DOC to point of lay. There is awareness of benefits of rearing layers from point of lay but this is not common due to challenges (space for bio-control, housing, time it takes tying up limited capital, knowledge on vaccinations etc.). Similarly, there is awareness of the cost saving benefits of doing own feed formulation and mixing but this is not common due to challenges (technical knowledge, labour required without mechanised mixing equipment, need for close supervision, cost of mixing equipment) of own feed mixing and formulation. While feed price is a factor in deciding which brand to purchase, producers in this category tend to be loyal to a particular brand they have found to be reliable and regularly available, and are aware that changing feed brands can negatively impact on laying.

Basic bio-control measures are practiced. Producers usually employ at least one person with poultry keeping experience or training, including knowledge of the administration of vaccines and medicines. Newer entrants at this scale may also the veterinary services and advice from point of lay providers and hatcheries in Lusaka (e.g. Yielding Tree, Quantum Feeds, Hybrid Poultry).

Medium scale producers have more limited capacity than large-scale producers for storage, quality control, distribution and sale of eggs produced. Their main strategy is to develop a loyal customer base and sell surplus eggs in local markets. Constraints to developing loyal customer base include limited capacity to maintain a constant egg supply due to the limited size of the operation and the limited numbers of houses. There is also a very competitive egg market during periods of peak production (particularly around Lusaka and the Copperbelt) which causes egg traders to shop around producers for the lowest price.

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22 It is a common terminology used in Zambia to describe farmers who range between small-scale and large-scale.

2.6.3 Typology, constraints and risks facing small-scale egg producers

This category covers a range of small-scale egg producers, with similar characteristics to the medium scale producers, but with smaller operations. Most have transitioned or diversified from broiler production into egg production. Deep litter production systems are predominant, with automated lighting to optimise egg production and in some cases automated water supply systems to the laying sheds. The majority purchase point of lay hens and source their feed from a local supplier. Basic bio-control measures are practiced, and producers usually employ a labourer with poultry keeping experience. Newer entrants at this scale use the veterinary services and advice from point of lay providers and hatcheries in Lusaka and more experienced producers may do this themselves.

Small scale producers typically have very limited capacity for the storage, distribution and sale of eggs produced. As with medium scale producers, their main strategy is to develop a loyal customer base and sell any surplus eggs in local markets. They are even more limited in their ability to develop a loyal customer base due to limited capacity to maintain a constant egg supply.

This category of producers, because of the smaller scale of operations, is potentially better able to bear risks associated with price fluctuations in feed and eggs, mainly because the egg production is one of a number of enterprises/income streams. It is common for example, for poultry manure to be used in vegetable production for sale, adding value and saving costs. The smaller scale of the operation means that most of the manure produced can be used on the same farm, with minimal costs associated with manure management and disposal off the farm.

2.6.4 Typology, constraints and risks facing inputs suppliers and service providers

Commercial Hatcheries: This is a relatively well developed sector in Zambia, with at least five large scale commercial hatchery operations. There is significant export of both hatching eggs and day old broiler chicks to neighbouring countries. However, the hatching of layer chicks is less developed than broiler chicks, with only of the main hatcheries currently supplying layer chicks. Both of these operations have to import grandparent breeding birds for layers, whereas at least one of the hatcheries produces its own grandparent birds for broilers. Very stringent bio-controls are in operation to minimise risk, with an estimated 60% of costs going to hygiene related measures, and a further 30% of costs being labour[23].

The current demand exceeds the local supply of day old layer chicks, so there are opportunities for further expansion of supply. There are also risks attached to further investment by the largest hatchery because other hatcheries currently producing only broiler chicks may diversify into layer chicks, and significantly increase supply. There are also potential complications relating to competition in the industry as the largest producer of eggs which imports all of its DOC is a competitor of the owner of the hatchery which is also the second largest producer of eggs. Disease

[23] This compares with about 8% of costs for hygiene and about 10% of costs for labour in commercial egg production – personal communication, General Manager, Quantum Feeds.

outbreak is a constant risk for hatcheries, but very stringent bio-control measures are in place to manage this risk.

A constraint faced by hatcheries during the period of study was import restrictions on the importation of live birds to an avian flu outbreak in the Southern African region. This makes it more difficult to source quality grandparent stock needed to breed parent birds for the hatchery, lowering production capacity. A further constraint is fluctuating demand for DOC, linked to unstable feed prices and variations in demand from export markets, which given the length of the breeding cycle makes it difficult for hatcheries to be agile in terms of responding to increases in demand. Cancelled orders by farmers at short notice are also a risk and costly as the hatchery has produced DOC which need to be delivered the next day, but there may not be an alternative producer ready to take these at short notice when a large order is cancelled. For new initiatives in the hatchery segment of the VC there are also constraints relating to gaining a licence to import grandparent stock and negotiating access to patents and breeder's rights for particular layer breeds.

Small-scale incubation services: Emerging in the market are small-scale producers of DOC using locally-fabricated or imported incubators and mainly targeting the higher end of the broiler market for "village chicken" The eggs are hatched from either local breeds or imported improved breeds (e.g. Australope) and reared either in the rural or peri-urban areas targeting the urban market for "village chicken" meat. The supply of DOC from these into the egg VC is therefore not taken into account in this study. One of these operations is supplying high quality dual purpose hens, with good laying capacity, imported from Kenya and who is unable to meet the current demand. The main constraint he is facing is importation of new parent breeding stock due to the high costs and amount of bureaucracy involved.

Financial institutions: While a number of national banks provide loans for agriculture, the terms of the loans render this unviable under current operational conditions, due to high interest rates and charges. Medium and small-scale farmers appear to lack access to cheaper capital from external sources that the largest producers can benefit from. Farmers interviewed stated they are generally averse to taking on high-cost debt when the egg market can be quite volatile. The team was cited instances where egg producers who borrowed from local banks ended up shutting down operations or losing their real estate when they could not cope with debt servicing requirements when the market dipped in 2016.

Consultation with medium and small-scale producers indicates they do not access working capital finance from local intermediaries because they are able to negotiate trade credit of variable duration for the supply of critical inputs such as feed grains and veterinary products. This option appears to be available to some larger producers, who have stronger networks and more long-standing business relations with other service providers, and also more leverage in negotiating because of side of their operations. The largest operations are also well-placed to source low-cost offshore finance for major capital investments. Business advisory services needed by the small and medium-scale producers appears to be a gap in the market, as some of the producers visited reported making mistakes in their investment.

2.7 Value chain governance: coordination, information flow, regulation and policy

As depicted in Figure 2.4, there is a wide range of actors in Zambia's egg value chain. The relationships which exists between these players also vary, leading to the emergence of different forms of value chain governance, which as noted by Gereffi et. al (2005), influence the activities required to bring a product or service to its end use. Those identified in the egg value chain in Zambia are discussed in this section.

2.7.1 Market governance in Zambia's egg value chain

As is typical in cases of market governance, which involve relatively simple transactions which are influenced principally by price, access to most segments of the table eggs market in Zambia appears to be largely unfettered. Partly because the main product, table eggs, are largely undifferentiated in most segments of the market, including the predominantly informal export market. Brand power is crucial mainly where producers supply to major supermarkets. The cost of branding, which may include "renting" allocated shelves, can lead to exclusion of some producers, mainly the small and medium-scale producers. However, this segment of the market is comparatively small, relative to the very large informal market.

As noted in Section 2.5.1, "wholesalers" (middlemen) in the major urban markets tend to control who can sell directly in those markets. Their influence has, however, been diluted by the distribution strategies adopted by different producers. Large-scale producers are the main suppliers to these traders but they also sell to micro-retailers (ntembas) and others through their distribution centres and from their trucks. The BOP distribution system successfully piloted by GLL (Box 2.3) represents another means by which large-scale producers can avoid market control by the middlemen and sell more directly to the micro-retailers (ntembas). The small/medium-scale producers sell to community-based "wholesalers" (middlemen) who distribute to retailers. Some of the retailers also buy directly at farmgate from the producers. As a result of competition in the market, brand loyalty is largely absent and buyers are influenced mainly by price and availability.

It is evident that the dominant market leader is the price setter in the table eggs market. Wholesale prices are virtually set by the market leader in egg production – at ZMW 23 (i.e. €2.04) per tray. All other large-scale producer sell at this price, including into the main exit market into the largest export destination, which is the DR Congo. Farmgate prices for medium and small-scale producers as well as margins for wholesalers are set around this benchmark price (demonstrated in discussions on Financial Analysis in Section 3.2). Furthermore, the financial analysis reported in Chapter 3, reveals that *de facto* price cap set by the market leader often implies tight margins, especially at the lower end of the production scale. Enterprise viability is therefore determined to a large degree by the extent to which production is cost-efficient. Some of the other governance systems found in the value chain appear therefore to have emerged as a response to competitive pressures by the key players.

2.7.2 Emergence of hierarchical governance in egg value chain

Hierarchical governance, which is characterised by vertical integration, is emerging especially among the large-scale egg producers. An example is where Quantum Foods, producers of DOCs, have integrated egg production into their operations. This has been driven partly by downturn in demand as many medium and small-scale producers get squeezed out production due to spikes in the cost of major feed ingredients (maize and soya). Another example is the integration of feed formulation with egg production, which is very common among large-scale producers and is emerging among some medium-scale producers. Others such as GLL and Zamchick are engaged in crop farming, concentrating mainly on maize and soya production. These investments are aimed not only at moderating price shocks but also to reduce supply uncertainty. There is also the additional drive by some large-scale producers such as Chicol Estates Ltd. towards integrating egg production with pelletising chicken manure. This helps to ease waste management challenges and whilst also boosting non-egg revenues. The main form of vertical integration found among small and medium-scale producers is that of linking egg production to the production of high-value vegetables. In addition to helping in managing disposal of chicken droppings, which they use as organic manure, they are able to diversify their revenue stream, including enabling some of them to market both eggs and vegetables to supermarkets.

2.7.3 Relational linkages in the egg value chain

Relational linkages tend to emerge to govern interactions between different players for mutual benefit. The most common case found in the egg value chain in Zambia exists between producers of POL hens and the small/medium-scale egg producers. Many of the POL producers provide extension advice as well as distribute quality feed sourced from the major feedstock producers to their customers. These services are reported to help improve the technical efficiency of production by the small/medium-scale egg producers, who tend to have limited access to reliable extension/advisory services. It was mentioned in the course of consultations undertaken during the study this strategic relationship is crucial to the specialised POL producers in sustaining and growing their market share. The relationship is also important to small/medium-scale egg producers due to their limited capacity to invest in efficient rearing facilities. It is however common to find medium-scale egg producers switching to rearing DOCs to the point of lay as they scale up.

2.7.4 Maintaining enabling regulatory and policy environment for table egg production

Regulatory agencies which govern activities in the egg value chain in Zambia include the following:

- **Department of Livestock (Ministry of Fisheries and Livestock)** – coordinate policy on livestock research and extension services and regulations and policies on the internal movement and importation and exportation of live animals and germ-plasm (including hatching eggs), vaccines and veterinary drugs and pre-mix for poultry feed.

- **Zambia Environmental Management Agency (ZEMA)** – regulations and issues relating to environmental impact of functional units in the value chain (including environmental impact assessment for establishment of new breeding, rearing and egg production units).

- **Ministry of Labour and Social Welfare** – workers conditions and health, especially in egg production units.

- **Ministry of Health** – oversight of human health risks relating to the egg production sector, public health services including monitoring of nutritional status of infants and infant feeding extension and support programmes,

- **Ministry of Agriculture** – Regulation of export and import of grain (maize and soya), Zambia Agricultural Research Institute regulation of the importation and production of inoculum for soya, testing of new agro-chemicals used on soya and maize, phytosanitary controls relevant to soya and maize production. Seed Certification Institute, oversight and regulation of the seed sector, relevant to varietal release and seed quality control for soya and maize production.

- **Local authorities (City, Municipal and District Councils)** – enact and oversee bylaws which relate to the operation of local markets, relevant to egg trading operations and also levies on grain (maize and soya) which passing out of districts *en route* to millers and grain stores.

It was apparent from the field visits that the regulators focuses on enforcement of statutes mainly at the level of the large-scale players in egg production and the supply of inputs and services. The team did not observe proactive interactions between the regulators and key value chain actors to reform and/or sharpen enforcement of regulations with the primary aim of minimising adverse environmental impact. For example the old legislation on citing farming operations close to human settlements is creating tensions between some producers and the communities in which they reside. This is particularly the case in peri-urban settlements close to Lusaka but can soon emerge in the Copperbelt. A thorough review where clearer operating conditions are set rather than total exclusion may be an option worth considering. To identify these and other relevant issues collaboration between regulators and industry representatives need to be deepened.

2.7.5 Creating and maintaining enabling policy environment for table egg production

Some of the generic challenges facing players in the egg value chain which can be mitigated by policy interventions include easing access to regional export markets as well as remote domestic markets which are under-served because the poor state of the roads increase distribution costs substantially. This issue is particularly important to the large-scale egg producers who dominate exports into the regional markets. However, it is apparent that where export restrictions create temporary over-supply of eggs, as occurred in 2016 (see Section 2.2) all egg producers are adversely affected. In addition, the operations of suppliers of inputs and services, including producers of DOCs and POLs are impacted negatively.

The Ministry of Commerce, Trade and Industry (MCTI), which is responsible for private sector development policies related to agri-business as well as the Zambia Development Agency (ZDA) have expressed interest in promoting exports, especially into the DR Congo market[24]. It is uncertain the extent to which the bottlenecks facing egg exporters (see Section 2.52) will be prioritised.

Whilst market expansion is important to egg producers, those consulted indicated that even more problematic for them is stability in the grains markets (for maize and soya). GRZ efforts to sustain growth in especially maize production involves direct market intervention through the FRA. Its role includes setting floor prices which, according many grain traders, tends to distort the market and constraints the development of market institutions which promote stockholding within and between seasons. GRZ also tends to restrict exports when there is a deficit, ostensibly to ensure lower cost of staple food grains and feed ingredients. However, as some of the players consulted eloquently put it, their reliance on non-market levers creates uncertainties which often go beyond a particular season. For instance, as noted in Section 2.2, interventions in 2016, increased the volume of carry-over stocks of maize and soya into the 2017 harvest, thereby depressing producer prices and potentially blunting incentives for sustained increase in production. The base for policy dialogue therefore needs to be broader and the evidence available need to be more robustly evaluated and used.

For most small/medium-scale egg producers access to technical, veterinary and business advisory services appears to be a key gap. No evident programme to address this gap was found in the course of the study. Furthermore, it is clear that the existing financial services are not tailored to the needs of the small/medium-scale egg producers. Innovations in this direction are crucial if greater inclusiveness in the value chain is to be promoted along with generic industry growth.

The main mechanisms for communication between policymakers and the main stakeholders appears to be mainly informal. The ZNFU, together with its affiliate PAZ, provide a formal platform for stakeholder engagement and communication on important issues relating to the value chain. PAZ has a number of sub-committees at national level, to deal with different aspects of poultry, which includes a committee for layers. It also has a network of district associations which provide potential platforms for raising issues at local level and also dissemination of important information. Both ZNFU and PAZ have been active in lobbying government on issues of importance. PAZ also acts as a channel for disseminating important information, such as the decision to reactivate the Avian Influence National Response Committee

In terms of power and particularly influence, shapers of relevant public policy include influential actors within the egg value chain who are impacted by government policy. Some managers of large-scale egg production units and feed manufacturers sit on the PAZ and/or ZNFU committees and are able to voice strong views on what government should or should not do in relation to the egg value chain. Views are voiced through feature articles in the national press, and via radio and

24 Source: https://af.reuters.com/article/africaTech/idAFKCN0SO1OG20151030

TV broadcasts, websites, social media and open letters to government published in the national press. Another relevant organisation shaping policy is the Indaba Agricultural Policy Research Institute (IAPRI) which undertakes studies and publishes the results to promote evidence-based policymaking in the agricultural sector in general, and also organises stakeholder workshops and provides policy advice to government ministries. Informal dialogue and lobbying is also common, as the community of influential voices is relatively small and individuals often meet at events or socially.

While PAZ provides a platform through which smaller egg producers can also voice their views, interviews indicated that many of the smaller-scale egg producers are not either aware of PAZ, or if they are aware are not actively engaged with PAZ. They are automatically PAZ members through a levy paid when they purchase day-old chicks from the hatcheries. This situation has been complicated by a recent decision made by the second hatchery supplying layer chicks not to collect this levy for PAZ. This situation makes it challenging for PAZ to keep an accurate and up to date list of its members and their contact details for purposes of effective communication with egg producers.

3. THE ECONOMIC ANALYSIS

3.1 Introduction

The economic analysis reported in this chapter is intended to answer two key framing questions:

- What is the contribution of the egg value chain to economic growth in Zambia?; and
- Whether growth in the chain is inclusive.

In answering these questions the following steps were taken in accordance with the standard methodology adopted for the study:

a. Undertaking financial analysis of the key actors

b. Assessing overall effects on the national economy

c. Analysing the sustainability and viability of the chain within the international economy

d. Assessing the inclusiveness of growth in the chain

Consistent with the adopted methodology, the bulk of the analysis is based on market prices. The key actors covered are selected on the basis of defined boundaries for analysis in the study, as stated in Section 1.2 of this report. These actors:

Egg producers:
Among the factors which distinguish the operations of these actors and impacts on their financial viability are the production technology adopted (mainly whether it is the deep litter or battery cage production system), the scale of operation and whether or not they have installed on-farm capacity to formulate feed for the layers. All the large-scale producers use the battery cage production system whilst some of the medium-scale producers have transited or are transiting to this system. Most of the medium-scale producers and all small-scale producers use the deep litter production system. Based on this consideration the analysis covers the following:

- Large-scale egg producers with more than 200,000 in-lay hens on farm and an average of population of in-lay hens of about 385,000.
- Large-scale egg producers with in-lay hen population ranging from 10,000 to 100,000. The average population of in-lay hens for this category is about 65,000 birds.
- Medium-scale egg producers with average population of in-lay hens of just over 5,000 birds and who are at the top end of this category and who use the battery cage system of production.
- Medium-scale egg producers with average population of in-lay hens of 1,755 birds who use the deep litter production system but formulate their feed on-farm.
- Medium-scale egg producers with average population of in-lay hens estimated at 1,030 birds and rely on feed procured from the major feed-millers.

- Small-scale egg producers with average in-lay bird population of 245 and who use the deep litter system and are reliant on feed from the feed-millers.

Traders:

- At the top end of the egg traders are the supermarkets (formal retailers)
- Wholesalers based in the major urban markets who, on the average, trade about 150 trays of eggs (30 eggs per tray) per day.
- Community-based wholesalers who buy directly from the medium and large-scale producers and sell to community-based retailers. They trade about 220 trays per trip and average 3.5 trips per week.
- Community-based retailers who sell about 2 trays per day.

Producers of point-of-lay (POL)birds:

- These generally fall within the category of large-scale producers as their scale of operation is from 30,000 to 200,000 birds per annum. The main target offtakers are small-scale producers and some medium-scale producers, especially those at the lower end of that category.

Suppliers of goods and services:

These include the following:

- Day-old chicks producers (hatcheries);
- Feed manufacturers;
- Producers of the main feed ingredients (soya and maize);
- Providers of veterinary services; and
- Transporters.

Excluded players:

The main group of players who were exclude from the analysis include micro-scale egg producers, principally because their output, in general, does not enter the table egg market as it is either hatched for production of "village chicken" or consumed by the household. Also not analysed are free range egg producers as it was not possible to obtain data on these producers in Zambia.

3.2 Financial analysis of agents' operations

The financial analysis involves assessing how profitable the key actors are. The main tool of analysis is the operating account, taking into account only flows involving market exchange and therefore applying actual market prices. Due to difficulties in obtaining details on actual capital investments by the key actors, the main benchmarks used in assessing overall financial performance of the actors is return on turnover (total sales). Though this is applied to all the actors, it is relatively more important for the larger-scale operators, for whom this may represent an indication of the efficiency of their investment. For the smaller-scale actors in the chain, how income generated from the chain contributes to overall household income and wellbeing may be the more relevant issue, hence we compare the net income (net profits) generated with national minimum/living wage in Zambia.

The format set out in Box 3.1 was used in computing the operating accounts of the key actors. The outcome is reported below.

Box 3.1: Computation of operating accounts of key actors

Value chain agents' operating accounts have been calculated based on the following outline:

- Production / output
- Farmgate / sales price
- Value of production
- Cost of Production
  - Intermediate Goods and Services
  - Value Addition (direct VA)
    - Value of rented land
    - Value of hired labour
    - Financial charges
    - Taxes / duties
    - Subsidies
- Gross profit
  - Depreciation
- Net profit

Source: Based on Study Methodological Framework.

3.2.1 Financial analysis for the main egg producers in Zambia

The financial analysis reported in Table 3-1 shows that all categories of egg producers are profitable. However, the margins are pretty tight at the lower end, the lowest return on turnover being 5.23% for the small-scale producers. At the top end of the scale, the return ranges between 24.13% and 31.38% for the two categories of large-scale producers. These margins are not dependent on any forms of subsidies. The Government (GRZ) has considered extending its inputs subsidy programme to include micro-scale egg producers but this is yet to take off on any significant scale and this category of producers is not analysed in this study.

At the small-scale end, the average annual earnings of ZMW 4,662.01 (or €416.33) tends to be seen as supplementary household income as it well below the average annualised minimum wage of €714.16[25] and even far lower than the annualised living wage in Zambia, which is estimated at €3,403.20 (or €283.60 per month[26]). Even at the lower end of medium-scale egg production, the net annual income of €2,577.86 for egg production is 24.2% below the annual living wage. Hence, it is only when producers reach the scale of production of about 1,750 in-lay birds and are able to invest in on-farm formulation of feed (third column in Table 3-1) that net income is able to support

[25] Source: Government of republic of Zambia Statutory Instrument no. 46 of 2012.
[26] Source: Wage Indicator Foundation, 2016.

the average family. Beyond that scale, the evidence in Table 3-1 also shows that egg production can be commercially sustainable. However, that requires investing in the battery cage production system and access to finance for such investment was reported by most of the actors consulted during the study as being very difficult and also very expensive (with interest rates of 30% and above per annum).

3.2.2 Feed costs and its implications for main egg producers in Zambia

One implication of the tight margins at the lower end of the production scale is its impact on enterprise sustainability during periods of sharp price hikes for the main feed ingredients such as maize and soya. The price cap on table egg prices set as a result of the structure of market (see Section 2.9 for details) implies that producers have limited scope for adjusting to rising inputs prices through raising farmgate prices for table eggs. Hence, many small and medium-scale producers struggled to survive sharp increase in the prices of maize and soya in 2016. Some temporarily exited from the poultry industry or shifted to broiler production. They opt for this coping strategy because broiler production is over a shorter production cycle and can be timed to coincide with seasonal demand, thereby minimising feed cost per bird

Item/ producer	Small-scale	Medium (deep litter)	Medium (deep litter from DOC)	Medium (battery)	Large-scale (10-100,000 birds)	Large-scale (over 200,000 birds)
BASIC INFORMATION						
Average in-lay hen pop.	245	1030	17	5004	125,000	385,000
Egg price/tray	27	26	26	26	23	23
Price/spent hen	28	28	28	28	28	28
Price/DOC	NA	NA	8.7	8.7	8.7	8.7
Price/POL	70.10	70.10	NA	NA	NA	NA
REVENUE						
Table egg sales	75,678.19	342,028.04	521,696.93	1,431,805.56	27,772,500.00	89,786,250.00
Sale of spent hens	7,000.00	32,853.33	52,266.67	142,333.33	2,940,000.00	9,450,000.00
Manure sales	6,443.30	60,481.10	96,219.93	131,013.75	4,059,278.35	13,047,680.41
Gross revenue	**89,121.49**	**435,362.47**	**670,183.53**	**1,705,152.63**	**34,771,778.35**	**112,283,930.41**
VARIABLE COSTS						
Cost of DOC/POL	17,525.77	82,254.30	18,050.67	49,155.83	941,752.58	3,027,061.86
Pre-lay feed cost	0.00	0.00	42,437.63	115,566.76	1,688,102.62	5,426,044.12
Layer mash	54,474.08	54,474.08	255,664.99	281,812.55	652,320.56	11,851,685.81
Veterinary products	1,205.76	5,659.01	9,002.97	24,517.02	517,241.91	1,662,563.27
Egg trays	1,176.35	5,526.40	13,160.00	35,837.50	733,437.58	2,357,477.93
Labour for rearing	0.00	0.00	21,074.67	57,390.83	533,452.50	1,714,668.75

Item/ producer	Small-scale	Medium (deep litter)	Medium (deep litter from DOC)	Medium (battery)	Large-scale (10-100,000 birds)	Large-scale (over 200,000 birds)
Labour for laying	9,727.53	45,654.56	72,632.00	89,006.63	500,589.16	804,518.29
Gas/charcoal for brooding	0.00	0.00	280.00	1,880.83	41,263.16	132,631.58
Electricity	259.79	1,219.30	2,016.00	1,525.00	119,368.42	383,684.21
Transport costs	51.55	241.92	373.33	1,016.67	22,105.26	71,052.63
Council levy	38.66	181.44	280.00	762.50	16,578.95	53,289.47
Total variable cost	**84,459.48**	**396,401.93**	**461,119.82**	**1,028,980.14**	**16,965,577.93**	**48,758,822.00**
Interest	0.00	0.00	110,223.95	264,774.04	4,241,394.48	9,751,764.40
TVC + interest	84,459.48	396,401.93	571,343.76	1,293,754.18	21,206,972.41	58,510,586.40
Gross margin	4,662.00	38,960.54	98,839.77	411,398.45	13,564,805.94	53,773,344.01
Depreciation	0.00	9,910.05	23,055.99	102,898.01	4,241,394.48	14,627,646.60
Total costs	84,459.48	84,459.48	406,311.97	594,399.75	1,396,652.20	25,448,366.90
Profit before tax	4,662.01	4,662.00	29,050.49	75,783.78	308,500.44	9,323,411.45
Tax (@ 10% p.a.	0.00	0.00	0.00	0.00	30850.04379	932,341.15
Net profit after tax	**4,662.01**	4,662.00	29,050.49	75,783.78	277,650.39	8,391,070.31
Return on turnover (%)	**5.23**	**5.23**	**6.67**	**11.31**	**16.28**	**24.13**
Earnings per producer (€)	**413.66**	**2,577.68**	**6,724.38**	**24,636.24**	**744,549.27**	**3,126,098.28**

Table 3-1: Operating accounts for egg producers per average in-lay hen population (in ZMW)Source: Computed from data collected from PAZ and consultations with producers. NA – not applicable

As depicted in Figure 3.1, the cost of feed accounts for an estimated 69% of total variable cost of table egg production as in Zambia. The estimate is based on industry-wide average data but as further illustrated in Figure 3.2, there are significant variations in feed cost relative to overall production cost depending on the production system and the scale of operation.

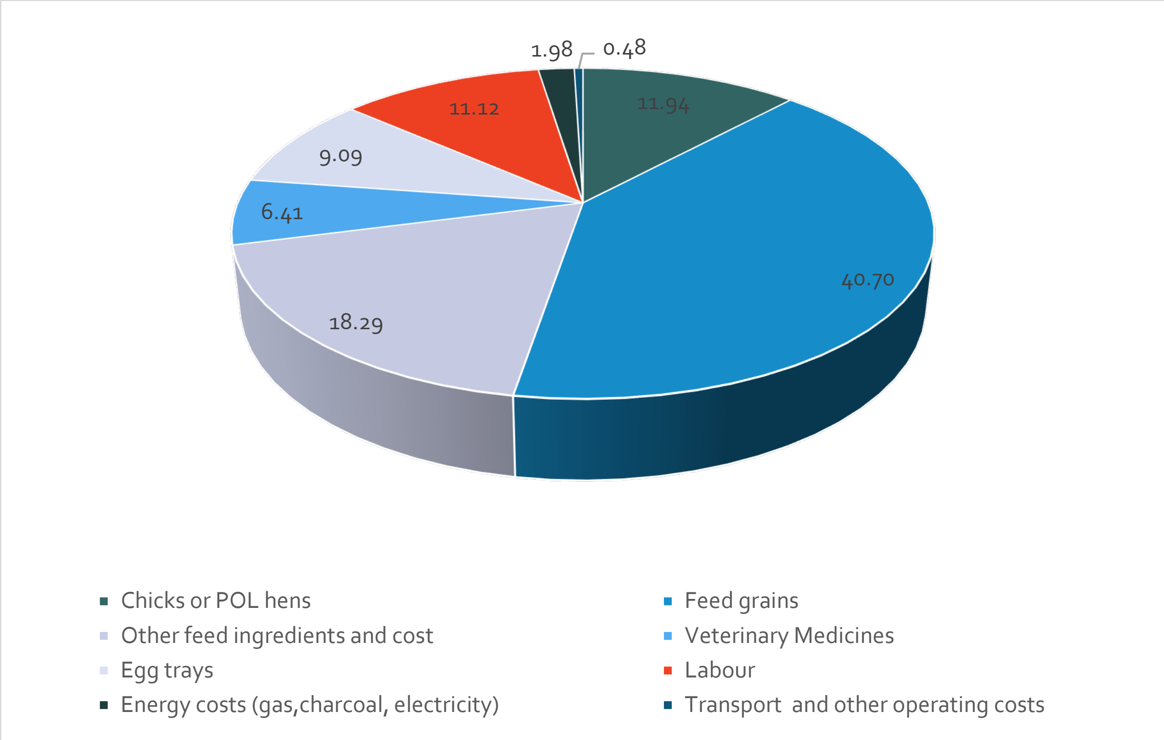

FIGURE 3.1: BREAKDOWN OF TOTAL VARIABLE COST OF EGG PRODUCTION IN ZAMBIA IN 2015

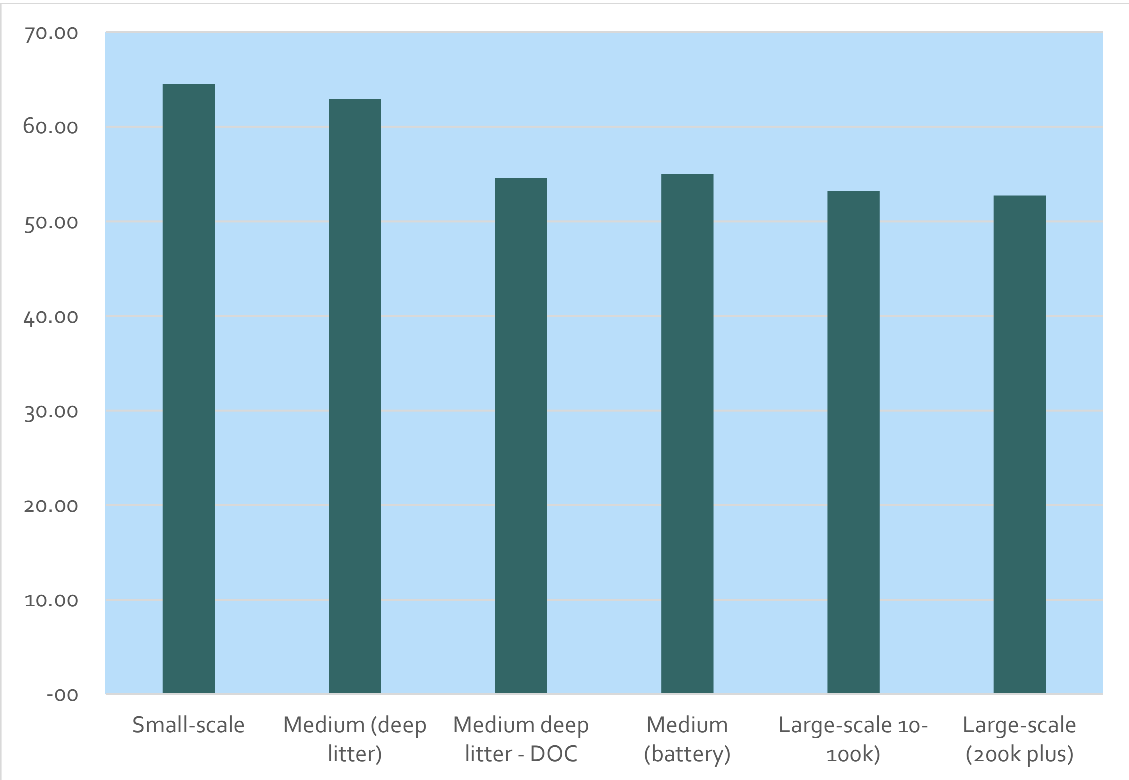

FIGURE 3.2: FEED COST AS SHARE OF PRODUCTION COST FOR DIFFEENT CATEGORIES OF TABLE EGG PRODUCERS IN ZAMBIA (%)

Large-scale producers can cope better with price hikes for feed ingredients, partly because the battery cage production system, which they use, reduces feed wastage and is therefore more cost-efficient. They are more able to finance uptake of this technology because of relatively easier access to finance from the local banking industry as well as offshore. Furthermore, they produce feed more cheaply on-farm. The cost of feed per productive bird drops by about 20% when producers opt for on-farm feed formulation even if they continue to use the same production technology (i.e. deep litter production system). The drop of feed cost per productive bird is even steeper when there is a change from deep litter to battery cage system among medium-scale producers – by 31%. The difference with those at the top end using environment-controlled battery cages is a very high 48% drop. Consequently, feed cost as percentage of overall cost of production is lower as production is scaled up as shown in Figure 3.2.

The option of on-farm feed formulation is, however, not available to smaller-scale producers even though they can obtain advice on feed formulation from Livestock Services. This is largely because they lack the means to invest in required equipment and also need to avoid quality variability when they formulate feed on-farm as it affects the productivity of layers. A third factor is that, due to the scale of inputs procurement by the larger-scale producers, they are able to negotiate highly favourable trade credit terms – payment within 30 to 90 days and at zero interest rates. Such terms are unavailable to the smaller-scale producers.

3.2.3 Financial analysis for egg traders in Zambia

As is the case for egg producers, egg traders differ in terms of scale and type of trading. Four categories of traders are covered in the analysis. It is a profitable operation for all traders as shown in Table 3-2. The trade margins are very tight for wholesalers based in the urban markets – estimated at 6.85%. These traders are directly supplied by the large-scale producers, who use their own distribution trucks (e.g. in Figure 3.3). The producers also deliver directly to the supermarkets but in branded trays as against unbranded trays delivered to the other traders. The community-based wholesalers tend to collect from producers located within or close to the communities.

Trade margins exceed 11% for supermarkets and community-based wholesalers and retailers. Though margins are tight for wholesalers based in the urban markets, the net income generated by these operators is more than double the annual living wage in Zambia (€3,403.20). This implies that the households who are dependent on this trade can sustain their livelihood. The community-based wholesalers are even better endowed in terms of income-generation through the egg trade. Their margins are also close to 65% more than what is obtained by the market wholesalers.

FIGURE 3.3: GOLDEN LAY DISTRIBUTION TRUCK (FROM FARM TO MARKETS)

The net earnings generated for community-based retailers is estimated at €242.24 per annum. This is despite the rather high return on turnover of 12.5%, the highest within the egg trade. To put this figure in context, it can actually make a difference in terms of household income in poor urban households. In Zambia an estimated 60.5% of the population is below the national poverty line estimated in 2011 by the World Bank at US $1.90 a day or €581.30 per annum. The contribution from retailing eggs therefore constitutes about 42% of the income threshold. This is important, considering that the households involved in the trade often sell other essential food items, including especially nutrient-rich vegetables.

Item/producer	Wholesalers in urban market	Community-based wholesalers	Community-based retailers	Supermarkets
GENERAL INFORMATION				
Average trays sold per day	150	60	2	380
Egg price per tray	25	26	30	30
REVENUE (per year)				
Table egg sales	1,170,000.00	1,041,040.00	21,840.00	12,160,158.00
Gross revenue				
VARIABLE COSTS (per year)				
Cost of eggs	1,076,400.00	880,880.00	18,200.00	9,322,788.09
Hired labour	12,480.00	12,480.00	0.00	1,025,506.69
Transport costs	0.00	30,030.00	546.00	0.00
Council levy	936.00	936.00	364.00	60,800.00
Total variable cost	**1,089,816.00**	**924,326.00**	**19,110.00**	**10,409,095.57**
Interest	0.00	0.00	0.00	104,090.96
TVC + interest	1,089,816.00	924,326.00	19,110.00	10,513,186.53
Gross margin	80,184.00	116,714.00	2,730.00	1,751,062.81
Annual depreciation	0.00	0.00	0.00	105,131.87
Total costs	1,089,816.00	924,326.00	19,110.00	10,618,318.39
Profit before tax	80,184.00	116,714.00	2,730.00	1,541,839.99
Tax (@ 10% p.a.	0.00	0.00	0.00	154,184.00
Net profit after tax	**80,184.00**	**116,714.00**	**2,730.00**	**1,387,655.99**
Return on turnover (%)	6.85	11.21	12.50	11.41
Earnings per producer (€)	**7,114.82**	**10,356.17**	**242.24**	**123,128.30**

Table 3-2: Operating accounts for egg traders in Zambia per trader (in ZMW)Source: Computed from data collected from PAZ and consultations with producers

3.2.4 Financial analysis for POL producers in Zambia

The average scale of production of POL hens is about 113,000 per annum. The operation yields an annual return on turnover estimated at 9.36%, without any form of subsidy. The role of these players is critical to competitive engagement of producers below the level of the medium-scale producers using the battery cage system. This is because they invest in crucial biosafety systems which minimise DOC mortality rates. Furthermore, by supplying POL to the smaller-scale producers they substantial shorten the lag time required for the birds to be productive from 16 to 18 weeks to days or maximum two weeks.

As demand for their main output is from producers who are vulnerable to price shocks for feed grains, their operation tends to be affected by volatility in the prices for grains. For instance, many of them coped with the price hikes which occurred in 2016 by scaling down production by about

20%. Some retrenched staff or reduced "benefits" though reportedly leaving basic salaries unaffected, with the promise of restoring "benefits" when the industry recovers. They also provide technical advisory services to their customers in order to optimise the productivity of birds as customer loyalty appears to switch quickly when layer productivity trends downwards on individual farms.

3.3 Assessment of contribution of egg value chain in Zambian economy and of its viability in the international economy

This assessment focuses on determining the contribution of the egg value chain to the economy of Zambia, both in terms of the nominal value of the contribution and what it represents as share of gross domestic product (GDP) in the agricultural sector. Also computed are the contribution of the value chain to public finances in terms of taxes and levies paid by as well as subsidies received by players in the chain. In addition, the net contribution of the chain to balance of trade is computed based on valuation of the imported Intermediate Goods and Services (IGS) against the estimated value of foreign exchange earnings from exports.

Computation of value addition generated through the chain is based on the consolidation of the operating accounts of the key players in the chain – noting that in this study the specific boundary is limited to producers of POL hens, egg producers of all size (excluding micro-scale producers) and egg traders (including wholesalers and retailers in both formal and informal sectors). Details of the operating accounts for these players are reported in Table 3-1 and Table 3-2.

The computation value added in the egg value chain includes both direct value addition from the key actors (reported in Table 3-3) and indirect value addition (from the main suppliers and service providers and reported in Table 3-4). Total value added for the chain is consolidated from the two and reported in Table 3-5.

- Value added per actor in the chain is computed as total production less the value of Intermediate Goods and Services (IGS) used. This is based on the average operating accounts per actor, reported above (using actual market prices[27]), and estimates of number of actors country-wide as shown below[28]:

- Small-scale egg producers: 750
- Medium-scale producers using deep litter production system: 140
- Medium-scale deep litter egg producers rearing DOC on-farm: 70
- Medium-scale producers using battery system: 25
- Large-scale producers: 22
- Middlemen in urban markets: 175
- Community-based middlemen: 55
- Micro-retailers (in communities and in "street shops": 18,000
- Major supermarkets involved in egg trade: 10

[27] The prices were obtained from some of the producers consulted and officials of PAZ.

[28] It must be stressed that the estimates are not based on validated data but on communications with stakeholders consulted, including officials of PAZ. Investing in a census of value chain actors in order to improve the quality of industry statistics will be valuable, especially as the chain position itself for sustained rapid growth.

- The IGS is disaggregated into imported component for both the value chain actors and suppliers/service providers.

The value added in the chain is allocated according to the flows generated by the following: value of hired labour, financial charges, taxes and levies paid to public organisations, subsidies provided by the government, and net profit. Depreciation is also taken into account but, in this specific study, the value of rented land is not included in the accounting, principally because there are no financial flows associated with this for the main actors in the chain. For most small and medium-scale producers, the egg production units are located on residential premises for which specific land rental attributable to the operation is not directly charged. The large-scale operators also do not tend to pay land rental as the units are cited on owned land. Other issues which are addressed from this analysis are the rate of integration of the egg value chain into Zambia's economy and the viability of the chain within the global economy.

3.3.1 Contribution of egg value chain to GDP in Zambia

Total value added in the egg value chain in Zambia in 2015 is about ZMW 1.71 billion (equivalent to €151.7 million). The direct value added is estimated at ZMW 1.54 billion (equivalent to €137.0 million) and indirect value added (contribution from suppliers) is estimated at ZMW 165.45 million (€14.7 million). The total value added in the egg value chain constituted 13.6% of agricultural GDP in Zambia in 2015. This figure is almost double the contribution of fisheries and aquaculture and 1.2 times the contribution of forestry and logging.

	At production						Others		TOTAL
Item	Small-scale	Medium (deep litter)	Medium (deep litter with DOC)	Medium (battery)	Large-scale (10-100,000 birds	Large-scale (200,000 plus)	Point of lay producers	Traders	
Total production	66,841,000	60,515,000	48,253,000	44,334,000	521,553,000	773,618,000	59,797,000	817,622,000	2,392,533,000
Imported IGS	3,887,700	3,382,400	2,658,300	2,446,000	20,779,000	26,816,000	14,357,000	7,263,000	81,589,400
Remaining IGS	44,875,300	29,656,600	15,999,700	13,336,000	102,712,000	113,352,000	17,251,000	429,350,000	766,532,600
Hired Labour	7,295,500	9,345,900	6,746,900	3,806,000	11,374,000	10,076,000	1,253,000	18,345,000	68,242,300
Financial charges	0.00	0.00	7,939,000	6,884,000	46,655,000	39,007,000	8,775,800	15,212,000	124,472,800
Depreciation	0.00	2,377,800	2,060,000	2,675,000	46,655,000	58,510,000	2,551,200	10,628,000	125,457,000
Taxes	29,000	25,300	20,100	822,000	20,408,000	25,875,000	660,000	38,804,000	86,643,400
Net profit	10,753,500	15,727,000	12,829,000	14,365,000	272,970,000	499,982,000	14,949,000	298,020,000	1,139,595,500
Value added	**18,078,000**	**27,476,000**	**29,595,000**	**28,552,000**	**398,062,000**	**633,450,000**	**28,189,000**	**381,009,000**	**1,544,411,000**

Table 3-3: Summary of values of production and value addition by eggs/POL producers and traders in Zambia in 2015 (in ZMW)

Item	DOC producers	Feedstock producers	Veterinary products suppliers	Transporters	Maize suppliers	Soya suppliers	TOTAL
Total production	27,012,000	66,000,000	15,253,000	35,900,000	91,392,000	80,160,000	315,717,000
Imported IGS	8,103,000	13,200,000	3,589,000	10,770,000	33,320,000	20,875,000	89,857,000
Remaining IGS	4,821,000	19,618,000	2,801,000	1,770,000	16,730,000	14,671,000	60,411,000
Hired Labour	1,891,000	6,600,000	1,794,000	8,975,000	19,040,000	20,875,000	59,175,000
Financial charges	4,052,000	9,900,000	3,589,000	5,385,000	9,520,000	12,525,000	44,971,000
Depreciation	1,750,000	3,300,000	762,000	1,795,000	2,284,000	2,004,000	11,895,000
Taxes	2,343,000	3,482,000	922,000	3,615,000	2,881,000	2,530,000	15,773,000
Net profit	4,052,000	9,900,000.00	1,796,000	3,590,000	7,617,000	6,680,000	33,635,000
Value added	**14,088,000**	**33,182,000**	**8,863,000**	**23,360,000**	**41,342,000**	**44,614,000**	**165,449,000**

Table 3-4: Summary of values of production and value addition by suppliers to eggs producers in Zambia in 2015 (in ZMW)

Item	Direct value added for VC actors	Indirect value added for VC actors	Consolidated value added for VC actors
Total production	2,392,533,000	315,717,000	**2,708,250,000**
Imported IGS	81,589,400	89,857,000	**171,446,400**
Remaining IGS	766,532,600	60,411,000	**826,943,600**
Hired Labour	68,242,300	59,175,000	**127,417,300**
Financial charges	124,472,800	44,971,000	**169,443,800**
Depreciation	125,457,000	11,895,000	**137,352,000**
Taxes	86,643,400	15,773,000	**102,416,400**
Net profit	1,139,595,500	33,635,000	**1,173,230,500**
Value added	**1,544,411,000**	**165,449,000**	**1,709,860,000**

Table 3-5: Consolidated direct and indirect value added for actors/suppliers in eggs value chain in Zambia in 2015 (in ZMW)

As shown in Table 3-6 and further illustrated in Figure 3.6, the bulk of the value added, about 60%, is generated by large-scale egg producers. Together the medium-scale and small-scale egg producers contribute about 6.1% of overall value added in the chain. The contribution by the egg trade to value added in the trade is quite sizeable. It is estimated at 22.1% and is exceeded only by the contribution by the large-scale egg producers. This segment of the chain is also dominated by informal wholesalers and community-based retailers as the share of formal traders, including the supermarkets, is limited to about 10-15% of the domestic trade in eggs. The aggregate contribution of maize and soya suppliers in the form of the grains utilised in formulating feed for the birds is about 5%. The other players in the chain make up the remaining 6.5% of value added.

Value chain actor	Share of value added (%)
DOC producers	0.8
Point of lay producers	1.6
Small-scale egg producers	1.1
Medium-scale egg producers	5.0
Large-scale egg producers	60.3
Egg traders (formal/informal)	22.1
Feedstock producers	1.8
Veterinary products suppliers	0.9
Transporters	1.4
Maize suppliers	2.4
Soya suppliers	2.6
Total Value Added	100.0

Table 3-6: Contribution of players to value added in egg value chain in Zambia (2015). Source: Authors

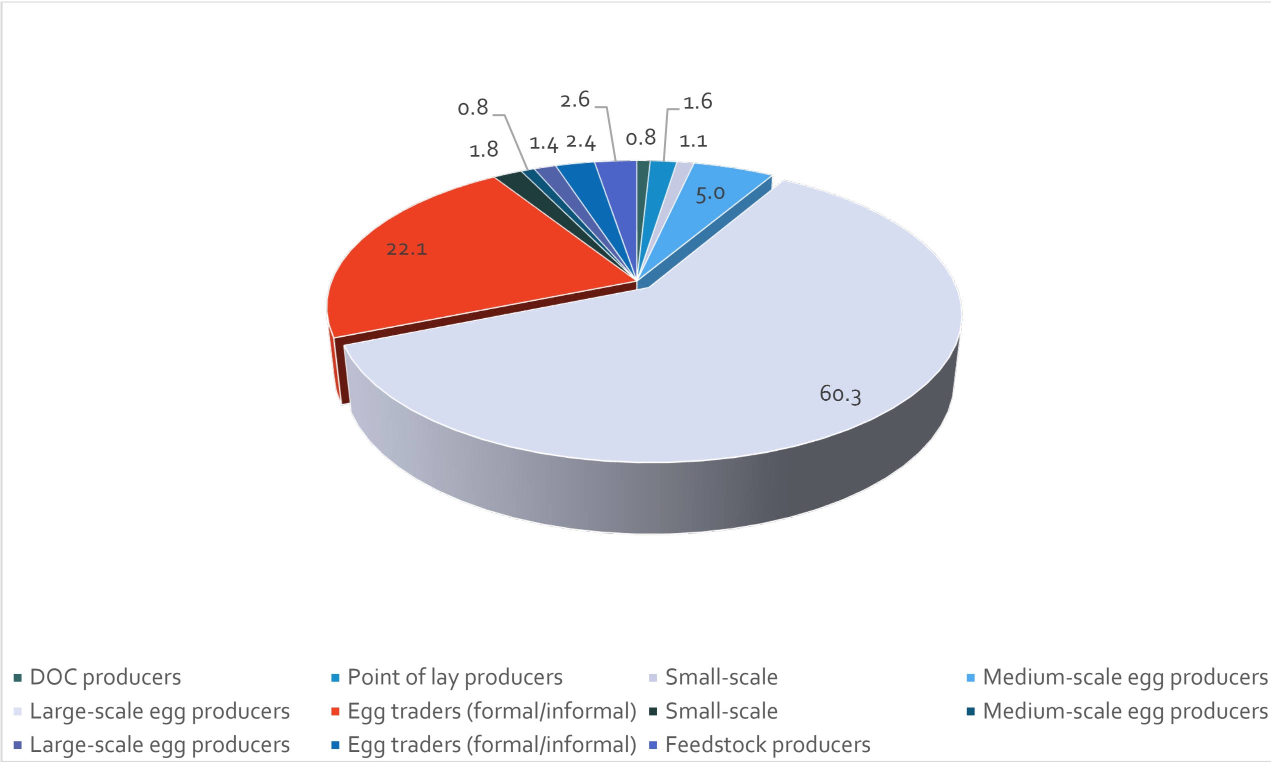

Figure 3.4: Contribution to various players to value added in Zambia's Egg Value Chain, 2015 (%)

Source: Authors

Figure 3.5 shows the breakdown of value added in the egg value chain. Net profit or income to players in the chain is by far the largest proportion of the value added, about 69%. Financial charges and depreciation together represent 18% of the value added, whilst taxes and council levies account for 6%. Only 7% of the value added is allocated to hired labour. This is an indication of rather low labour-intensity of the chain. This is in contrast with the agriculture sector in the country in general, which despite contributing only 8.1% of GDP employs over 70% of the labour force – a situation which, as argued by (Mulungu and Ngombe 2017) makes the sector "a repository to which labour goes when it cannot find income elsewhere". Furthermore, the buoyant growth, which the chain and the poultry industry in the country as a whole has experienced, places it in a strategic position drive sustained economic growth, in especially the grains subsectors. In particular, the fact that is absorbs about 35% of soya produced in Zambia (about 87,300 tonnes) suggests that growth in the egg value chain can sustain increased output of the crop, thereby enhancing the capacity of farmers to diversify beyond maize production – a policy objective of GRZ.

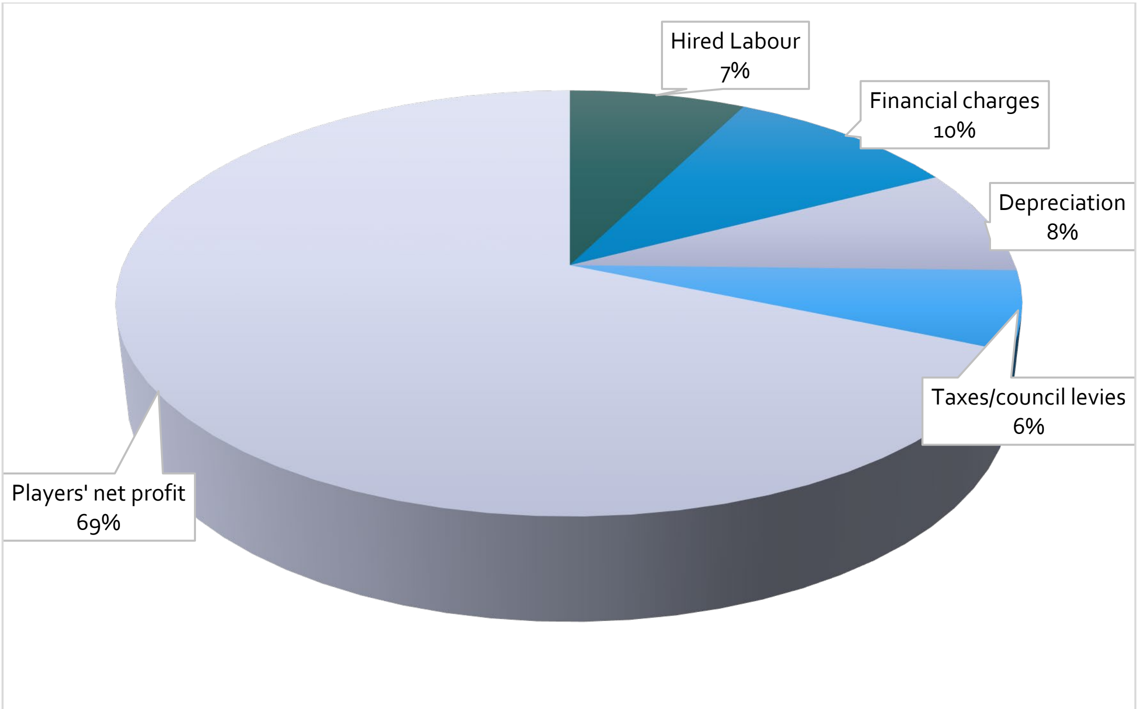

FIGURE 3.5: ALLOCATION OF VALUE ADDED IN EGG VC IN 2015
SOURCE: AUTHORS

The distribution of net profit or players' income is skewed in favour of the predominant egg producers, the large-scale producers as depicted in Figure 3.6 below. The share of net profit received by this category of producers about 66%. The egg trade has a rather large share of the income generated but, it has to be noted that this share is distributed among a large number of players, including over 18,000 micro-retailers in especially the low-income, high-density communities in urban areas. The share received by medium-scale egg producers is about 4%, whilst small-scale producers obtain only 1% of the net profit generated in the chain. DOC and POL producers as well as feedstock manufacturer and other suppliers/service providers together share the remaining 4% of the net profit generated in the egg value chain.

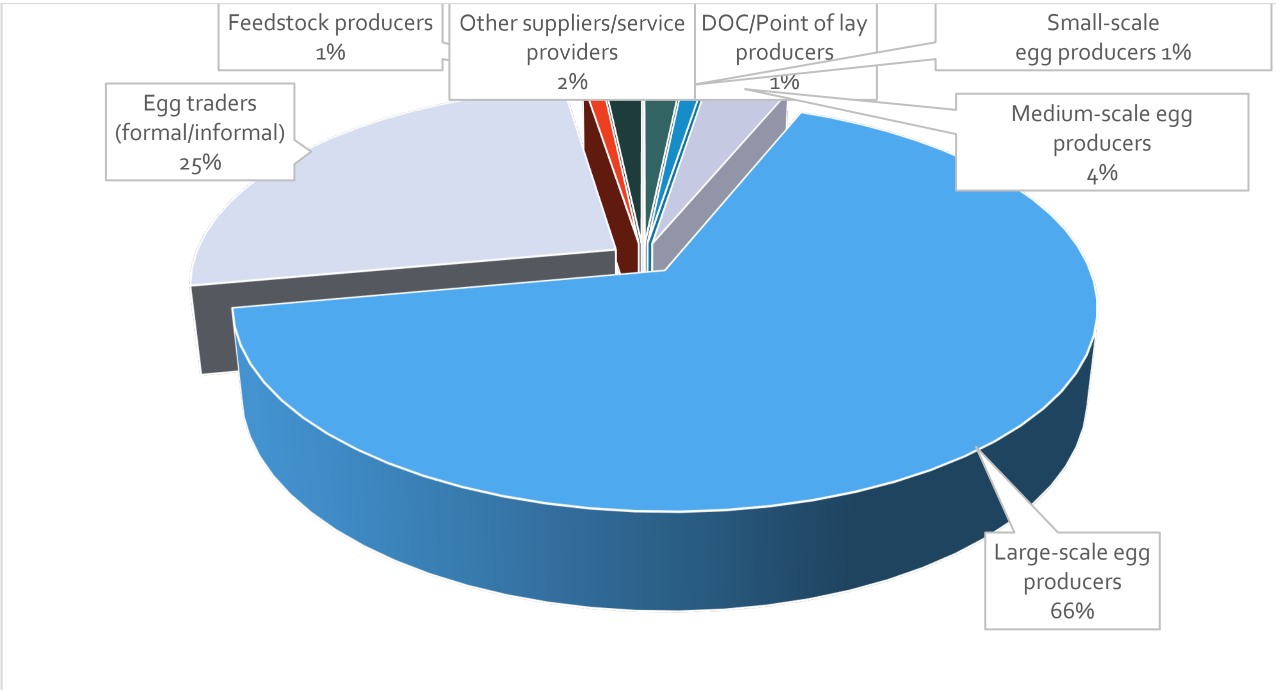

FIGURE 3.6: DISTRIBUTION OF NET PROFIT IN EGG VC IN 2015
SOURCE: AUTHORS

3.3.2 Contribution of egg value chain to public finances

The egg value chain contributed an estimated ZMW 102.4 million (approximately €9.1 million) to Zambia's public finances in 2015. No subsidies are provided directly to any of the egg producers as well as suppliers and traders. This contribution is relatively low, only 0.3% of overall domestic revenue generated by GRZ in 2015, which is estimated at ZMW 34.2 billion by Bank of Zambia (BOZ)[29]. The contribution of players in the egg value chain to the finances of local government authorities may be rather more significant. In 2015 players in the chain paid a total of ZMW 13.9 million (€1.24 million) as council levies. We demonstrate the importance of this contribution citing the case of the Lusaka City Council. According to a report of Zambia's Auditor General, in 2015 the City Council (LCC) mobilised a total of ZMW 18.0 million (€1.59 million) in levies. Taking into account the concentration of the egg value chain in the Lusaka and Copperbelt Provinces, we estimate that at least 40% of the total levies paid by the chain players would have been paid to the LCC. This will imply that close to 30% of levies generated by the Council is paid by various players in the egg value chain. It is noteworthy that most local government authorities in the country have major revenue mobilisation challenges (Chulu 2014). Hence, a relatively more formalised chain, such as the egg value chain, will ease the collection of levies and enhance the capacity of councils to offer required services.

An observation made by the team during field interaction with especially the small and medium-scale egg producers is that most of these producers fail to reclaim value added tax (VAT) on supplies such

29 Source: Bank of Zambia Annual Report, 2016.

as formulated feed and veterinary products. It is estimated that altogether they may be foregoing VAT refund to the tune of about ZMW 7,952,000 (€705,590) per annum. The large-scale producers are able to claim the requisite VAT refunds from the revenue authorities.

3.3.3 Contribution of egg value chain to balance of payments

From available data, foreign exchange generated from export of table eggs from Zambia in 2015 is estimated at ZMW 205.1 million (€18.2 million). The total value of imported intermediate goods used in the value chain is estimated at ZMW 171.4 million (i.e. €15.2 million), meaning that the chain generated net foreign exchange proceeds of ZMW 38.0 million (i.e. €3.0 million) during the year under review. Though BOZ does not even report foreign exchange generation from export of eggs, it is evident from Table 3-7 that the contribution to balance of payments is higher than other more recognised non-traditional agricultural export products such as horticultural products.

Commodity/product	Value of export revenue (€ million)
Maize and maize seed	175.0
Cane sugar	118.7
Burley tobacco	85.0
Cotton lint	43.8
Table eggs (from study)	18.2
Fresh (cut) flowers	10.8
Fresh fruits and vegetables	10.1
Raw hides, skins and leather	10.1
Wheat and Meslin	9.7

Table 3-7: Major agricultural and related non-traditional exports from Zambia (2015)
Source: Based on Bank of Zambia (2016) data reported in US dollars.

There are very good prospects for significant rise in the capacity of the chain to generate foreign increased foreign exchange inflows. On one hand, this is because egg production capacity in areas close to the regional export markets is increasing, especially in the Copperbelt. Second, demand within the regional markets could far exceed current levels of export. For instance, as noted in Section 2.5.3, unmet demand in DR Congo could reach over 340 million eggs per year if per capita consumption in the Katanga Province reaches about 60% of current levels in Zambia. This will mean the potential to generate over €20 million from export of table eggs to DR Congo. Some of the large-scale producers consulted, who are planning capacity expansion in the medium-term, are also looking to other markets such as Angola.

3.3.4 Sustainability of egg value chain in global economy and integration in Zambia's economy

Based on the standard methodology for the study, the domestic resource cost (DRC) ratio in the chain was computed to assess the extent to which it depends on imported inputs and as an indication of its viability within the global economy. The DRC is calculated by dividing the sum of domestic production factor costs by the total output of the value chain minus tradable inputs (i.e. imported inputs). Farm family labour is assigned an opportunity cost of zero in this case and land value is also not included because, as noted above, for most of the players land is not rented.

The DRC for the egg value chain in Zambia is 0.17, which is well below unity (i.e. <1), and indicates that the value chain is viable within the global economy and Zambia has comparative advantage in the production of table eggs. Evidence on the extent to which the egg value chain in Zambia is integrated into the local economy is assessed by computing a coefficient which involves dividing total value added in the chain by the value of total production. The result, which is 0.67, indicates that the chain is well integrated.

3.4 Assessment of growth inclusiveness of the egg value chain in Zambia

Table 3-8 and Figure 3.7 show that the bulk of income generated in the egg value chain in Zambia, which is estimated at 45%, accrues to large-scale egg producers. Small/medium-scale producers together receive just over 3% of the income generated. Employment generation is, however, higher at the lower levels of the scale of production, especially among small-scale producers, as discussed below.

Value chain actor	Amount (ZMW)	Share of income in chain (%)
DOC/Point of lay producers	19,001,000.00	1.11
Small-scale	10,753,500.00	0.63
Medium-scale egg producers	42,921,000.00	2.51
Large-scale egg producers	772,952,000.00	45.21
Egg traders (formal/informal)	298,020,000.00	17.43
Feedstock producers	9,900,000.00	0.58
Grain suppliers/service providers	19,683,000.00	1.15
Workers' wages	127,417,300.00	7.45
Banks' income (interest/other charges)	169,443,800.00	9.91
Depreciation	137,352,000.00	8.03
Government taxes/levies	102,416,400.00	5.99
Total	1,709,860,000.00	100.0

Table 3-8: Distribution of income (value added) generated in Zambia's egg value chain (2015) Source: Authors

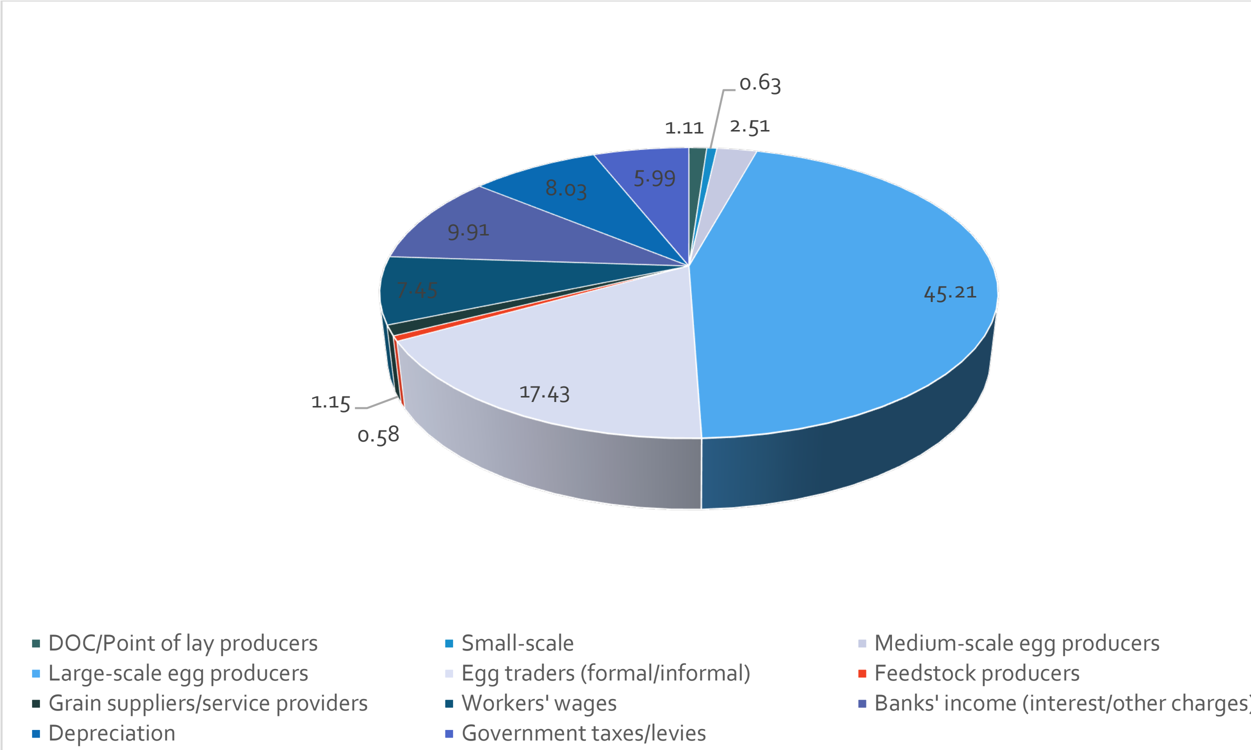

TABLE 3-9: DISTRIBUTION OF INCOME IN EGG VALUE CHAIN IN ZAMBIA (2015)

The evidence above may suggest that the chain is not inclusive, favouring principally the large-scale producers. Their competitive edge is attributable to the more cost-efficient production technology they can afford to utilise as well as their capacity to bargain for highly favourable trade credit from suppliers. In addition, they exert highly significant influence on the price of table eggs in the domestic market. For instance, the wholesale price per tray, which was ZMW 23 per tray in 2015, has remained unchanged largely because it is set by the large-scale producers. All other prices in the market, including retail prices at the community level, are set around this benchmark.

It is at the table egg trading level that the egg value chain becomes most inclusive, receiving over 17% of the total income generated in the chain. This income is well-spread among over 500 “wholesalers” (mainly small-to-medium-scale middlemen) and an estimated 18,000 micro-retailers. The “wholesalers” are not the typical relatively well-capitalised traders in other commodity and consumer items trade. Start-up capital for these range from ZMW 7,500 (€665.00) to ZMW 11,250 (close to €1,000.00). This is often generated through micro-retailing of various produce in the main urban markets. The “wholesale” trade is dominated by men but the retail and, especially micro-retailing in the communities, is dominated by women.

Though benchmark prices are largely determined by the large-scale producers, the medium and small-scale producers are able to compete due to proximity to the large informal market players. For instance, most of the medium-scale producers sell to community-based wholesalers and retailers at ZMW 2-3 per tray because those buyers avoid the higher cost of transport when they buy from intermediaries in the main markets. For similar reasons, small-scale producers tend to sell directly to micro-retailers in the communities at a price which is about ZMW 4-5 per tray higher than the wholesale price. There is gender diversity among the small and medium-scale producers, often involving households but with women in control of the enterprise. As noted in the social analysis, the involvement of the medium-scale producers has broader welfare implications as many of the investors at this level are professionals who see this investment as a form of retirement income source. They are reported to be able to sustain remittances to the extended family even in retirement as a result of income from this type of investment.

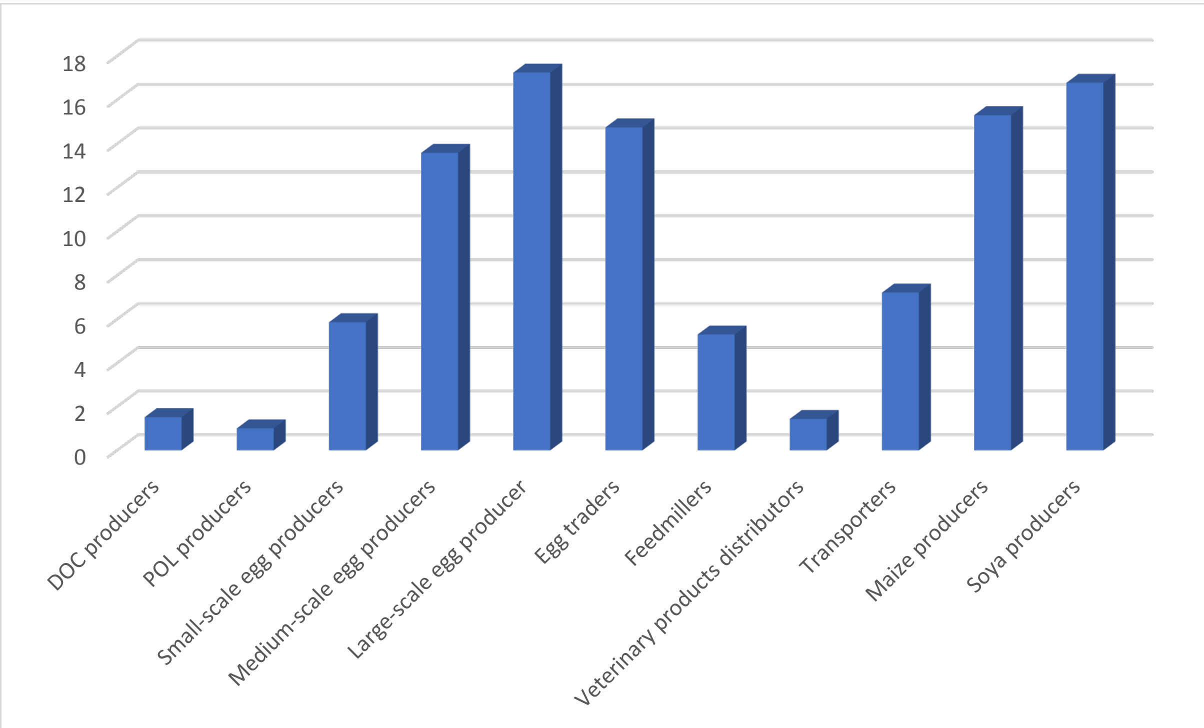

FIGURE 3.7: DISTRIBUTION OF HIRED LABOUR INCOME IN ZAMBIA'S EGG VALUE CHAIN (2105)

Hired labour income appears to be evenly distributed across the egg value. Large-scale egg producers lead in spending on hired labour but their spending share of 17% of total workers' wages is far less than their share of production, which is estimated at 87%. In contrast, medium-scale producer account for only about 8% of production capacity yet spend about 13.5% of total wage income in the chain. It is therefore apparent that growth in the medium-scale producer segment of the chain can generate higher levels of increase in wage income than at the large-scale level. Furthermore, overall growth in the egg value can exert significantly positive wage income effects in the maize and soya subsectors.

Enhancing competitiveness at the level of medium-scale egg producers appears to be a strategy which can ensure more inclusiveness at the level of production. This will require actions which can improve their access to quality feed ingredients at predictable prices as well as to competitively-priced finance.

3.5 Going forward: potential drivers of inclusive growth in egg value chain in Zambia

Generic growth within the egg value chain is anticipated in the medium-term due to demand drivers in the domestic and regional export markets. In the domestic market, it is anticipated that GLL's role in setting market prices as a result of its dominance will continue to boost demand within urban poor households. Stability in DR Congo and opening up of other regional export markets will also sustain rising demand for table eggs from Zambia. This is particularly because the competitiveness of the egg value chain in the country will enable it maintain a strong presence in the regional markets. DR Congo is, for example, dependent on imports of maize and soya from Zambia and South Africa and will therefore not be in a position to rapidly enhance the competitiveness of its egg value chain relative to that of Zambia. To achieve the apparent growth potential some issues identified below need to be addressed.

3.5.1 Exchange rate appreciation and volatility

As illustrated in Figure 3.8, the exchange rate of the Zambian Kwacha (ZMW) against major currencies including the US Dollar and Euro, was volatile during the latter part of 2015. In 2016, however, in addition to volatility the currency also appreciated. The rate of appreciation in 2016 is estimated at 18% by BOZ. Owing to the fact that the dependence of the chain on imported intermediate goods is low, as discussed in Section 3.3.4, the impact of this volatility on the operations of producers is likely to be minimal.

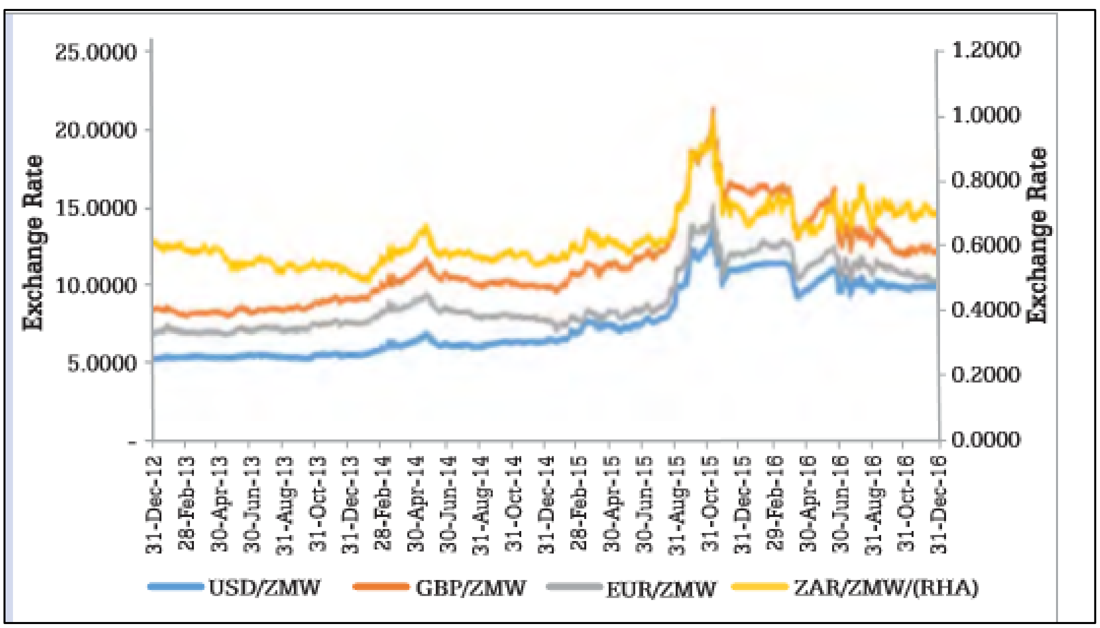

Figure 3.8: Exchange rate ZMW against major currencies (2012-16)

Source: Bank of Zambia (2016)

However, a major exchange rate risk is that of the appreciation of the local currency. This is particularly relevant to major producers such as GLL which have taken foreign currency-denominated facilities. Active involvement in the export of table eggs eases servicing of these facilities. However, appreciation of the domestic currency can reduce inflows and create challenges in meeting financing obligations. This challenge is macro in nature and affected players will find it difficult to manage on their own. Maintaining macroeconomic stability will help mitigate this particular risk.

3.5.2 Domestic supply of major feed ingredients: managing price shocks

Integration into the domestic economy carries with it the risk of rising inflation squeezing producer margins and impacting negatively on the operations of value chain actors. In particular, severe spikes in the price of feed ingredients such as maize and soya, can exert significant growth-reducing effects as discussed in Section 2.2 of this report. One means by which many of the large-scale producers are attempting to mitigate supply uncertainty and price risk is to pursue backward integration involving cultivation of maize and soya. GLL has also been involved in a pilot outgrower scheme under which it can secure supply of soya.

The main drawback the team found with the pilot, described in Box 2.2, are the delivery terms for the participating smallholder farmers. They are supplied with inputs on credit and are required to repay in the form of soya with the volume delivered being determined by the producer price at harvest. In a deficit season when producer prices at harvest are high as occurred in 2015/16, the effective cost of servicing inputs credit for farmers is relatively low (volume delivered to repay is low). NGHL officials consulted during the study confirmed this, stating that during the harvest in May 2016 most of the participating farmers repaid inputs credit for both soya and cotton with the delivery of soya. However, during the harvest in May 2017 producer price for soya virtually collapsed. According to ZAMACE the producer price per tonne was US$265.00 but field reports indicated that it was even lower, about US$200 per tonne. Data from ZAMACE suggest that it was only during the harvest season in 2006 that soya producer prices were that low.

The situation can potentially increase the risk of side-selling leading default in repayment of inputs credit and undermine sustainability of the outgrower scheme. However, the promoters perceived this risk as low since participating farmers obtained higher yields than non-participants. It is our view that introducing greater flexibility in delivery/repayment terms will enhance sustainability of the scheme and for that reason propose the following:

a. Where producer price at harvest are sufficiently remunerative, farmers can repay at harvest; and

b. If not the deliveries can be made at harvest but stocks collateralised and sold when market prices recover. Even in the 2017/18 marketing season when prices collapsed, they have recovered and as at the end of February 2018, the price per tonne reported by ZAMACE was US$405. Stocks held over the 8-month period would have incurred carrying cost[30] estimated at US$65 per tonne. Increased income per tonne due to the price rise is almost US$140, implying an incremental income of US$75 per tonne, equivalent to 28% of the producer price at harvest. Such an option will not only be more attractive financially to participating farmers but it will also allow NGHL to re-finance inputs credit if the stocks are held in ZAMACE-certified storage facilities.

3.5.3 Enhancing competitiveness through improved distribution system

One of the main challenges facing producers is how to reach retailers in the communities on a cost-efficient basis. The outcome of the BOP model piloted by GLL has been successful as proof of concept. It is evident that the system is financially sustainable as illustrated below:

- Extra margin charged for delivery to micro-retailers (ntemba) = ZMW 3-5/tray, which is equivalent to a minimum of ZMW 240 (i.e. €21.30)/day for delivery of 80 trays per day;
- Commission per day for rider, assuming 24-day month is equivalent to €5.0;
- Leaving projected margin of €16.30 per day – which we project is more than sufficient to cover amortisation of the cost of the bicycle and other operating costs.

The example can be replicated by other large-scale producers but as viability has already been demonstrated and start-up costs are unlikely to be high, there can be no justification for subsidising this investment. This is particularly because small/medium-scale producers are unlikely to invest in such a system as they take advantage of their proximity to the micro-retailers and community-based middlemen to sell at prices which incorporate a similar margin of ZMW 3-5 per tray.

3.5.4 Access to finance

Access to finance for capital investments in improved housing and cost-efficient production technology as well as working capital is a challenge for most players in the egg value chain. Interest rates remain high in the domestic money market and the local capital market involving the Lusaka Stock Exchange is rather thin. The main source of finance is therefore banks, which are reluctant to lend to players in the agricultural sector largely because of the perception of high risks in the sector in general. The perception is reinforced by a report asset quality within the banking industry in Zambia. According to BOZ (2016) though the share of credit allocated to agriculture allied sectors was 17.3% of the total, its proportion of non-performing loans during that year was 20.8%.

It is evident that the financing obtained by GLL from the AAF has proved critical in enabling it to expand and establish itself as a dominant market leader. The company was able to cope much better than most during the downturn in 2016 partly because it had been able to invest in a highly efficient production technology. Interestingly, some of the large-scale producer see the investment as having

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[30] Carrying cost is the cost of storage (fees) plus any financing cost. In this example we have assumed financing at 80% of the value at harvest and at prevailing interest rate of 32% per annum.

demonstrated the capacity of the major players to effectively utilise competitively-priced offshore financing. Some are considering this option as they plan significant scaling up of operations.

To enhance the competitiveness of medium-scale egg producers and therefore ensure inclusiveness at the level of egg production, they will require finance to invest in improved technology, some as basic as enabling them to shift from deep litter to battery production. They also need better access to quality feed ingredients at predictable prices. As noted, the capacity of both medium and small-scale producers to absorb major price shocks in the maize and soya markets is quite limited. There was consensus among stakeholders consulted that government interventions to moderate price hikes for these commodities, including *ad hoc* bans imposed on exports tend to only compound market uncertainty. One option will be to promote the use of ZAMACE-certified storage infrastructure to build up inventories in order to secure access and also mitigate price volatility. This opportunity needs to be further explored for the benefit of this category of producers as well as other stakeholders. It will also be worthwhile to explore how innovative financing packages supported by governments, such as the Nigeria Incentive-based Risk Sharing System for Agricultural Lending (NIRSAL). Under this system the government of Nigeria offers loan guarantees to encourage banks to lend to players in the agricultural sector. Borrowers are required to take up insurance cover against insurable risks, including against weather risks. They are also entitled to substantial rebates on interest paid in order to reduce the cost of borrowing. However, this incentive regime kicks-in only when borrowers repay loans. These options need to be further investigated.

4. THE SOCIAL ANALYSIS

4.1 Introduction

The social analysis of the Zambia Egg value chain (VC) encompasses a wider span than the economic and environmental analysis, which focus more in-depth for the egg producers and traders. Three main segments of the egg VC are identified: 1) small-scale production and sale of soya and maize the main layer feed inputs (including the suppliers of services to small-scale farmers); 2) commercial production and distribution of table eggs for the urban and export markets (including the local suppliers of services to egg farmers); and 3) the retailers, purchasers and consumers of table eggs and soya products in high density urban areas. The social analysis of commercial egg production takes account of different scales of production, but differentiates between fewer categories, as the main differentiation in the social factors is between family based enterprises of small to medium scale which involve modest levels of investment contribute to family income and provide limited employment on the one hand, and on the other hand commercial enterprises of large or very large scale which require substantial investment, provide substantial incomes and profits, and provide a wider range of employment opportunities.

The analysis addresses questions relating to the social sustainability of the egg VC and its inclusiveness. With regard to social sustainability, the framework differentiates six basic domains: working conditions, land and water rights, gender and social inclusion, food and nutrition, social capital, and living conditions.

The qualitative data was analysed using content analysis, while the focused survey of egg and soya consumption was analysed using SPSS. Findings are presented which summarise an exploration of the two main research questions and the specific questions under each of the six social domains of inquiry.

Respondent Gender	Respondent age group					Total
	16-20	21-30	31-40	41-50	Above 50	
Male	7	18	23	10	1	59
%	12%	31%	39%	17%	2%	
Female	40	26	12	9	4	91
%	44%	29%	13%	10%	4%	
Total	47	44	35	19	5	150

Table 4-1: Formal Survey Egg and Soya consumption - Respondents Gender by Age group

4.2 Overall social analysis research questions:

The two over-arching research questions which are addressed together, though answered separately are:

a. Is the Zambia Egg value chain socially sustainable? and
b. Is economic growth in the Zambia Egg value chain inclusive?

In addressing these questions more broadly, it is helpful to differentiate between three distinct segments of the Egg VC which are:-

1. small-scale production and sale of soya and maize the main layer feed inputs (including the suppliers of services to small scale farmers);
2. commercial scale production and distribution of table eggs for the urban and export markets (including the suppliers of services to egg farmers); and
3. the purchase and consumption of table eggs and soya products in high density urban areas.

Following a social analysis of these three segments of the Egg VC, a more detailed analysis of the social sustainability of the egg VC in relation to each of the six domains of the social profile is provided.

4.2.1 Small-scale production of soya and maize segment

In this segment of the Egg VC, the production of soya and maize is embedded within rural livelihood systems in which single season rainfed crop production is the principle source of both income and food for most rural households. These households rely mainly on family controlled labour and land, typically have limited cash available for investment in agriculture, and often have limited access to markets and technical services, although access has been improving as a result of both private investment and publicly funded initiatives. Rural small-holders are typically constrained by cash and labour shortages during peak periods. When growing soya and maize, shortage of cash places greater reliance on credit to secure farm inputs, while shortage of labour places increased reliance on purchased inputs which reduce labour demands, particularly herbicides and also fertilizers. This scenario raises the risks of financial loss and indebtedness for small-holder producers in years when producer prices are low, or when climatic conditions are unfavourable.

Inclusivity

This segment has been significantly inclusive, with a fourfold increase of small-holders, of both genders, involved in soya production in the five years prior to this study; from 42,000 (3.5%) in 2011/12 to 202,000 (15%) in the 2016/17 season[31]. There is considerable scope for greater inclusion of small-holders in viable soya production, particularly if some of the current barriers are addressed. The main barriers which can be addressed in the short to medium term are: limited access to inputs[32], particularly inoculum; quality of technical advice for households with resource limitations; and

31 Calculations is based on the analysis of original data from Ministry of Agriculture and Livestock and Central Statistics Office Crop Forecast Surveys (for small and medium scale holdings) for this period

32 Hichaambwa, M. et al., (2016) found that in two districts of Copperbelt Province, with relatively good rural infrastructure and services, the main production challenges faced in soya production were availability of inputs (including certified seed) and spraying services.

availability and quality of technical advice on household utilisation and value addition activities for soya.

Opportunities for of women in input supply and marketing support to small-scale soya producers have increased through more widespread uptake of the "aggregator" model. While gender disaggregated data on this was not accessed, limited enquiries suggests that this model has successfully included a number of mature women (often widows) who are well regarded and trusted within their local communities.

Social Sustainability:

Working conditions: family labour predominates, with an increasing proportion of households hiring labour for the most demanding tasks during soya production, including crop spraying, harvesting and threshing. Labour is usually paid for in cash, or in kind (often grain). The rates (either a daily rate or a piecework rate) are locally agreed between the two parties and usually the same for a local area. As labour is usually provided by neighbouring households, it is common for longer relationships of inter-dependence to be sustained over time. Local youth are involved in small-scale soya production, young males usually as providers of labour, including higher risk work such as land clearing and crop spraying. Younger men mostly lack the financial and social capital necessary to launch into profitable crop production enterprises in their own right. Younger women are generally expected to marry and farm under the supervision of their husband under a system of social reproduction which has functioned in much of Zambia rural for several decades, and is in this respect social sustainable[33]. As small-scale soya producers are technically "self-employed" their effective working conditions are also impacted by pricing decisions and contract conditions over which they have limited influence. For example, the high price of certified seed (particularly for soya) poses a risk of default on seed loans when the small-holder is locked into a contract which requires pay-back of the loan in kind after harvest, when prices are usually lowest. If the soya seed on loan arrives late this poses a further risk to sustainable self-employment in the Egg VC for small-holder soya producers.

Land and Water Rights: Access to land and water by small-scale farmers growing soya and maize is typically gained through membership in a local community through customary land tenure arrangements which have proved to be social sustainable for the previous 100 years. However there are forces in play which undermine the social sustainability of customary tenure systems in the longer term. These include increasing commercialization of agriculture, increasing rural populations competing for available land and the introduction of land title registration measures which allow conversion of customary land to individually held land. Particularly in rural areas of higher population density practicing cash cropping, the uncertain profitability of small-scale farming can encourage sale

33 In Northern Zambia a system of "matri-local" marriage was traditionally practiced, in which a man married in the village of his wife and started farming under the supervision of her older relatives, before moving back with his wife to his relatives after he has proven himself. This system has been gradually declining since the 1950s and is now relatively uncommon.

of family land by older family heads, limiting the amount of family land available for the next small-scale farming generation.

Gender equality: Within rural households, the gender norm that the man is responsible for making the main decisions relating to crop production and marketing of grain, continues to influence household decisions. The norm is that the husband decides how much maize and soya to plant, which inputs to get on credit and how much of the harvested crop to sell. In some households these decisions are made unwisely, or selfishly, and not in the best interests of the whole family. For example if a husband is over-ambitious and takes a large input loan and is not able to manage the crop well, or sells grain at low prices to get cash to buy things for himself and runs down the household grain store so that the household runs out of grain long before the next harvest. Such gender dynamics significantly increase the vulnerability of married households in relation to potential debt and food insecurity and their potential for sustainably going into soya production.

Food and nutrition security: Sustainable household level food security risks related to land rights and gender norms have been identified above. With regard to nutrition even though rates of infant malnutrition in many rural areas are a significant issue, many households grow soya purely as a cash crop, using local purchased seed without inoculum, or expensive seed (with or without inoculum), and remain uninformed about its potential use for infant feeding, as a household food and also other value adding options. Particularly during seasons when prices are low, such households face significant risks and vulnerabilities. There is also a risk that an increase in the herbicide based mono-cropping of cash crops, will result in a reduction in the area planted to traditional household food crops, particularly cucurbits (pumpkins, squash, cucumbers) and food legumes (cowpeas, kidney beans, velvet beans) which were traditionally intercropped with cereals. With suitable investment in programmes to manage these risks there is therefore scope for further increasing the inclusiveness of this segment of the Egg VC.

Social capital: While the rural households growing soya and maize are somewhat resilient, having developed coping strategies involving building up social capital within their local communities to manage the significant risks associated with small-scale cash cropping, this has been a protective strategy, helping to limit the effects of external shocks. Building social capital based on sustainable business relationships with service providers is still largely embryonic. Risks remain for both small scale producers and those supplying them with services, relating to the development of sustainable business relationships and the development of a level of mutual trust required for such relationships. The risks for the small-holder grain producers relates to indebtedness (not being unable to pay back loans), food insecurity and/or financial loss. The risks to the service providers include un-recovered loans, and uncertain future demand for goods and services. A short-term approach to business relations is currently widespread among many small-scale grain producers, some input providers, and most grain traders. This is taking place alongside national policies aimed to keep urban food prices low (i.e. policies relating to the operation of grain markets and exports, targeted agricultural subsidies to small-holders as part of social protection measures which are often mediated by political party affiliations.. The result is a situation in which the small-scale households growing soya and maize remain marginalized and largely players, with very limited voice and influence in this segment of the Egg VC.

Living conditions: the living conditions for small-scale soya and maize producers have been gradually improving overall over the past decade, on a generally sustainable basis. The steady economic growth at national level and continued support from international donors has allowed continued investment in publicly funded health and education services which extend into rural areas. Rural water supply and sanitation programmes funded jointly by government and donors have improved this aspect of living conditions in the targeted districts, including districts where small-holder soya and maize are grown. These services are not notably affected by the egg VC, and remain sustainable as long as the economic continues to grow and public services are sufficiently funded and effectively managed. Vocational training, particularly for the rural youth, remains a relatively neglected area by the public sector in rural areas, with patchy initiatives mostly funded by charitable initiatives. Improvements to rural housing has largely been by families from various sources including remittances from relatives in urban employment. In years of good harvest and higher grain prices improvements to rural housing and household level water supply and sanitation (through investment in digging of wells and pit latrines) have been enabled through crop sales, including sales of soya.

4.2.2 Commercial scale egg production segment

Social Inclusion

The decade from 2005 to 2015 saw a major and steady increase in the volume of eggs produced and the number of players involved. This included an increase in employment opportunities[34] for semi-skilled and unskilled employees. These could be working on egg farms, working in the poultry feed production, distribution and supply outlets, and also working for the agro-dealers providing equipment and veterinary inputs for layers.

A more recent trend, rendering this section of the Egg VC less socially inclusive is increasing capital investment in automated housing for layers and in labour saving equipment, reducing the ration of employees to laying birds, and requiring staff with more specialist skills and knowledge. This segment of the Egg VC, the production of table eggs for sale has increasingly been dominated by a smaller number of larger players using advantages arising from economies of scale, vertical integration and capital investment through externally source finance at low rates of interest. Further investment in automation is also taking place in the feed processing sector, with similar implications for employment opportunities.

34 A recent analysis by the World Bank of job opportunities in the poultry and aquaculture value chains emphasizes the major importance of the poultry feed sector for job creation, rather than poultry (broiler) production (World Bank 2017).

Increasing competition in the poultry feed industry and also in the supply of veterinary products and services, has improved the accessibility and range of products available to producers. This growth and diversification has also widened the range of new opportunities for inclusion in either formal employment, or small-scale business agro-dealer start-ups. While not all of these newer ventures will be financially sustainable in the longer term, due to the pressures of competition and economies of scale, they do provide good opportunities for acquisition of transferable skills and knowledge, and the learning associated starting and building an enterprise. The social costs are risks of job loss for the employees of failed enterprises, and running into debt for the newer entrants. Regarding the impact on youth employment, in the short to medium term this growth is creating more employment opportunities for male youths in the heavier manual tasks and both genders of youths in the retail outlets for feed and veterinary products supplying medium scale and some large-scale egg farms.

The limited capacity of local hatcheries to meet the increased demand for day-old layer chicks since around 2014, resulted in the largest egg farms importing day-old chicks from Europe, and this is continuing. If the capacity of local hatcheries was significantly increased this would create additional employment opportunities, particularly because hatcheries are more labour intensive than egg farms.

While the demand for table eggs remains high, with demand still unmet in some areas, this segment of the Egg VC has also become socially less inclusive in terms of the requirements for new entrants to egg farming. The barriers for new egg farmers are higher now than about 4 years ago. This is due to lower margins, increased competition from established large producers and new large-scale entrants able to access external funds for investment at low rates of interest. In response to rising input prices (particularly feed), reduced demand and low egg prices due to the closing of the DRC border in 2015, many smaller egg farmers either stopped or scaled down their operations during 2015 and 2016. Under the current conditions, the high cost of borrowing from local banks is prohibitive and highly risky for an individual wishing to start up in egg production[35]. The option of keeping a few "backyard" layers, including improved layers, in urban areas remains popular and viable in the lower density urban areas where households have the space. This is not an option for the majority of middle and low income urban households in higher density areas who have a greater need for affordable high quality protein foods.

While the potential demand for eggs in rural areas is high, rural households interested in going into smaller scale egg production lack easy access to the inputs (i.e. equipment, point of lay pullets, feed, veterinary services and technical advice) required to service this local demand. This is an opportunity for social and economic inclusion that could be further explored.

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35 Interest rates cited were in the range of 32-35% per annum, with additional borrowing charges on top, making borrowing to fund capital costs for set-up or to fund expansion of the operation highly risky.

Small-scale farmers (mainly women and children) in the rural areas keep "traditional" breeds of chickens and other poultry under extensive low management systems[36]. The hens produce limited numbers of eggs; the priority being to hatch these into chicks ear-marked for future sale or expansion of the flock – as a "mini-bank". There are a number of initiatives to increase access of poorer farmers in rural areas to poultry, which focus mainly on production of village chicken for sale[37]. This parallel development does not currently pose a source of competition for commercial egg producers, because the various initiatives focus on "village chickens" which are kept primarily for sale to households for the table, rather than for egg production. At present the potential for increasing the production of eggs from hardy cross-breeds, as distinct from producing birds for meat, is receiving limited attention. This could be an opportunity for targeting youth and poorer households in rural areas but no analysis of the potential viability of this as a potential rural micro-enterprise was undertaken in this study[38].

Social sustainability

In relation to the six domains of the social profile, social capital, working conditions and living conditions are most relevant to this segment of the Egg VC.

Social capital in terms of trusting relations between producers is generally low and not very sustainable, either due to a sense of competition and tendency to secrecy between among the larger players, and a relative isolation from other producers among the smaller players. The larger players are better placed to sustain strong links with others in the supply chain, particularly suppliers, and gain inputs on account.

Working conditions are generally social sustainable across the range of egg producers, because producers understand the importance of having employees who are reliable, conscientious and understand their role in the egg production enterprise. For this reason employers aim to keep their staff through contracts (formal or less formal) which are relatively competitive to alternative source of employment. With regard to living conditions, smaller commercial producers are generally more likely to provide housing on the farm, while the largest producers see this as increasing the disease risks for

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36 A 2007 publication estimates that "village chickens" accounted for more than 50% of the total poultry population in Zambia (Phiri et al., (2007).

37 Initiatives to enhance village chicken production reported in national and regional press include: https://www.daily-mail.co.zm/village-chicken-hatchery-unveiled/; and https://www.africanfarming.com/free-range-village-chickens/. The University of Zambia has established the Agricultural Technologies Demonstration Centre (ATDC) which is looking into promoting knowledge on improved village chicken (personal communication with the ATDC Director).

38 There is limited accessible published information on the actual production and consumption of eggs from traditional chickens in rural areas, and what has been validated to increase rural egg production and consumption in Zambia. Unpublished data provided by IAPRI from the 2015 Rural Agricultural livelihoods survey indicates that 87% of rural households keep village chickens and consumed an average of 161 eggs per year and sold an average of 66 eggs per year. Data from a recent study in Tanzania indicates that village chickens contribute 20% of the eggs consumed in rural and urban areas. https://www.sapoultry.co.za/pdf-statistics/tanzania-country-report.pdf. A study undertaken 1990 in Western Province of Zambia demonstrated the viability of keeping hybrid layers under improved conditions in the villages (http://www.fao.org/docrep/U9550T/u9550T0v.htm.).

their operations, and prefer to limit the number of staff living on the farm. The relative profitability of egg production, enable employers to provide health insurance benefits for the higher paid employees, while lower paid employees would usually depend on public health services.

Gender equality in relation to pay and conditions of employment is formally recognised by national legislation. Male domination of most of the jobs in this segment is attributed by owners and employers to the physical demands of the work for the lower paid roles, and to the lack of suitably trained and experienced applicants for the higher paid management and specialist roles.

4.2.3 Small-scale trading and consumption of eggs and soya products segment

Social Inclusion

While statistical data on egg consumption and egg trading is very limited, interviews with key informants suggest that the steady and significant increase in the volume of table eggs produced during the decade up to 2015 corresponded with a similar increase in the proportion of households, particularly urban households, regularly consuming eggs. Interviews also indicated that this trend was matched by a steady increase in the number and range of intermediaries ("egg traders") supplying these households.

In terms of social inclusion, this development is the most significant segment of the Egg VC. While two decades ago, eating eggs was regarded as aspirational, and mainly restricted to the "better off", by 2014/15 eggs were commonly consumed by households in lower income areas. The closure of the DRC border in September 2016, effectively halting the export of about 30% of Zambia's table egg production. This further increased the local supply of eggs improving availability in Zambia as producers and traders extended their egg distribution into remoter areas of Zambia in response. Interviews with the largest producers indicated that this pattern of extending distribution to remoter areas has continued after the DRC border re-opened, as these producers are continually exploring ways to extend their range of market outlets to hedge against the risks of having large stocks of unsold eggs, as they don't have cold storage facilities. The majority of eggs consumed in Zambia are distributed and retailed through the informal market sector, including small kiosks/groceries, with an estimated 5-10% being sold through supermarkets[39]. Eggs sold across the border into DRC and other countries (estimated at 30-40% of production) are also distributed and sold through informal marketing arrangements. While the margins are relatively small for each player, this provides a major source of added value and income for a large and increasing number of individuals (mostly males) involved.

[39] According to a survey on consumption of livestock products undertaken in 2012, egg sales via informal markets comprised 71% of sales, groceries/kiosks 18% , and supermarkets 5%. It is possible that super-markets and kiosks have increased their market share since this survey. The survey of 150 members of public interviewed in Lusaka for this study indicated that 45% purchase from informal markets, 23% from kiosks, and 29% from supermarkets. However, because shopping in supermarkets is seen as higher status, this may have influenced the responses to the question "where do you usually buy your eggs?".

The significant increase in the production of Soya over the past decade, mainly fueled by increased demand for stock-feed and also cooking oil[40], has been accompanied by more players involved in soya processing and the production at scale of a wider range of soya food products for household use[41]. Products now fairly widely available in supermarkets include soya flour, soya burgers, soya sausages, tofu, soya milk and soya chunks and strips. The more affordable soya products, soya chunks and soya strips, are now also widely available in local informal markets and sold affordable sized packages. Some soya products (soya flour, soya milk and soya strips) have been distributed free of charge by local health centres and other programmes, to poorer families with vulnerable members, including children under 5. Most of the soya products are favourably priced when compared with animal based protein equivalents[42]. As a result of these developments, soya product trading and consumption are now also a significant value-adding spin-off from the Egg VC with positive benefits in terms of social inclusion and social sustainability.

Social sustainability

In relation to the six domains of the social profile, food and nutrition is by far the most relevant to this segment of the Egg VC. Over the past decade, due to relatively stable prices for eggs and also for soya products, the Egg VC has provided increasing numbers of lower income urban households with an affordable sustainable and reliable source of quality protein which is relatively convenient and widely accessible. With regard to general equality, while men tend to dominate informal egg trading with small proportions of female egg traders, this appears to be more by choice than by specific gender roles, though men state that egg trading is more physically demanding. Women tend to dominate informal trading in broilers, which apparently involves different skills and labour requirements.

4.3 Main findings from the six domains of social inquiry

The general findings on the social sustainability of the Egg VC are summarised in the radar diagram (in Figure 4.1) and elaborated further in the appended social profile spreadsheet tool in Annex 2. This includes supporting evidence in relation to 57 of the total 63 questions in the tool, which were judged to be relevant to the egg VC.

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40 When soya prices are low relative to other sources of cooking oil, greater quantities of locally produced soya are likely to be processed for cooking oil.

41 This is noted in recent studies of the soya sector in Zambia, including Hichaambwa et al., (2014).

42 For example a family can purchase a package of soya pieces for K5 from local market stalls, which is enough to prepare the relish for a family meal for 4-5 people (usually with the addition of salt, onion and tomato).

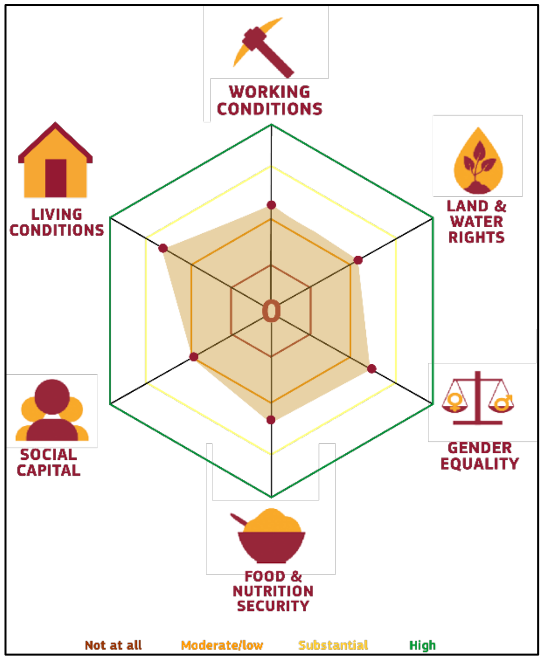

FIGURE 4.1: ZAMBIA EGG VALUE CHAIN SOCIAL ANALYSIS RADAR CHART

4.3.1 Working conditions in the egg value chain

The main question answered here is whether working conditions throughout the Zambia Egg VC are socially acceptable and sustainable? This question applies primarily to the commercial scale egg production segment of the VC. Labour laws[43] in Zambia are in line with the 8 fundamental ILO international labour conventions and the International Covenant on Economic, Social and Cultural Rights (ICESCR) and International Covenant on Civil and Political Rights (ICCPR). There is long-standing legislation on minimum wages and employment conditions[44].

Discussions with large egg farm managers/owners and their responses to a questionnaire, suggest a range of opinions on the extent to which labour laws and ILO conventions are actually upheld by employers and enforced by the relevant authorities. Large-scale producers have clear written contracts with employees, based on the Zambia Farm Employers Association 3 year collective agreement signed in July 2015 which covers retirement and gratuity benefits, funeral and medical assistance and subsistence and tool allowances. A wage agreement, with a 14.8% increase, was reached and made effective from 1st Nov 2016 for farm workers. Smaller scale egg farmers interviewed mostly had verbal agreements with their employees.

Given the need for seasonal labour, mainly in the grain buying season, "Casual" labourers paid on a daily rate are engaged at large egg farms and by grain traders and feed producers. Such employment

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43 See http://lauraandpartners.com/index.php?view=article&id=77%3Azambia-labour-laws&format=pdf&option=com_content&Itemid=2

44 Laws of Zambia Chapter 276, Minimum Wages and Conditions of Employment Act, 1982 amended in 1994.

practices do not appear contrary to labour laws. Some employees of both large and medium scale egg farms live on site with housing and services provided as part of their package, although large scale operators had concerns that this increased risks associated with hen disease management. Job safety practices and a high level of awareness of managers of health and safety were evident in the large egg farms which are tightly managed, and also at the feed mill visited. In the rural small-scale farming sector the rapidly increasing and widespread use of agro-chemicals when producing soya and maize for feed raises health and safety risks due to unsafe practices.

In terms of gender inclusion, both large and medium scale farms, and the mills and grain traders visited/consulted, indicated that their work force was largely male, due to the physical demands of the work involved. Female employees were regarded by some managers as more careful, honest and conscientious, and employed mainly for office based tasks and the lighter tasks including sorting of eggs and working in the hatcheries and rearing units for day-old chicks. The egg trade in informal markets was also largely dominated by males; the explanation being the amount of heavy lifting of trays involved, although female egg traders were also observed and interviewed who used men to help with the lifting.

Small-scale soya producers are “self-employed” with access to contract farming arrangements which are enforceable in principle, but also depend for their success on the development of mutual trust over time. The "fairness" of contracts is limited by the fact that they do not have any price guarantees, which exposes farmers to high levels of risk when soya prices are low.

Youth are also employed by both large and medium-scale egg farms, where literacy and numeracy skills are valued by owners/managers due to the increasingly high level of poultry husbandry required to run a viable operation. Children are not employed by either large or medium-scale egg farms. Children do assist their parents during weekends and school holidays in small-scale soya and maize production operations (e.g. especially planting, weeding and harvesting). Some children were observed selling eggs, including boiled eggs, around urban centres and markets.

4.3.2 Land and water rights

The research question is: are land and water rights, socially acceptable and sustainable? This is examined even though in comparison to neighbouring countries, Zambia has a relatively low population density and there are still relatively large areas of land which are under-utilised.

The Lands Act of 1995[45] recognizes two land tenure systems in Zambia: “state” and “customary” and includes a provision for the conversion of customary tenure into leasehold tenure. Particularly in areas of lower population density, this has enabled large tracks of customary land to be converted to state land for agricultural and non-agricultural development purposes[46]. To some extent, particularly in

45 See http://www.parliament.gov.zm/sites/default/files/documents/acts/Lands%20Act.pdf

46 See videos on the impacts of large-scale land acquisitions in Zambia at http://www.zla.org.zm/

more recent years, this demand for land has been driven by foreign investors seeking to engage in agricultural enterprises. Another driver is the increasing number of educated Zambians interested in going into agriculture as a side enterprise, as a retirement livelihood, or simply claiming or purchasing areas of customary land at low cost with the aim of selling at a higher price later. The process of converting customary land to state land is ongoing and a general increase in land disputes has been reported as a result such conversions for the establishment of commercial farms[47]. While an opportunity to acquire land cheaply by investors and well connected individuals, the process of conversion is not only time consuming and expensive for the majority of rural people, but may also create tensions and divisions within families. Land acquisition, whether through conversion from customary to leasehold, or through other means, can also displace people and negatively impacts on their livelihoods. This includes situations where out-grower schemes for crops such as sugar cane, involve utilizing significant areas of family held land.[48]

According to Chu et al. (2015)[49], the Voluntary Guidelines of the Governance of Tenure (VGGT)[50] are not well known or used by large-scale investors who displace people when they acquire land in Zambia. The World Bank's Operational Policy on Involuntary Resettlement and the International Finance Corporation's (IFC's) Guidance Note 5 are better known. There is a draft National Land Policy for Zambia which emphasizes the need to provide equivalent protection to customary land rights, stating "customary land rights shall henceforth be equal in weight and validity to documented land claims", and this is linked to providing the adequate compensation of evicted households[51].

The large and medium-scale egg farms visited all used existing state land for their layer operations, and did not therefore need to apply for conversion of tenure. However, the large scale egg farms have started and appear to be progressing a strategy of vertical integration; producing some of their own maize and soya for feed and using their chicken manure to reduce their fertilizer costs for grain and pasture production. If this strategy continues the demand for arable land will increase with a growing risk that any land still under customary tenure situated closer to large egg farms will become a target for acquisition by these farms.

In one rural area visited (Mpongwe District), where commercial farms established through the conversion of customary into state land border established village settlements, there was evidence that while providing local employment opportunities, such land acquisition this had reduced future access to land by local farming families. There was also evidence that in some cases family land still under customary tenure was being "sold" by family heads, with the permission of the local chief, to individuals who were settling in the area. The result was that the descendants of the family head

47 See https://landportal.info/book/countries/ZMB

48 Source: Matenga and Hichaambwa (2017).

49 Source: Chu J. et al., (2015).

50 Source: http://www.fao.org/docrep/016/i2801e/i2801e.pdf

51 Source: Republic of Zambia, (2015) Draft National Land Policy, Ministry of Lands, Natural Resources and Environmental Protection.

wishing to farm, did not have land to cultivate, and were therefore in order to grow food were forced to rent land to cultivate. It is evident that customary land tenure arrangements are in a state of transition in some rural areas due to both policy changes and increasing commercialization of the rural economy, and this places a large question mark against the longer term social sustainability of customary land tenure systems.

Land rights do impact, somewhat indirectly, on the egg trading segment as they influence the operation of informal markets. For example at the largest informal market for eggs at Kasumbalesa, the land is not controlled by the local authority but apparently by a group of local people who were given the land by the mining company which initially controlled it. This means that the local authority is not in a position to regulate trading operations at Kasumbalesa, including egg trading, which is in the hands of a local informal association. In other large informal markets, such as Soweto market in Lusaka, egg trading is controlled by local associations or informal groups, who members pay a fee to the local authority for having a stand at the market. The market stand fee provides a right to trade in the market area, but it appears that this does not in itself give rights relating to regulating who can bring produce to the markets to sell to the stand holders. These local trading groups, whether formal or informal, usually regulate who can bring eggs from the farm to the markets for resale, and are known to refuse access to the market to farmers who they do not have an agreement with. This is a significant form of exclusion/inclusion relating to land/territorial rights.

4.3.3 Gender equality in egg production segment

RQ: Is gender equality throughout the Egg VC chain acknowledged, accepted, and enhanced?

The Zambian government has paid significant attention, in both legislation and policy, to issues relating to gender equity and equality.[52] As a consequence of this and also as part of social changes associated with urbanisation, commercialisation and acculturation, customary norms and practices relating to gender are in gradual transition.

The Egg VC in Zambia, with regard to decision making and cultural conceptions of gender, largely functions within the above context; customary gender norms are most pronounced in rural areas and in the domestic settings of urban areas, while modernizing policies relating to gender equity are gradually influencings practices in formal workplaces, both in the public and private sectors.

In the grain production segment of the Egg VC, women's access to land, animal draft power and farming equipment is largely governed by the customary rules in operation, which themselves are in transition. The majority of rural areas in Zambia have matrilineal kinship systems, which allow adult

52 For example, The Ministry of Gender and Child Development Strategic Plan 2014-16 and The Zambia 2015 Gender Equity and Equality Bill. Older legislation, particularly, the 1989 Intestate Succession Act, Chapter 59 of the Laws of Zambia, has had a major impact on customary inheritance practices in urban areas and increasingly also in rural areas, protection the rights of widows and their children.

women, whether single or married, to access and inherit land rights, own livestock and farm equipment, and also have claims on other resources needed for agriculture (e.g. animal draft power, equipment, family labour). Data from national level livelihood surveys[53], the focused survey undertaken in Mpongwe District, and previous research by the social expert in various locations in rural Zambia indicate that women in many parts of rural do enjoy access to land, and when they occupy a senior position in the family they are able to inherit and control both land and livestock. More recent Zambian laws relating to widows and inheritance, are designed to address a customary practice in matrilineal inheritance, that widows were left destitute when their husband died and his relatives came to claim all of his property.

However, in married households men are formally the decision makers with regard to year to year decision making in terms of which cash crops to grow, getting farm inputs on credit, the area to be planted, how much to sell and when, and use of the proceeds of crop sales. In practice wives are often consulted about these decisions, as one farmer explained when discussing this; *"Women may propose but men decide - farming is so laborious that you can't be so selfish as to make decisions on your own".*

In female headed households women usually make the above decisions. They depend on male relatives for support with some operations traditional done by men, such as ploughing and spraying, but it is not uncommon for women also to take on these "male" tasks when men are not available to do them.

Both men and women farmers are able to access farm inputs on credit, and some providers such as NWK have specific targets for including female farmers. NWK policies do not differentiate whether the females registering for credit are household heads, or wives of male farmers. The very experienced NWK manager interviewed reported that loan repayment rates are higher for females compared with males. There was limited time to explore the scenario of a wife registering for credit in cases where her husband has de-faulted, and the implications for gender decisions within the household and also lending policies relating to such a situation.

53 Source: Central Statistics Office 2015 Rural Agricultural Livelihoods Survey Dataset

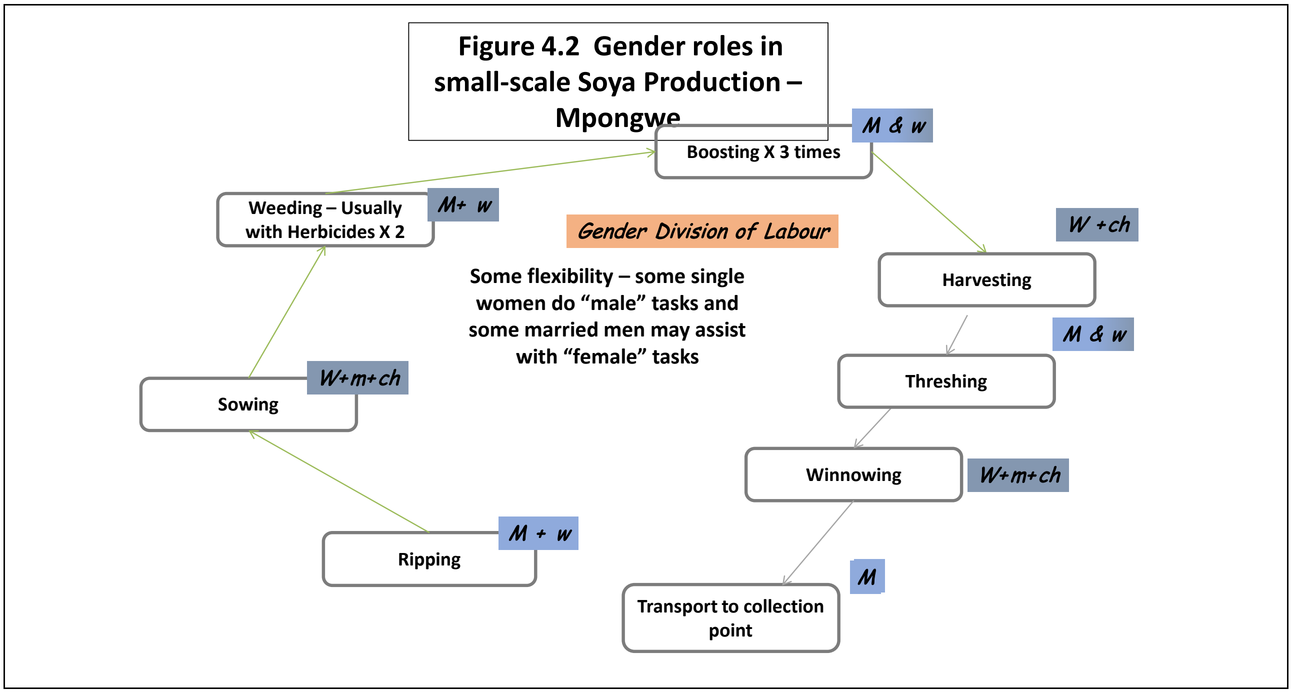

Figure 4.2, provides an example of the typical division of labour by gender in soya production based on data from the focused survey in Mpongwe District

Youth involvement in the grain production segment of the egg VC is mainly restricted to the younger men who provide labour for land clearing and preparation, crop spraying (of herbicides and foliar fertilizers), and the transportation and loading of grain. Younger women tend to marry quite early, and as wives provide labour in the planting, weeding, harvesting, threshing and winnowing operations for soya and maize.

In the egg production segment of the Egg VC, "heavy" tasks are mostly assigned to men due to cultural norms. The result is that the majority of employees with manual tasks are male. The supervisory, managerial and senior technical jobs are also male dominated on egg farms and at feed mills. The reason is that either the occupants of these positions have been promoted from less senior manual roles, or they have been recruited according to merit from a pool of largely male applicants. Agricultural graduates at degree, diploma and certificate level in Zambia are predominantly male, and this influences the gender balance in more senior positions in the agricultural sector, include egg production. A manager of a large egg farm reported making specific efforts to increase the number of female senior employees, including vets. He reported his experience that once recruited, female graduates were more difficult to retain because working with poultry is seen as low status (and smelly) work. During a visit to one large farm, a female manager of the egg sorting house, when asked about gender preferences in recruitment of staff for egg sorting, stated a gender neutral position very clearly; "I choose who is good at the task, male or female". In principle, and lending policies, access to credit by egg farmers is not influenced by the gender of the applicant.

The egg trading sector is largely dominated by men; the explanation for this being the heavy lifting involved in off-loading and overnight storage of trays of eggs. The off-loading and heavy lifting work in the informal markets is usually done by male youth. While some women do also participate as egg traders it is more common for women to trade in sale of broiler chickens, which they tend to dominate. With regard to the consumption of eggs, in urban areas eggs are widely eaten by both genders (see below)54.

4.3.4 Food and nutrition

The research question answered here is whether food and nutrition conditions relating to the Egg VC are acceptable and secure?

Food comprises the largest item in household budgets in Zambia, "food and beverages" making up over 50% of the budget in the lowest income group55. While there has been a surplus of maize and other food crops produced at national level in recent years, 16 districts are assessed as chronically food insecure 56. Nutritional status remains a significant concern, particularly infant malnutrition and stunting57. Improving human nutrition is now a significant focus at programme level58, and the importance of animal food sources for nutritional sufficiency in Zambia has been highlighted in recent publications59

In terms of the nutritional benefits, compared with other sources of protein60, eggs generally compare favourably, and are known to contain essential fatty acids, vitamins A, B (B2,B5,B12), D and K and riboflavin, folate, iron, selenium, phosphorous, zinc and copper. Eggs are known to be high in cholesterol, but recent reviews of evidence suggest that eggs do not adversely affect blood cholesterol.61 Soya, one of the main feed ingredients used to produce table eggs, is also a food which

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54 Customarily, in many areas of Zambia, it was considered taboo for women, particularly younger women, to eat eggs. However, these customary taboos are largely ignored in the urban areas and are also breaking down in the rural areas.

55 World Bank Zambia Consumption data http://datatopics.worldbank.org/consumption/country/Zambia

56 http://www.fews.net/southern-africa/zambia

57 A recent survey found a high rate of stunting (54%) in children aged 18-23 months, with 25% in this age range being "severely stunted", and that children in rural areas (42%) are more likely to be stunted than in urban areas (36%). P157-8 Government of Zambia, (2015) Zambia Demographic and Health Survey 2013-14. Central Statistics Office, Ministry of Health and other organisations.

58 E.g. The Government of Zambia and IFAD (2015) Operational Plan for Mainstreaming Nutrition in SAPP Interventions in Zambia, was launched in response to the survey finding that in the 10 Districts participating in the Smallholder Agribusiness Promotion Programme, the household food consumption pattern was "inadequate to meet the nutritional requirements of the target beneficiaries" and that "there were no deliberate actions to promote food consumption among farmers". P4

59 For example: Zhang et al., (2016).

60 For instance, at current prices protein from kapenta (tiny, dried local fish) which is traditionally regarded as a lower status relish for lower income families, is approximately double the cost of protein from eggs. Dried kapenta price was ZMK208 per Kg in April 2017, approximately 13 times the price of eggs (ZMK15/kg) but only has 6 times the percentage of protein (75% compared to 13% for eggs).

61 There are numerous weblinks to sites promoting the health benefits of eggs. E.g. http://www.healthline.com/nutrition/10-proven-health-benefits-of-eggs#section1

is high in protein and fat content, containing also antioxidants and phytonutrients, some of which can inhibit uptake of minerals and which can be reduced by boiling, sprouting or fermenting. [62]. Both eggs and soya products are relatively affordable and available in the urban areas of Zambia.

With regard to the grain production segment of the Egg system, food crop production in Zambia has been steadily increasing over the past decade, along with incomes, but the benefits of this improvement in terms of household access to food and nutrition are not evenly distributed among the population. Child malnutrition (stunting) rates, while showing some improvement, are still very high in Zambia, and this indicates that much more can be achieved in improving the nutrition of under five year olds. While the causes of stunting are complex, and not a straight-forward outcome of inadequate household food access and intake, improving household level access to food throughout the year provides a solid strategy for addressing this endemic issue.

Zambia's rural population is particularly vulnerable to seasonal fluctuations in food availability and accessibility. Increased participation in cash cropping by rural households, including growing maize and soya as cash crops, carries known risks for the households involved. One main risk is when households get farm inputs on loan under an arrangement where they sell a proportion of the crop to back the loan, without a minimum price being agreed as part of the contract. If the selling price is very low, and the yields of that farmer are not good, then the household may have to sell not only all the grain produced from inputs provided on loan, but also additional grain produced, which threatens household food security and nutrition. A further risk relates to gender decision making in married households. The male household head usually makes the decisions in terms of which crops to grow, how much of each crop, how much of the crop is to be sold, when and at what price. Unwise decision making in this regard further places households at risk of food insecurity. The impact is not only that crops that could be stored for household food are sold, but also that increasing the area planted to crops for sale often results in a reduction of the area planted to other crops or varieties which are traditionally mainly used for household food. The end result is that such households typically run out of stored food supplies early, around from September/October, before the next planting season and a long time before their next crops planted are harvestable for food. The rapid survey undertaken in Mpongwe indicated that this is a common situation for the small-scale farming households, nearly all of whom depend on sale of crops as an income source.[63] This results in a cycle of poverty, food insecurity and indebtedness in rural areas. Coping strategies to manage such seasonal food shortages typically involve working on the farms of neighbours, and/or getting grain on loan from neighbours, to

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62 There are also numerous weblinks to sites documenting the nutrional benefits of soyabeans. E.g. http://www.healthline.com/nutrition/foods/soybeans#section6

63 A rapid exercise was undertaken to assess this. An NWK aggregator listed 54 households she had registered in her area and assessed the food security status of each based on her local knowledge. 38 (70%) of these were married male headed households and 16 (30%) were households headed by single females. "Food insecurity" was defined as running out of stored grain by October (6-7 months after harvest), and having to sell assets to buy grain, or get food on loan from neighbours. 30 (56%) of the 54 households were categorised as "food insecure"; 18 married households and 12 female headed households. 24 (44%)of the households were categorised as "food secure" (able to store enough grain to last until the next harvest); 20 married households and 4 female headed households.

be repaid after harvest[64]. Cases of this were identified during the field interviews in Mpongwe, during which the majority of farmers interviewed did not see soya as a source of food, but as a cash crop[65]. There is therefore significant scope for improving rural food security and nutrition through interventions to improve household level utilization of soya for food, and also value adding activities for soya to improve incomes[66].

With regard to the nutritional impact of the egg production segment of the Egg VC, eggs produced on large and medium scale farms are strictly for sale, and not for consumption by employees. In some egg farms visited, employees were given first refusal to purchase cracked eggs at a reduced price. The main nutritional impact of the increase in table egg production in Zambia is therefore the significant increase in the availability of eggs in urban areas of Zambia at a more affordable price than a decade ago.

With regard to the affordability of eggs as a nutritious part of the family diet, the results of informal interviews with a range of informants, followed by a formal survey of a 150 members of the public, indicate that eggs are widely consumed by households living in poorer high-density urban areas and provide a convenient and affordable source of "relish" for many households in these areas. The formal survey in Lusaka indicated that eggs are now a popular source of food and relish for all gender and age categories in Zambia (see Annex 1). This survey in Lusaka also found that eggs are being used in the food prepared by mothers for under 5s, although establishing the trend and extent of this practice would require further research.

The data from household interviews in Mpongwe and national level surveys indicate that in rural areas of Zambia eggs are less important in the household diet than in the urban areas. The main reason is that "village chickens" are kept mainly for breeding and sale as meat, and also that the local breeds used do not produce low numbers of eggs and eggs of a small size. Typically only about 25% of the eggs produced by village chickens are eaten, and the remainder are left for hatching[67]. There is scope to improve the level of rural egg consumption through appropriate interventions in poultry breed and husbandry improvements.

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64 In Mpongwe farmers call this system "Lilalimo" which in the local Lala Language is translated as "eat in advance (of payment)". Grain is provided which is valued at the prevailing price at the time it is provided. After harvest the loan of grain is repaid, either in grain or in cash. If repaid in grain it is at the current value of grain at the time it is repaid.

65 This may not be the case in all rural areas of Zambia. For example in parts of Eastern Province small-scale farmers have been growing soya for a longer time, in some cases as part of programmes including training in household level utilisation, as confirmed in two interviews with an NKW manager and a ZARI scientist.

66 It is well established that food security and nutrition is improved in rural households by improving incomes so that additional food can be purchased, or so that assets can be purchased which will eventually translate into improved food availability (e.g. livestock which can be sold in times of hunger, farm inputs for the next season).

67 With a hatch rate of about 50%, this means that about 37.5% of eggs produced by village chickens which could potentially be eaten are wasted.

4.3.5 Social capital

RQ: Is social capital enhanced and equitably distributed throughout the Egg VC?

The three identified segments of the Egg VC (small-scale grain production for feed, egg production, and egg trading and consumption) operate somewhat independently from each other with limited social capital being built up between the actors in each segment[68].

The increasing and significant number of small-scale farmers who are growing maize and soya[69] live in widely dispersed rural locations in across Zambia. Social capital and longer term local relationships of kinship and neighbourly interdependence while weakening in some areas, still enable rural households to organize agricultural production and provide a social safety net and the basis for social re-production. In contrast, longer term relationships of mutual trust between rural households and key actors in the grain production sector of the Egg VC, such as agro-input suppliers and grain traders, are generally not well developed.

The majority of small-scale soya and maize producers belong to a local cooperative association, as this has traditionally been an important linkage to the state through which they have access to free or subsidized farm inputs, most recently through the "E voucher scheme", which targets a significant minority of rural households[70]. This relationship remains important in the minds of small-scale farmers, who asked about how "E-vouchers" would work in interviews and focused group discussions during the study[71]. Relationships that are increasing in importance are between small-scale farmers and the growing number of agro-input dealers in rural market centres and farmer representatives (commonly known as "aggregators" or "lead farmers") of agro-trading companies in the rural areas.

These relationships provide a basis for longer term business relationships to be developed which are based on mutual trust, underpinned by honesty and reliability. Results from the field interviews and

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68 This statement does not apply to the large commercial egg farms in which vertical integration is the main strategy, and the principle of cost-reduction and profit maximisation supplants the need for building trusting business relationships.

69 According to official crop forecasting data, in the 2016-17 farming season 202,213 small-scale farmers grew soya, compared with 100,048 in the 2014-15 season, 91,856 in the 2013-14 season, 84,379 in the 2012-13 season, and 42,033 in the 2011-12 season. This represents an 381% increase over five years with an increase in all years. Over the same period, there were a much more modest (12% overall), but also steady increase in the number of small scale farmers growing maize (1,354,200 in the 2016-17 season, 1,299,754 in the 2014-15 season, 1,277,128 in the 2013-14 season, 1,230,128 in the 2012-13 season, and 1,209,452 in the 2011-12 season). Changes in policy regarding subsidy of inputs, giving small-scale farmers a wider choice of enterprises than seed and fertiliser for maize, may result in a lower increase in the numbers of farmers growing maize, but this remains to be seen given the popularity of maize as a rural food security crop.

70 E-Vouchers were piloted in the 2015-16 farming season and the system further extended in the 2016-17 season which plans for a more extensive rollout in the coming 2017-18 season.

71 . Although the Farm Input Support Programme was conceptualized as a transitional arrangement to enable farmers to get their farming operations onto a more solid footing, its effectiveness in helping small-scale farmers to climb out of poverty over the past 15 year has been questioned by a recent review (Kuteya and Chapato 2017).

other studies indicate that at current levels of trust and social capital between small-scale farmers and these intermediary actors are at a low level, and still embryonic. For example, the small agro-input suppliers interviewed operate on a strictly cash basis, and do not provide inputs on account or credit to their small-scale farmer customers. There was apparent inequity in that larger agro-dealers did provide inputs on account (to be paid at a later date) to commercial farmers, but not to small-scale farmers. These larger agro-dealers did facilitate free training in use of their products (agro-chemicals and improved seed) to small-scale farmers (training provided by the agro-input companies). One of the established agro-trading company managers interviewed did evidence a longer term perspective to building up relationships with small-scale farmers growing soya. In the context of low soya prices, he intended to put to senior management the option of extending the re-payment period for loans, with no additional or lower rates interest, in cases where farmers were not able to pay back or fully and/or on-time.

In rural Zambia, mechanisms exist to bring community members together to decide on important changes or projects to implement (e.g., building a school, fixing a bridge, lobbying for improved health care services). Knowledge relevant to the Egg VC, such as soya production and utilisation, is shared informally through hands-on experience, and in some cases through extension demonstrations and training provided by the government extension service or NGOs. During farm household interviews, it was apparently that there was a wide variation between households in their knowledge both on soya production and more particularly on the utilisation of soya beans for household food use (including infant feeding), production of value added products for sale, and use of crop residues for livestock feed.

In the egg production segment, interviews indicated clear evidence of relationships and trust being built between medium scale producers and service providers particularly with hatcheries and with stockists of feed and poultry equipment. For example in Lusaka it is common for new entrants to egg farming to seek advice and guidance from a well-established cooperative which sells inputs and provides technical information on the products provided which is trusted by poultry farmers. Also in Lusaka, an established supplier of point of lay pullets provides a range of technical advice and veterinary support services and back-up to the mainly medium scale egg farmers who are its main customers. Similar levels of support are provided by the two hatcheries in Lusaka supplying day-old chicks to both medium and large-scale egg farmers. In some cases the main hatcheries also supply day-old chicks on account and the main feed companies do the same. It is mainly the large-scale egg farmers who can benefit from this facility, which is indicative of inequity in this segment of the Egg VC which as with grain production favours the larger farmers.

Regarding development of longer term trusting relationships between egg farmers and egg traders, interviews with both egg traders and egg farmers indicate that this is not well developed. Farmers stated that they would like to develop longer term relationships with traders, but have found through experience that traders do like to “shop around” for the lowest possible price. In times of scarcity of eggs, some traders will pay for their eggs in advance of collection. This is an indication that while they don't trust the farmer to keep the eggs for them so they can pay on collection. The scope for longer term relationships is greater when farmers are supplying institutions, such as hotels, guest houses, hospitals, schools etc. which attach more importance to the reliability of the supply, and usually the expectation is that the farmer will deliver the eggs at the appointed time, and also be flexible with the arrangements and respond quickly to additional demand. While contracts with supermarkets provide a basis for a longer-term business relationship, egg farmers viewed such relationships as lower priority because of the amount of extra work required for packaging and quality control, and the strong bargaining power of supermarkets (resulting in generally lower prices received). A "bottom of the pyramid" (BOP) initiative funded by the EU has had some success in terms of developing longer term relationships between the largest egg farmer and small retailers in the Copperbelt.[72]

In terms of the development of trusting and longer term relationships at the "retail" end of the Egg VC, as the majority of eggs are purchased by customers either in the informal market, or from family owned small kiosks, there is scope for such relationships (expressed through customer loyalty, discounted pricing, consistent quality or eggs on credit) to flourish more in this segment of the Egg VC compared with other segments.

Given the current trend for vertical integration of the large-scale egg farms, the scope (and the need) for relations of trust and reciprocity to develop between different actors in the segments of the value chain is less important than for the smaller egg farmers operating on a commercial basis. One of the large-scale farms has its own grain farms, feed milling capacity, retail chain, in-house veterinary capacity, virtually removing any need for developing strong relationships with other key actors in the Egg VC. The largest egg farmers compete for the largest markets in Lusaka the Copperbelt and export to DRC through Kasumbalesa. During the study we found that there is a high level of secrecy and reluctance of larger egg farmers to share any commercially sensitive information, not only with each other, but also with the Poultry Association of Zambia (PAZ). This is the national producer association of which farmers are members by virtue of buying day-old chicks[73].

4.3.6 Living conditions

RQ: To which standards are major social infrastructures and services acceptable?

72 Technoserve, 2013, Evaluation of the Bottom of the Pyramid Distribution Opportunities. TAR005 RFP001

73 While some of the smaller-scale egg farmers interviewed had heard of PAZ, those interviewed were not familiar with its main functions, or aware that when the purchased day-old chicks, part of the price was a levy paid to PAZ. This may explain why PAZ did not appear to have a full list of its egg farmer "members", which effectively would be all those buying day-old chicks, both as broilers or layers.

For the small-scale grain production segment of the Egg VC[74], or “Egg system” the health services are generally adequate in rural areas[75], with free consultation and diagnosis and some treatment and medication provided free and others requiring payment. The same applies to primary education, which is provided free (sometimes with school feeding programmes), while there are expenses born by parents or relatives relating to school uniforms, books and “building fees”. Secondary schools are mostly located near or in towns and District Centres and are expensive for rural children to attend given associated school fees and transport and/or boarding fees. School attendance rates are somewhat higher in urban areas compared with rural areas.[76] Reciprocal arrangements are often made between relatives and friends for children from rural areas to stay in the towns so they can attend secondary school without the boarding expenses.

While relevant training in maize and soya production is provided by government extension officers, and increasingly by agri-business trainers, the training in soya utilization for improved food security, nutrition and value addition is, based on the interviews undertaken with farmers and extension staff, either non-existent or very limited. Vocational skills training for young school leavers or those not completing their primary or secondary education is also very limited in rural areas. This lack of relevant vocational training further limits the development of spin-off enterprises related to the Egg VC in rural areas. Moreover, human nutrition has been a neglected subject in Zambia’s universities and colleges of agriculture, and as a result few of the technical staff in the agricultural and public health extension services have adequate qualifications and training in this.

While housing styles vary between different ethnic groups in Zambia, housing is typically a main living structure of mud/dung and lathes or burnt bricks with a roof of either thatch or corrugated iron sheets. The floor may be mud/cow dung or concrete. The size and construction of the main house is an indicator of status and wealth. A house with a concrete floor, burnt brick walls and an iron roof requires the least annual maintenance, and is therefore a “labour-saving” asset. In some areas the kitchen is a separate structure. Most rural households have access to safe drinking water (from a communal borehole, well or protected spring), and have their own pit latrine.

Poor roads mean that linking rural people to input and output markets is difficult and costly. For example one of the main reasons that farmers sell their maize and soya to “brief-case” traders at low prices with unreliable weighing scales, is the high cost of transporting their grain to buying centres offering higher prices and the transparency of reliable weighing scales. Some of the costs relating to

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74 It is noted that Egg VC system boundaries for the social analysis are somewhat wider than for the economic and environmental analysis. This is due largely to a request from the EU delegation in Lusaka at the start of the study that the team consider aspects of the EU investment under TAF supporting to smallholder soya contract farming in the study.

75 However, according to a recent survey, twice the proportion of persons in rural are (18%) reported illness/injury compared with persons in urban areas (9%). Republic of Zambia (2016) Zambia Living Conditions Monitoring Survey 2015. Central Statistics Office.

76 The same survey, p3, above found somewhat lower school attendance rates in rural compared to urban areas; primary attendance 79% in rural areas and 90% in urban areas and secondary school attendance 73% in rural areas and 80% in urban areas.

input procurement and marketing associated with poor rural transport links are reduced through variants of the "aggregator" model being adopted in many rural areas[77].

Established rural settlements are typically closer to services; roads, health centres; primary schools, markets and shops, but have more limited access to arable and grazing areas for livestock due to greater population pressure. Households choosing to settle in more remote areas usually need more resources to establish themselves and also have more opportunities to expand their agricultural operations.

A further research question posed is: Does the Egg VC contribute to improving health, education, and training infrastructure and services?

As noted above, the main benefits of the Egg VC currently accrue to urban households in higher density locations, through the increased availability of a convenient and affordable protein food source. Peri-urban households also benefit to some extent through employment opportunities on egg farms as many of the egg farms are situated close to large urban populations.

With regard to improving the living conditions of rural people, activities in the grain production segment of the Egg VC do have the potential, but this is very much dependent on factors outside of the control or influence of small-scale farmers. For example, in a year when the right inputs are available on time, climatic conditions are favourable, and the price is higher for maize or soya, small-scale farmers can invest part of the proceeds from crop sales into improved housing (e.g. burning bricks, buying cement and iron roofing sheets) or for meeting expenses relating to education or health. If the converse situation applies (i.e. agro inputs arrive late or are not suitable, weather is adverse, crop prices are low) then small-scale farmers are not only not able to invest in these things, but are at risk of indebtedness and spiralling into poverty and greater dependency on programmes of agricultural subsidy and social safety nets. This does therefore make soya production risky. The risks would be greatly reduced if the timeliness of input supply to rural depots was improved and measures were taken to significantly reduce the immediate selling of soya harvested for cash (see recommendations on ideas for this).

4.4 Social profile summary

4.4.1 Issues identified

The social profile analysis has identified the following issues relating to the Egg VC, broadly defined to include small-scale grain producers and urban consumers:-

77 The Aggregator Model has been promoted by various development agencies, including DFID, to provide support to intermediary actors to improve links in the supply chain and marketing chain and reduce transaction costs for the producer. E.g. http://www.technoserve.org/blog/unlocking-opportunities-for-soy-farmers-in-zambia; http://foodtradeesa.com/portfolio-items/the-patient-procurement-platform-ppp-small-holder-aggregation-center-model-concept/,

- Small-scale farmers lack influence on the terms of contracts and are in a very weak bargaining position with regard to grain prices, and moreover lack the capacity (both physical and financial) to store soya and maize after harvest and wait for prices to increase. This situation of price volatility has been made more volatile now that Zambia is producing consistent surpluses of both soya and maize, which tends to drive down the farm gate price which otherwise might be influenced by consideration of import parity pricing.

- There are greater risks of indebtedness and food security, particularly for new entrants to small-scale soya production. This is because new entrants lack the hands-on knowledge and skills relating to soya production which results in lower yields, and because new entrants are more likely to depend on inputs supplied on credit (which may come late in the season which compromises timely planting) and which have to be repaid shortly after harvest.

- Limited quality and breadth of technical advice currently being offered to small-scale soya producers by both public and private extension providers impacts most on new entrants, who do not have the benefit of prior hands-on experience to draw on. The tendency is to provide "blanket recommendations to all small-scale farmers, rather than to tailor the advice to the farmer's circumstances (e.g. soil type, labour supply, access to draft power, cash availability) and climatic events. The narrow focus of extension advice on soya production, and neglect of advice on household utilisation and value addition options, is a further limitation for small-scale farmers.

- Variation between areas in the availability, quality and timeliness of input supply for soya production (particularly inoculum and improved seed) is an issue. Timely and easy access to the best adapted soya varieties and good quality inoculum are very important for viable small-scale soya cultivation for the market. The high cost of certified soya seed is also an issue particularly when prices are low, as seed is the most expensive cash input.

- With regard to longer term land security for rural households, low and uncertain profitability of small-scale farming can encourage sale of family land by older family heads to newer settlers. This limits the amount of land available for the next small-scale farming generation from these families, who then will either have to rent land locally or re-locate to another area where land is available.

- There is limited use of both eggs and soya products to improve the nutritional quality of infant diets and diets of vulnerable adults in both rural and urban areas. This is because both eggs and soya did not feature in dishes "traditionally" prepared for infants and vulnerable adults.

- Difficulties/barriers for new entrants to egg farming include: high and variable feed costs, low egg prices, high cost of borrowing for capital investment, limited social capital and weak cooperation between egg farmers. As confirmed by the financial analysis in Chapter 3, smaller egg producers face the smallest profit margins, making entry into this enterprise relatively risky.

- The longer term trend of increased automation and mechanisation in the large egg farms and in the related stock feed industries means that employment opportunities on these farms and stock-feed plants will not keep pace with the increased output of these enterprises.

- The employment opportunities for youth are limited in some segments of the value chain. Apart from some opportunities on egg farms and linked enterprises for youth with intermediate levels of education (e.g. secondary school leavers) most of the opportunities are for casual seasonal employment and working as self-employed egg traders.

4.4.2 Risks/benefits of non-intervention

- Intervention to regulate the egg trade is likely to stifle opportunities for the youth and less well educated adults to take up opportunities in this still expanding niche for self-employment,
- Lack of interventions in current arrangements for contract farming could mean that risks relating to rural indebtedness, food insecurity and malnutrition in households new to growing soya will potential continue at current level or increase further. Grain production is the most important small-scale farming enterprise, so low levels of returns to grain production repeated over a number of years is likely to increase rates of rural youth unemployment and rural to urban migration in the areas where small-scale maize and soya are the main cash crops..
- If opportunities to address current rates of malnutrition and the still high incidence of stunting in rural and urban areas are not taken up, this will be a missed opportunity to contribute to MDGs relating to malnutrition,
- In the longer term, without intervention regarding the process of converting customary land to state land, social and political risks associated with a future generation of landless rural households are likely to emerge.
- Without intervention to promote youth employment opportunities, both in rural small-scale grain producing areas and also in peri-urban areas where large egg farms, feed processing plants and grain stores are situated, the risks associated with high rates of youth unemployment are likely continue.
- Without intervention large commercial players will continue to extend their dominance of egg production, squeezing out medium and smaller-scale egg farmers this will make it harder for new local players to enter the egg VC.

4.4.3 Key mitigating measures

- **Grain price volatility for small-scale farmers**: explore scope for improved contracts for small-scale soya producers and improved opportunities for household and community level options for adding value to grain produced.
- **Trusting relations between small-scale producers and agribusiness**: Along with the improved contracts above, improve other forms of support to small-scale farmers either growing soya or in

locations suited to soya production with the aim of improving levels of mutual trust and building sustainable business relations between the these agencies and participating farmers. (see below)

- **Blanket technical recommendations**: provide more carefully tailored services to small-scale grain producers: technical advice on land husbandry and pest control, supply of inoculum and seed, credit packages as part of contract arrangements, marketing support, taking account of the variation within the small-scale sector. The aim would be to reduce the current risks faced by small-scale farmers growing soya, and improve the opportunities (including value addition at village level) for sustained small-scale production of soya which is profitable and also improves household food security and nutrition. This implies involvement of extension services (public or NGO led) which are not driven primarily by short-term commercial interests.

- **Infant malnutrition and stunting**: provide initiatives to raise awareness and empower households to use the improved availability and affordability of eggs and soya (including soya products) for feeding infants and vulnerable adults in both rural and lower-income urban areas,
- **Emergence of Landless rural families longer term**: measures, such as awareness raising and training of local chiefs involved in land matters, which discourage irresponsible sale of family land, and thereby provide greater security of access to family held farm land for the next generation of rural small-scale farmers.
- **Youth unemployment**; specific initiatives targeting the youth, to improve their inclusion in the Egg VC, including training for employment in egg farms and the agencies servicing these farms, and setting up viable small-scale enterprises in rural areas to add value to the soya produced, and to increase the local production of eggs from chickens reared by households.
- **Dominance/potential for oligopoly trend**: Strengthening the producer organisation/s supporting the medium scale egg farmers and new entrants, so that this sector is not further marginalised and squeezed out of production by the large players, with the attendant negative consequences for employment (not only on smaller egg farms but also the agencies servicing them).

4.5 Recommendations on social inclusion and sustainability

The following interventions are suggested as having potential for improving social inclusion and the sustainability of the Zambia egg VC.

- Improve the support to small-scale farmers either growing soya or in locations suited to soya production. The improved support should be channelled through the relevant agencies, with the aim of improving levels of mutual trust and building sustainable business relations between these agencies and participating farmers. The services (technical advice, supply of inoculum and seed, credit packages as part of contract arrangements, marketing support) need to be more carefully tailored, taking account of the variation[78] within the small-scale farming sector. The aim should

[78] This includes variation between farmers in terms of levels of resource ownership and access, current levels of indebtedness, health situation, knowledge and capability to manage risks.

be to reduce the current risks faced by small-scale farmers growing soya, and improve the opportunities (including value addition at village level) for sustained small-scale production of soya which is profitable and also improves household food security and nutrition.

- Increased focus on interventions to promote appropriate and more widespread use of both soya products and eggs (as more affordable sources of high quality protein and key vitamins and minerals) in the diet of infants and vulnerable adults, to improve human nutrition both in rural and urban areas,
- Specific initiatives targeting the youth, to improve their inclusion in the Egg VC, including vocational training in rural areas for employment in egg farms and the agencies servicing these farms, and setting up viable small-scale enterprises in rural areas to add value to the soya produced, and to increase the local production of eggs from chickens reared by households.
- Strengthening of egg producer organisation/s, with a specific focus on supporting the medium scale egg farmers and new entrants, so that this sector is not further marginalised and squeezed out of production by the large players, with the attendant negative consequences for employment (not only on smaller egg farms but also the enterprises servicing them).
- Interventions to improve the participation of the medium and smaller egg farmers in PAZ, and in particular to improve key services for new entrants, such as business advice and technical advice on DOC rearing, vaccination, feed formulation, and egg production and marketing, should reduce barriers to entry for this category.

5. THE ENVIRONMENTAL ANALYSIS

5.1 Introduction and objectives

Food production addresses one of the most important and basic human needs. Agriculture and food systems are major contributors to both local and global environmental change. Sustainability is increasing important as societal goal. Eco-efficiency and materials footprint are becoming mainstream elements in successful businesses, including commercial agricultural enterprises. Design and management for sustainability are becoming core components of social responsibility and market position vis-à-vis consumer expectations in a world moving fast to new life styles.

Life cycle thinking refers to a sustainability management approach that requires integration of all relevant supply chain activities associated with a product/service. This approach facilitates the identification of opportunities to improve resource efficiencies and reduce emissions whilst being aware of potential trade-offs, which may occur between different types of impacts or different supply chain steps as a result of management decisions. The leading standard for assessing environmental performance is life cycle assessment (LCA). LCA evaluates the relative potential environmental and human health impacts of products and services throughout their life cycle, beginning with raw material extraction and including all aspects of transportation, manufacturing, use and end-of-life treatment. LCA methodology is defined by the International Organization for Standardization (ISO) 14040-14044 standards (ISO 2006a, ISO 2006b[79]). ISO standardized framework provides prescriptive guidance for characterizing material and energy inputs and emissions along product supply chains. LCA addresses how these flows relate to a range of resource use, human health and environmental impact potentials.

LCA was traditionally applied to analyse industrial production systems, but in recent decades has been adapted to assess the environmental performance in agriculture and food production processes. However, agriculture does not consume resources in a linear sense and is not a pure "cradle-to-grave" process: many agricultural systems are interlinked and therefore changes to one system will have trade-offs. Even so, aiming at measuring and reporting sustainability, LCA became a key tool for a comprehensive asset management, supporting decision-making while improving transparency and stakeholders' knowledge within the agri-food sector.

The **general goal** of the present study is to perform the LCA of the egg value chain (VC) in Zambia. This includes life cycle inventory and environmental impact assessment along the whole value chain, comprising crop production (wheat, maize and soybean[80]), milling, compound feed preparation, parents stock and egg production and transportation to market gate in Zambia. The main environmental LCA focuses on larger scale commercial egg production systems in Zambia. Other elements in the Egg VC are also considered in the analysis in this chapter (see definitions in Table 5-1).

[79] ISO (2006a) 14040: Environmental management. Life cycle assessment–principles and framework. Geneva.
ISO (2006b) 14044: Environmental management. Life cycle assessment–requirements and guidelines. Geneva.

[80] Egg production companies indicated these crops as the main protein sources for layers feeding in Zambia.

The **specific goals** of the study are to identify and measure resources used and substances emitted throughout the different stages of the Egg VC, reviewing their impacts on a set of several environmental categories. Among them are water and land use, eutrophication, resource depletion, presence of toxic material and release of carbon equivalents. This then is aimed at informing on potential damages, risks or benefits for i) human health, ii) ecosystem quality and iii) resource depletion. The mitigation potential of specific interventions to improve resource use efficiency and to reduce emissions in Zambian egg sector are also part of the study objectives. The driving force is a EU policy perspective towards better environmental performance with economic and social benefits to Zambia society[81].

LCA has previously been applied in several egg production supply chains along different countries and industrial scenarios (e.g.: Pelletier et al., 2016, 2014; Leinonen et al., 2012; Mollenhorst et al., 2006; Verge et al., 2009; Wiedemann and McGahan, 2011). These studies scope are not homogenous but highlighted main value chain interactions and challenges, including crops, feeds and manure management roles in egg life cycle impacts. However, no LCA study regarding Zambia egg production was carried out previously.

5.2 Scope

5.2.1 General Framework

The population of in-lay hens in Zambia is estimated at 3.5 million, producing about 1.15 billion eggs during in 2015[82]. The market value of eggs is estimated at Zambia Kwacha (ZMK) 920 million[83]. In addition, the chain sells about 3 million spent hens per year, valued at ZMK 75 million[84]. There is also an emerging market for chicken manure but that was not quantified. Total value generated by the egg value chain is therefore estimated at about ZMK 995 million, representing 7.94% of total agricultural GDP. Growth in the chain over a five-year period (including 2015) was estimated at 15-20% per annum. However, in 2016, a number of factors contributed to a steep decline in production, as the in-lay population of birds dropped sharply by about 30% to an estimated 2.5 million birds. A recovery is underway in 2017 as the egg trade with Democratic Republic of Congo (DRC) has resumed with the opening of the border and prices of maize and soya are trending downwards (Onumah et al., 2017).
Egg producers vary in significantly in terms of scale of production and technology deployed, as depicted in Table 5-1 below. Poultry Association of Zambia (PAZ) has adopted a classification of egg

[81] The LCA commissioner is EU DEVCO-Directorate General for Development and Cooperation. The report intends to provide DEVCO with data and information regarding potential environmental impacts of egg value chain in Zambia and to identify the most appropriate practices and/or policies towards the mitigation of negative environmental impacts on current and future value chain developments.
[82] Source: PAZ (*pers. comm.* Dominic Chanda, Executive Manager of PAZ, 15/05/17)
[83] Estimate based on average price of ZMK 24/crate of 30 eggs.
[84] Estimate based on average price of ZK25 per spent hen sold.

producers and the functional analysis in the current VCA4D project adopted a modified classification (Onumah et al., 2017).

Population of in-lay hens	PAZ classification	VCA4D classification	Market share est. (%)
Over 100,000 birds	Corporate	Large-scale	85
50,000 – 100,000 birds	Commercial		
20,000 – 50,000	Large-scale		
10,000 – 20,000 birds	Medium-scale		
1,000 – 10,000 birds	Small-scale	Medium-scale	10
100 – 1,000 birds		Small-scale	3
Below 100 birds		Micro-scale	2

Table 5-1: Categories of egg producers in Zambia

Source: Draft report Zambian egg value chain analysis, 2017.

As can be seen in Table 5-1, large-scale egg producers dominate the value chain in terms of the volume of eggs marketed. The 3 large-scale producers facilities visited during the first mission to Zambia carried out in the framework of the present study were corporate (2)[85] and a commercial type producer (1). They account for over 85% of the market share. They tend to be highly integrated vertically, incorporating functions such as rearing Day Old Chicks (DOC) to point of lay, on-farm feed formulation, provision of on-site veterinary and related services, and the distribution of eggs (one of the major breeders/hatcheries also runs an egg production operation). Their farms tend to have very strict bio-control systems, which are managed by highly skilled employees, with many of these staff housed on the farm. All have their own grain buying operations and storage facilities, maize milling and feed mixing equipment and produce cage farms. Three of them produce maize and two produce soya from their own farms in 2017.

Corporate/Commercial egg producers tend to use fully automated poultry housing systems and many of them appear to reinforce the level of investment in automation if necessary. They have facilities for storage, quality control, distribution and sale of eggs and sell either through proprietary outlets or formal retail chains. They also deliver directly to traders in the big informal markets in urban areas, namely Lusaka (Soweto market) Kasumbalesa (DRC border) and Nakonde (Tanzania border).

The environmental LCA intended to be representative of Egg VC in Zambia based on the large-scale producers. Medium, small and micro producers represent only 15% of egg production considering VCA4D classification and where considered out of scope.

[85] The most significant corporate company is, most probably, Goldenlay Limited. Official sources and technical reports highlight its role and already in 2012 it was said "…Golden Lay is the leading producer and distributor of table eggs in Zambia, supplying mainly to the informal sector in the Copperbelt, Central and Lusaka provinces of Zambia as well as in the Katanga province of DRC" quoted in: ABRAAJ Group Annual Review, 2012.

5.3 Description of the products studied

5.3.1 Functional unit

Life cycle assessment relies on a functional unit (FU) as a reference for evaluating the components on a common basis. The FU for the present study is 1000 kilogram (kg) of eggs at market gate in Zambia. The reference years are 2011-2016 but the main data sources are from 2016[86].

The FU is equivalent to:

6208 eggs (average weight 61,7g).
94 kg-protein

5.3.2 Reference flows

Specific quantities of materials required to produce 1 FU are called "reference flows" (RF). The RF used in this analysis includes both direct and upstream processes inputs and emissions characteristic of crop production, milling to compound feed preparation, feed pullets and feed layers and production and transportation of egg products to market gate. With regard to the RF for the Egg VC it is important to note, due to losses between egg collection ("cage-gate") and market, that:

- 1000 kg of eggs at market gate require 1020.4 kg at farm gate (AFG);
- 1000 kg of eggs at farm gate require 1250 kg of eggs produced at "cage gate".

5.4 System boundaries

5.4.1 General system description

As a rule, LCA of agricultural products covers six steps: farm inputs, agricultural stage, production, distribution, use/consumption and waste management. In the present case, the system boundaries for this analysis encompass the relevant material and energy inputs and emissions attributable to processes in the cradle-to-customer supply chains of egg production in Zambia. The Egg VC has been grouped into the following principal processes and products from maize/soya/wheat production to-market-gate:

1. Fertilizers and pesticides transportation from known (identified) export countries to Zambia;
2. Maize, soybean and wheat agriculture production that yields milling inputs – representing Zambia commercial average;
3. Milling to compound feed preparation – adapted to Zambia from international standard average;
4. Feed production – representing Zambia commercial average;
5. Inputs to parent farm stock (PF) and egg farm stock (EF) - representing Zambia commercial average;
6. Egg distribution to retail market – Zambia commercial average (Lusaka, RDC/Tanzania borders).

[86] The use of robust data sources was a main priority in the current study, as discussed in Section 3, 3.3.2 - System boundaries.

LCA considers all identifiable direct and upstream inputs and emissions to provide as comprehensive a view as is practical of the product system within each of the above processes. This analysis addresses cradle-to-market gate impacts of egg production. In this way, the production chains of inputs are traced back to raw materials.

A schematic view of the Egg VC is shown in Figure 5.1 that encompasses the system boundary framework for the current LCA.

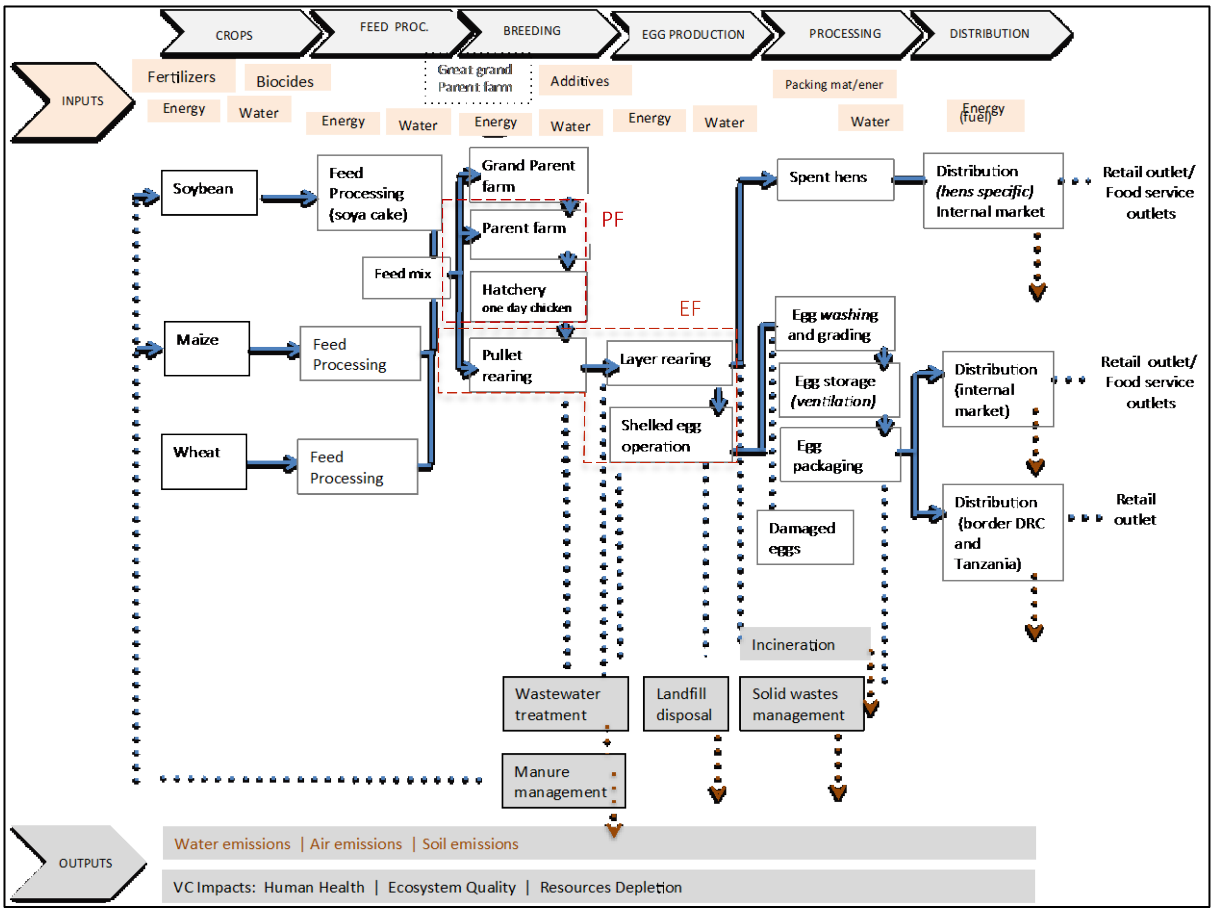

FIGURE 5.1: SCHEMATIC OF THE LCA EGG VC (ZAMBIA)

5.4.2 Temporal and geographic boundaries. Cut off criteria.

The environmental LCA intended to be representative of Egg VC in Zambia based on the processes of the large-scale producers who provided data for this study. Assumptions used reflect their current equipment, processes and market conditions. These processes are likely to be very similar to the processes used by commercial egg producers in Zambia (or elsewhere).

Regarding the temporal boundary, data was retrieved from the best available source data or year, but most statistics are from 2016. There is some potential for variability in inventory data between individual farmers, not so much in egg production facilities. It is possible that future changes in market demand (e.g. export markets), farming practices or climatic conditions could have significant impact on agri-food production, which would affect the LCA results. Temporal differences may induce changes in key variables used in the LCA such as crop yields, use of agricultural lime, fertilizers, pesticides and herbicides. In order to minimize the effect of recent temporal variations a multi-year average has been used when available for the years 2011-2016 for this type of data.

Substantial modifications in technological processes are not expected or foreseen. Short and long-term emissions were considered. While certain technological processes generate emissions over longer period of time (*e.g*. manure disposal in soils), all emissions are represented as though they occur at the same time.

The Egg VC LCA analysis did not include the following inputs, factors and/or associated emissions:

- Potential CO_2 exchanges related to land use changes in agriculture as a result of changes in tillage regime and attendant impacts on Soil Organic Carbon (SOC) were excluded;
- Loss of pollinators due to pesticide use;
- Uptake of heavy metals by crops used in rotation;
- Vitamins, antibiotics and other nutritional/medicinal preparations and detergents;
- Enteric fermentation for poultry;
- Avian plant building construction/infrastructures;

Processes and product components were included in the present LCA if the required information was available, either from Zambia sources or from international literature and internet sources. Thus, no additional cut-off was applied.

5.5 Methods

5.5.1 Allocation, Recycled content and transportation

Allocation

A methodological decision point in LCA occurs when the system being studied produces co-products. The criterion for distinguishing between a co-product and a waste is whether or not the material co-produced is actually used. This is the case regarding egg and spent layers that involve co-product relationships that require allocation decisions. Spent hens sold for food or rendered for animal feeds are treated as co-products, whereas those that are buried, composted or incinerated are not.

ISO 14044 prioritizes the methodologies related to applying allocation to be used to resolve multi-functionality. ISO 14044 provide definitions of products and wastes, where wastes are defined as materials that the process owner is required to, or intends to, dispose of. All co-products are allocated, whereas wastes are not. Several processes in Agri-footprint and Ecoinvent databases provide multiple functions and allocation is required to provide inventory data per function or per process. The current LCA study used a mass allocation method.

Recycled content and end-of-life recycling

Recycling systems are an example of multi-output processes. By providing a waste treatment service also valuable materials or energy for use in other applications are produced (e.g. manure). The current LCA applied by default the cut-off approach to allocating recycled content and recycling at end-of-life.

Transportation

The boundaries of the egg supply chain in Zambia start at the origin of primary material (agricultural field and crops for layers feed source production) and related inputs (fertilizers and pesticides) and then go through each step until egg distribution at market gate. Several reports highlight the impact of transport services in Zambia and in the regional competitiveness[87]. Therefore, the present LCA study integrates this issue as much as possible considering available information and traceability[88].

A critical factor on product transport analysis is the allocation between mass or volume because terrestrial and marine vehicles have both a weight capacity and a volume capacity. In the present study, relevant transport of inputs and products - fertilizers, pesticides, crop, eggs and manure - are mass-limited due to their specific weight. Agri-footprint database was used considering road, rail and sea transport inventory based on weight-limited approaches. Annex 2.5 presents transport model assumptions.

5.6 Life cycle inventory

5.6.1 Data sources and assumptions

Bill of Activities. Unit process inventory data

The life cycle inventory includes inputs from technosphere and from nature, as well as emissions to air, water and soil. Unit processes are produced by combining the bill of activities with existing data representing each of the material and energy inputs into the system, as well as accounting for direct raw material use and emissions. In this regard, the cornerstone of LCA studies is the data quality of the inventory. However, agronomic and food process data is limited in many tropical contexts due to deficiency of national statistics, market informality and farm record keeping. In addition, emissions can vary substantially among different sites and even within the same field. Besides, there is a lack of suitable methods to estimate emissions at regional level, namely in Africa (Perrin et al., 2014).

LCI data were originated mainly from Agri-footprint 2.0 database. Ecoinvent v3.1 database was used in wastes and water irrigation. Much of the data in both databases represents European settings and

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[87] Roberts S., Vilakazi T. (2015). *Regulation and rivalry in transport and fertilizer supply in Malawi, Tanzania and Zambia*, University of Johannesburg.

[88] Several other LCA studies recommend inclusion of transportation from and to overseas destinations when assessing transports (see Cooper J.S., Woods L., Lee S.J. (2008). *Distance and backhaul in commodity transport modeling*. Int. Journal of Life Cycle Assessment, 13:389–400).

their use to represent Africa processes and tropical regions may introduce some biased analysis. Therefore, a strong effort was pursued to disclose information from Zambia regarding the table-egg value chain, namely from scientific literature and related databases (open access or not) and internet sources. Modeling feed compositions for breeder flock, pullet and layer facilities, production-weighted average compositions based on producer-reported data was employed and was validated by the largest Zambian egg producer, Goldenlay Limited.

In Annex 2.1 up to Annex 2.5, Crop production, Milling and Feed compounding, Table Egg production, Energy model and Transport model descriptions are presented.

Key assumptions

Foreground data were collected from a breeder flock hatchery, pullet rearing and egg producing facilities with a focus on commercial scale egg production in Zambia. Validation was provided by Goldenlay. All data were collected under a non-disclosure guarantee.

Background system data for the current analysis was carried out to complement foreground data. This included data on crop yields and production, production and supply of feed inputs, water, energy, packaging and transport. Other background system data was mostly derived from Agri-footprint database, modified whenever possible to best approximate Zambia conditions.

Manure management strategies may entail liquid or solid manure handling and storage, variable storage times and varied uses of the manure. An average excretion rate was assumed for both pullet and layer facilities. For mass of liquid manure management systems, manure handled was assumed to be equivalent to the mass of manure excreted. For dry manure management systems, manure handled was assumed equivalent to 50% of manure mass excreted.

National and provincial layer supply chain statistics

National production statistics relating to pullets, eggs and annual feed consumption were provided by PAZ with data from 2011-2016. The mass of one egg was defined as 61.7g on average.

Modeling N, P and methane emissions from poultry manure

A nutrient mass balance model based on feed composition was used to calculate nitrogen and phosphorus excretion rates. In turn, estimated nitrogen excretion rates were used to calculate direct dinitrogen monoxide (NO_2), indirect dinitrogen monoxide (NO2), ammonia and methane emissions from manure management following IPCC (2006) Tier 1 protocols and default emission factors at time of deposition, storage and application. Phosphorus emission to surface water due to the use of manure was calculated following Agri-footprint 3.0 model, based on Struijs *et al.* (2010) (*cf*. Annex 2)

Modeling feed input supply chains

Feed inputs were reported as contributing to breeder flock, pullet and layer feeds. The three major inputs to feeds for egg production supply chain in Zambia are maize, wheat and soybeans. Input data for pesticides and seeds use were obtained from a major commercial crop producer. Energy inputs were based on Agri-footprint 3.0 data. Ammonia, dinitrogen monoxide, nitrate and carbon dioxide emissions are calculated following IPCC (2006) Tier 1 protocol using default emission factors (*cf*. Annex 2).

Data on fertilizers and pesticides imports were taken from United Nations Comtrade Database (Zambia, period 2012 to 2015), complemented with the Republic of Zambia Central Statistical Office Monthly publication (period 2012 to 2014) and were considered transported as defined in following sections. Pre-mixes and supplements vary widely and detailed composition data were not available unfortunately, thus they were excluded from the present LCA analysis.

Deforestation rate in Zambia is estimated to be 1.5% per year, 90% is transformed into crop land - calculation based on Vynia *et al*. (2011) and supported by documents from Goldenlay. Emission factors for direct land use change were estimated based on the PAS2050 methodology as recommended in LEAP Feed Guidelines, using the emission factors provided for Zambia for the three crops cultivated under conventional tillage (Annex 2.1.3)

Compound feed production.

Consumption average feed formulations were modeled using commercial feed composition supplied by Zambia companies and validate by a local egg producing company.

Egg production

The egg production model includes both an egg farm sub-model and parent farm sub-model. The avian development stages considered in each sub-model are the following:

- Parent Farm
    - chicks and pullets (up to 20 weeks old)
    - breeders (21 to 72 weeks old)
    - spent birds / hatching eggs
- Egg Farm
    - chicks (1 to 3 weeks old
    - pullets (4 to 17 weeks old)
    - laying hens (18 to 81 weeks old)
    - spent hens / table eggs

Parent stock was modeled using information provided by Lohmann (2017), while Egg Farm stock model was based on the data provided by Goldenlay. Model details, and emission rates, are presented in Annex 2.3.

Egg packaging

Data was obtained from commercial information in Zambia.

Energy carriers and mixes

Energy life cycle inventory models were taken from the Agri-footprint and EcoInvent database but adapted to the Zambia energy mix. Production-weighted average electricity mixes were modeled for crop input production, feed input processing and breeder flock, hatchery, pullet and layer facilities. Annex 2.2 presents the energy model description.

Transportation

Production-weighted, producer-reported transport modes and distances were applied wherever possible. Assumptions were based on Zambia imports and local information regarding distances and truck types. Annex 2.5 indicates transport model assumptions.

Waste Management

Incineration is the process used to dispose of bird's carcasses. Wastewater treatment and landfill management are practically absent in egg farms' facilities and thus were not considered. Manure land disposal is not within waste management since utilized as an organic fertilizer (cf. 5.2.3). Waste management model assumptions presented in Annex 2.3.

5.6.2 Data quality and assessment method

Existing data from available literature and databases was utilized where possible. Foreground data were collected from egg producers during two field missions (April and July/August 2017) and a validation workshop held in Lusaka in August 2017. The main foreground data was collected from main egg-producing companies. All data were collected under guarantee of non-disclosure with respect to individual facilities. Technology coverage, representativeness, reliability and uncertainty of the information were foreseen as prescribed in ISO 14044.

LCA data quality was addressed considering the methodology proposed by the European Commission in the ILCD Handbook, 2010. This considers the following indicators: i) Technological representativeness (TeR), Geographical representativeness (GR), Time-related representativeness (TiR), Completeness (C), Precision / uncertainty (P) and Methodological appropriateness and consistency (M). Overall LCI Data Quality Rating (DQR) and Data Quality Level (DQL) assessment is prescribed and other methodological information can be obtained in the aforementioned document.

5.7 Impact Assessment

5.7.1 Impact assessment method and indicators

Impact assessment classifies and combines the flows of materials, energy, and emissions into and out of each product system by the type of impact their use or release has on the environment. The method used to evaluate environmental impact was the LCIA method ReCiPe[89], version ReCiPe 2016 Endpoint (H). There are two mainstream ways to derive characterisation factors, i.e. at midpoint level and at endpoint level. ReCiPe calculates 18 midpoint indicators and 3 endpoint indicators. Midpoint indicators focus on single environmental problems and endpoint indicators show the environmental impact on three higher aggregation levels: 1) effect on human health, 2) ecosystems and 3) resource depletion or availability. Converting midpoints to endpoints simplifies the interpretation of the LCIA results but each aggregation step adds uncertainty. Figure 5.2 provides an overview of ReCiPe structure.

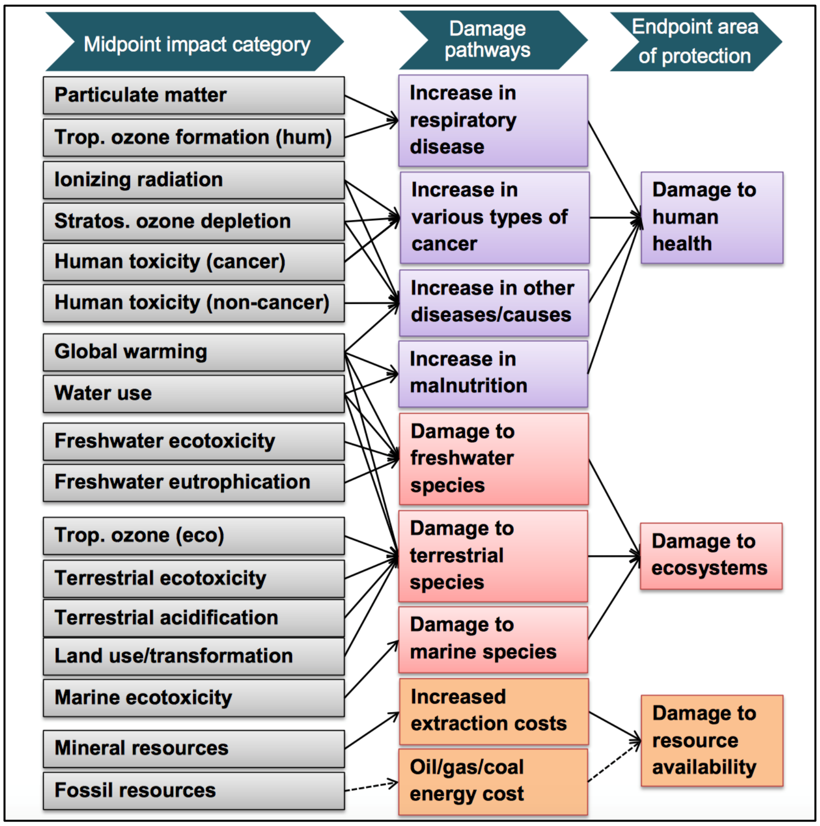


Figure 5.2: Overview of ReCiPe structure.

As can be seen, the endpoint indicators used in the current LCA are based on the following impact categories:

- **Human health impact category**: Impact that can be caused by the release of substances that affect humans through acute toxicity, cancer-based toxicity, respiratory effects, increases in UV radiation, and other causes. The evaluation of the overall impact of a system on human health follows the human health end-point in the ReCiPe methodology, in which substances are weighted

[89] - Goedkoop M.J., Heijungs R, Huijbregts M., De Schryver A.;Struijs J., Van Zelm R (2009). ReCiPe 2008 - A life cycle impact assessment method which comprises harmonised category indicators at the midpoint and the endpoint level; First edition Report I: Characterisation, RIVM Report.
- Huijbregts M.A.J. et al (2016). ReCiPe 2016 - A harmonized life cycle impact assessment method at midpoint and endpoint level, Report I: Characterization RIVM Report 2016-0104.

based on their abilities to cause each of a variety of damages to human health.

- **Ecosystem quality impact category**: Impairment from the release of substances that cause acidification, eutrophication, toxicity to wildlife, land occupation, and a variety of other types of impact. The evaluation of the overall impact of a system on ecosystem quality follows the Ecosystem quality endpoint ReCiPe methodology, in which substances are weighted based on their ability to cause each of a variety of damages to wildlife species.

- **Resources depletion impact category**: Depletion caused when nonrenewable resources are used or when renewable resources are used at a rate greater than they can be renewed; various materials can be weighted more heavily based on their abundance and difficulty to obtain. The evaluation of the overall impact of a system on resource depletion follows the resources end-point in the ReCiPe methodology.

Detailed ReCiPe information can be found at: https://sites.google.com/site/lciarecipe/home.
Finally, it should be noted that LCA is the right tool to assess sustainability complexity but LCIA does not intend to predict whether standards or safety margins are exceeded. The same precaution should be used in midpoints and endpoints analysis.

5.7.2 Calculation tool

SimaPro 8.1. software, developed by PRé Consultants was used to assist modeling, to link the reference flows with the LCI database and to compute the complete LCI of the systems in the present LCA study. LCI results were calculated combining foreground data (intermediate products and elementary flows) with generic datasets providing cradle-to-gate background elementary flows to create an inventory of the two systems.

Main digital database used in SimaPro 8.1 platform was Agri-footprint 2.0. However, whenever considered more appropriate Ecoinvent database v3.3 was used (e.g.: egg packaging, wastes and crop irrigation). Besides, when specific Zambian sources were reliable, data was adjusted as already indicated (see 6.5 Section). Some adjustments were minor (Tier 2) (e.g.: fertilizer compounds) but in some cases were rather significant (e.g.: egg system production).

5.7.3 Contribution analysis

Contribution analysis aims to determine the extent to which each process modelled contributes to the overall environmental impact. In this study, the contribution analysis was simplified and was based on observation of the relative importance of the different processes to the overall potential impact.

5.8 Results

5.8.1 Environmental life cycle inventory results

Life cycle inventory data for the production of 1000 kg of eggs (FU) in Zambia is presented in Table 5-2.

Process	Unit	Total
Crop Production		
Maize, at farm/ZM Mass	kg	3389,76
Soybean, at farm/ZM Mass	kg	1024,24
Wheat grain, at farm/ZM Mass	kg	3415,50
Milling		
Wheat bran, fr. dry milling, at plant/ZM Mass	kg	368,012
Soybean expeller fr. crushing, at plant/ZM Mass	kg	774,36
Maize crushed, from dry milling, at plant/ZM Mass	kg	2542,96
Feed Processing		
Compound feed for laying hens >17 weeks/ZM Mass	kg	3560,47
Compound feed for laying hens <17 weeks/ZM Mass	kg	499,15
Farm		
Consumption Eggs distribution /ZM Mass	kg	1000
Eggs, at farm gate /ZM Mass	kg	1020,4
Consumption eggs (from laying hens >=18w old) , at farm/ZM Mass	kg	1265,8
mass Pullets 4-17 weeks old, breeding, at farm/ZM Mass	kg	71,36
mass Pullets < 4 weeks old, breeding, at farm/ZM Mass	kg	11,18
mass One-day-chicks, at hatchery/ZM Mass	kg	22,68
mass Hatching eggs, layer parents > 20w, at farm/ZM Mass	kg	29,84
mass Pullets parent stock =< 20w, at farm/ZM Mass	kg	3,46
Water extraction		
Crops irrigation	m3	2215,4
Service water	kg	9998,0
Energy		
0 Electricity mix, AC, consumption mix, at consumer, < 1kV/ZM Mass	MJ	6901
Diesel, burned in machine	MJ	12912
Fuel Oil (process steam)	MJ	794
Packaging		
Recicled paper and corrugated board box	kg	113,45

Table 5-2 Life cycle inventory data for the production of 1000 kg of eggs (Zambia).

5.8.2 Environmental Life Cycle Impact Assessment

Egg system perspective

Environmental impacts induced by the Egg VC system in Zambia considering the end point areas of environmental protection Human Health, Ecosystems Quality and Resources Depletion are presented in Table 5.2.

	Table Egg Production System ZM		Crop Production	Milling	Feed Production	Parent Farm	Egg Farm	Egg at Farm Gate	Eggs at Market Gate	Waste Management
Human Health	6.53E-01	DAILY	94.62%	0.64%	0.04%	0.58%	4.03%	0.04%	0.02%	0.04%
Ecossystems	4.78E-03	species.yr	89.88%	0.16%	0.01%	1.98%	7.92%	0.02%	0.01%	0.02%
Resources	9.61E+03	USD2013	88.29%	0.76%	0.08%	0.75%	9.87%	0.08%	0.15%	0.02%
	per 1000 kg of table eggs at market gate		Contribution Analysis							

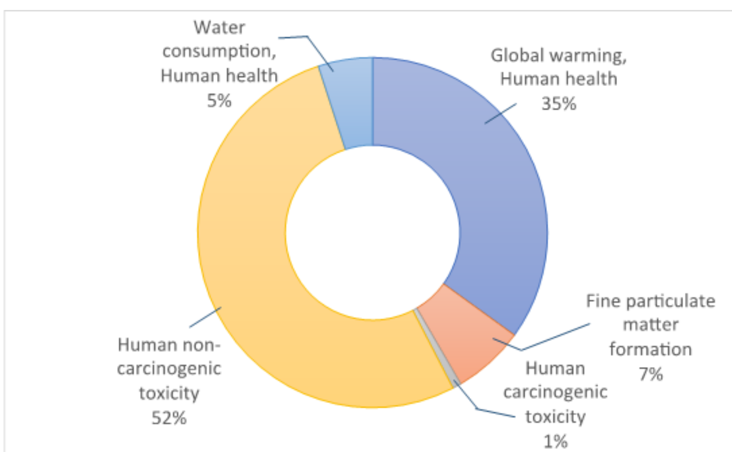
TABLE 5-3. ENDPOINTS RESULTS OF EGG VC SYSTEM (ZAMBIA) - RECIPE 2016 ENDPOINT (H).

Absolute impacts are expressed per functional unit, 1000 kg of table eggs, at market gate. Relative contribution to overall impacts is also provided (relative contribution is painted in red if >50%, in orange if 20-50%, in yellow if 5-20% and green if lower than 5%.

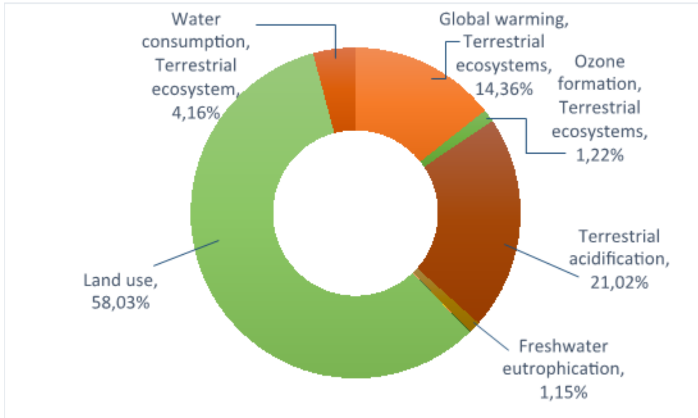
The LCA analysis highlights that Crop Production is by far the most significant environmental impact contributor when considering the entire Egg VC, disregarding the endpoint area of protection. This finding is consistent with most other agri-food LCA cradle to farm gate studies [90]. The second impact contributor is the Egg Farm. These two activities will be analysed in further detail in this Section.

Additional features regarding the environmental impacts of the Egg VC on endpoints areas are presented in Figure 5.3, showing the relative importance of each midpoint impact category.

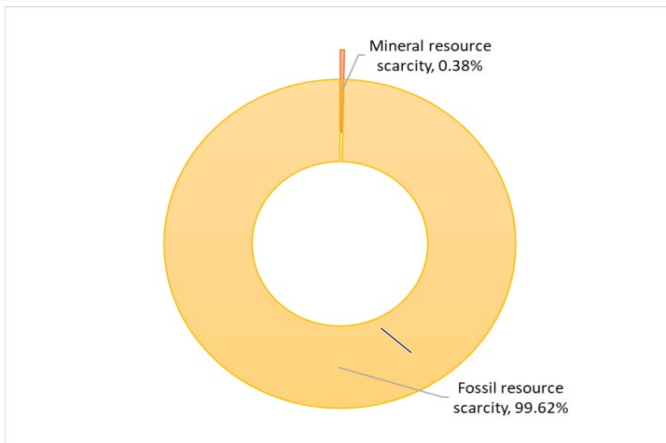
A.



[90] Weidema B., Wenaes H., Wiedemann S., McGahan E. (2011). Environmental Assessment of an Egg Production Supply Chain Using Life Cycle Assessment. Australian Egg Corporation Limited.



B.



C.

FIGURE 5.3. RELATIVE IMPORTANCE OF MIDPOINTS TO DAMAGE CATEGORIES OF EGG VC SYSTEM (ZAMBIA) - HUMAN HEALTH (A), ECOSYSTEMS QUALITY (B) AND RESOURCES DEPLETION (C) - RECIPE 2016 ENDPOINT (H).

As can be seen, Human Non-Carcinogenic Toxicity (52%) and Global Warning (35%) are the most significant midpoints regarding Human Health damage indicator (together they reach 87%). Ecosystem Quality is driven by Land Use occupation of arable land (58%) and terrestrial acidification (21,0%) and Resources Depletion is driven almost entirely by fossil resource scarcity (99,6%).

Human Non-Carcinogenic Toxicity category is mainly caused by metals (namely zinc, Zn) and is related with animal manure application in soils (Zn is a known element in chickens' diets[91]). Global Warning Human Health (nitrogen dioxide from manure (29%) and carbon dioxide (61%) from land transformation (30%), carbon dioxide from diesel consumption in machinery (19,7%) and the remaining is emitted by fertilizers application. Land Use is the main driver in Ecosystems Quality impacts because the use of arable land for crop cultivation hinders natural vegetation presence/re-growth. Extraction and combustion of non-renewable energy sources used for crop cultivation is the main focus on Resources Depletion.

[91] Brock, E. Q.M. Ketterings, and M. McBride (2005). Copper and zinc accumulation in manured soils. What's Cropping Up? 15(5): 5-7. Int. Symposium on Zinc in Soils. 2004.

Table 5-4 presents the absolute impacts of each midpoint category regarding the Egg VC system. Relative contributions of different value chain activities to each midpoint are presented also.

			Crop Production	Milling	Feed Production	Parent Farm	Egg Layers Farm	Eggs at farm gate	Eggs Distribution	Waste Management
Global warming, Human health	2.28E-01	DALY	91.92%	0.55%	0.06%	1.04%	6.23%	0.06%	0.00%	0.10%
Global warming, Terrestrial ecosystems	6.86E-04	species.yr	91.92%	0.55%	0.06%	1.04%	6.23%	0.06%	0.00%	0.10%
Global warming, Freshwater ecosystem	1.87E-08	species.yr	91.92%	0.55%	0.06%	1.04%	6.23%	0.06%	0.00%	0.10%
Stratospheric ozone depletion	1.52E-03	DALY	92.33%	0.00%	0.00%	1.55%	6.04%	0.02%	0.00%	0.06%
Ionizing radiation	6.38E-06	DALY	89.71%	0.11%	2.08%	0.49%	3.52%	3.97%	0.00%	0.10%
Ozone formation, Human health	4.07E-04	DALY	88.40%	0.46%	0.00%	1.53%	9.25%	0.06%	0.00%	0.06%
Fine particulate matter formation	4.32E-02	DALY	63.88%	6.65%	0.31%	2.82%	26.07%	0.21%	0.00%	0.03%
Ozone formation, Terrestrial ecosystem	5.83E-05	species.yr	88.39%	0.46%	0.00%	1.53%	9.27%	0.06%	0.00%	0.06%
Terrestrial acidification	1.00E-03	species.yr	58.94%	0.35%	0.02%	8.47%	32.17%	0.01%	0.00%	0.02%
Freshwater eutrophication	5.49E-05	species.yr	92.81%	0.00%	0.00%	0.97%	6.17%	0.05%	0.00%	0.00%
Terrestrial ecotoxicity	2.20E-06	species.yr	84.23%	0.84%	0.03%	0.42%	14.03%	0.14%	0.00%	0.01%
Freshwater ecotoxicity	1.13E-06	species.yr	98.68%	0.08%	0.00%	0.16%	0.96%	0.11%	0.00%	0.01%
Marine ecotoxicity	1.37E-07	species.yr	96.58%	0.19%	0.00%	0.28%	2.71%	0.20%	0.00%	0.01%
Human carcinogenic toxicity	5.27E-03	DALY	97.05%	0.11%	0.00%	0.33%	2.34%	0.15%	0.00%	0.01%
Human non-carcinogenic toxicity	3.42E-01	DALY	99.97%	0.00%	0.00%	0.00%	0.02%	0.00%	0.00%	0.00%
Land use	2.77E-03	species.yr	99.99%	0.00%	0.00%	0.00%	0.00%	0.01%	0.00%	0.00%
Mineral resource scarcity	3.66E+01	USD2013	99.29%	0.10%	0.00%	0.04%	0.32%	0.25%	0.00%	0.00%
Fossil resource scarcity	9.57E+03	USD2013	88.25%	0.76%	0.08%	0.75%	9.91%	0.08%	0.00%	0.02%
Water consumption, Human health	3.27E-02	DALY	97.79%	0.00%	0.06%	0.42%	1.71%	0.01%	0.00%	0.00%
Water consumption, Terrestrial ecosyst	1.99E-04	species.yr	97.79%	0.00%	0.06%	0.42%	1.71%	0.01%	0.00%	0.00%
Water consumption, Aquatic ecosysten	8.89E-09	species.yr	97.79%	0.00%	0.06%	0.42%	1.71%	0.01%	0.00%	0.00%
per 1000 kg of table eggs at market gate			Contribution Analysis							

TABLE 5-4 MIDPOINTS RESULTS OF EGG VC SYSTEM (ZAMBIA) - RECIPE 2016 ENDPOINT (H).

Absolute impacts are expressed per functional unit, 1000 kg of table eggs, at market gate. Relative contribution to overall impacts is also provided (relative contribution is painted in red if >50%, in orange if 20-50%, in yellow if 5-20% and green if lower than 5%.

Table 5-4 reveals that Crop Production is the core activity trigger along the entire Egg VC on all damage pathways (always higher than 50%), namely in particles air emissions (63,8%) and terrestrial acidification (58,9%). Second main activity is Egg Layer Farm with a similar focus in terrestrial acidification (32,2%) and air particle emissions (26,1%).

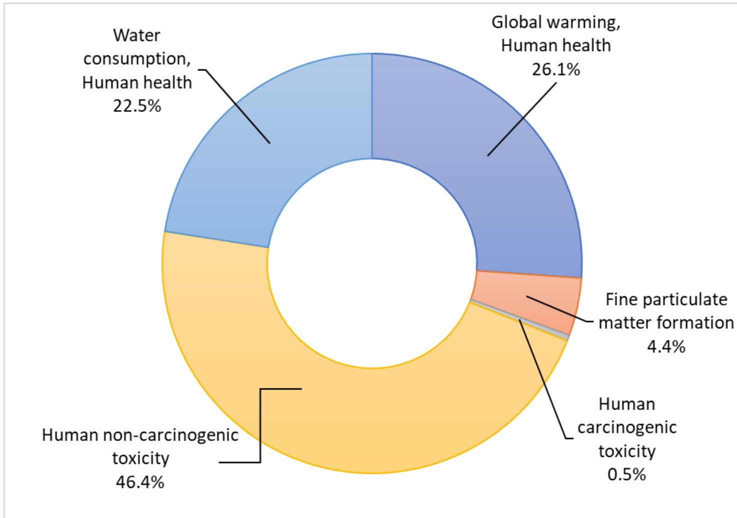
5.8.3 Egg VC: focus on crop production

Because Crop Farming was identified as the main activity regarding impact magnitude on Egg VC environmental endpoints, a more detailed analysis was carried out over such activity. Crop Production impacts are addressed by Table 5-4, Table 5-5 and Figure 5.4 Table 5.3 presents the analysis for Human Health, Ecosystems Quality and Resources Depletion indicators in Zambia.

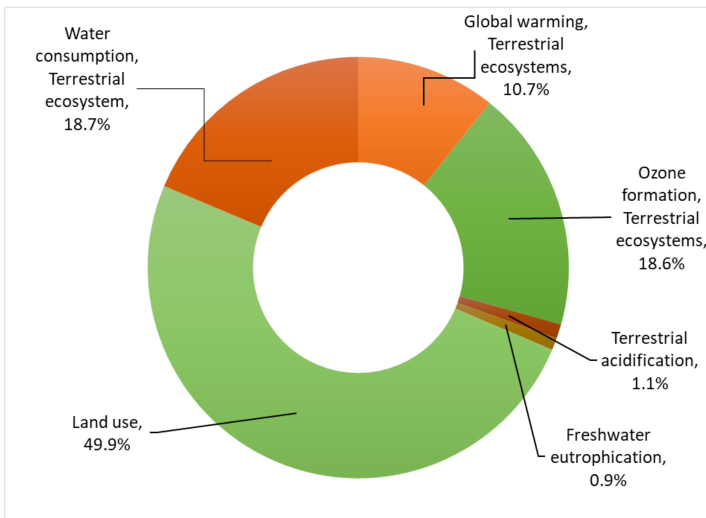
	Table Egg Production System ZM		Crop Cultivatior	Seeds	Pesticides	Fertilizers	Irrigation	Energy	Transport
Human Health	4.29E-02	DAILY	67.57%	1.22%	0.48%	2.06%	24.75%	1.86%	2.06%
Ecossystems	2.92E-04	species.yr	74.47%	1.39%	0.20%	0.90%	21.04%	0.48%	1.52%
Resources	5.38E+02	USD2013	35.14%	0.53%	2.02%	24.49%	14.16%	1.91%	21.75%
	per 1000 kg of table eggs at market gate		Contribution Analysis						

TABLE 5-5. CROP PRODUCTION - ENDPOINTS RESULTS OF CROP PRODUCTION IN EGG VC (ZAMBIA) - RECIPE 2016 ENDPOINT (H). Absolute impacts are expressed per functional unit, 1000 kg of table eggs, at market gate. Relative contribution to overall impacts is also provided (relative contribution is painted in red if >50%, in orange if 20-50%, in yellow if 5-20% and green if lower than 5%.

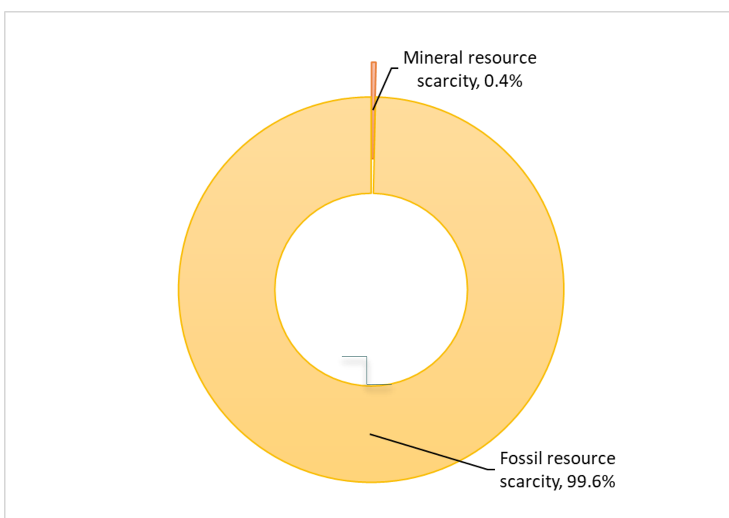
Crop Cultivation is the most important sub-activity impacting Human Health and Ecosystems Quality descriptors (>50%). Crop Cultivation and Fertilizer are the most important drivers regarding Resources Depletion (67,6% and 74,5%), but Transport is also significant (22%). Irrigation has also some importance in Human Health and Ecosystems. Pesticides role was not captured in this analysis (<5%). Additional information regarding the relative importance of each midpoint impact category in the aforementioned endpoints is presented in Figure 5.4.



A.



B.



C.

FIGURE 5.4 CROP PRODUCTION - RELATIVE IMPORTANCE OF MIDPOINTS TO DAMAGE CATEGORIES OF EGG VC (ZAMBIA) - HUMAN HEALTH (A), ECOSYSTEMS QUALITY (B) AND RESOURCES DEPLETION (C) - RECIPE 2016 ENDPOINT (H).

Figure 5.4 shows that Human Health is driven by Human non-carcinogenic toxicity (46%). Ecosystems Quality indicator by Land Use (50%) and Resources Depletion is completely dominated by Fossil Resource Scarcity.

Absolute impacts of each midpoint category regarding *Crop Production*, as well as the relative contributions of different value chain activities to each midpoint, are presented in Table 5-6.

			Crop Cultivation	Seeds	Pesticide Production	Fertilizer Production	Irrigation	Energy	Transport
Global warming, Human health	1.12E-02	DALY	77.78%	1.29%	1.06%	6.67%	4.22%	1.94%	7.03%
Global warming, Terrestrial ecosystems	3.37E-05	species.yr	77.77%	1.29%	1.06%	6.67%	4.22%	1.94%	7.04%
Global warming, Freshwater ecosystems	9.21E-10	species.yr	77.77%	1.29%	1.06%	6.67%	4.22%	1.94%	7.04%
Stratospheric ozone depletion	8.69E-05	DALY	93.37%	1.59%	0.04%	4.70%	0.18%	0.00%	0.12%
Ionizing radiation	3.08E-07	DALY	43.61%	0.73%	27.21%	11.42%	13.88%	0.32%	2.84%
Ozone formation, Human health	2.42E-05	DALY	37.73%	0.56%	0.03%	1.21%	23.61%	1.56%	35.32%
Fine particulate matter formation	1.90E-03	DALY	28.21%	0.43%	4.37%	6.90%	25.66%	30.30%	4.11%
Ozone formation, Terrestrial ecosystems	5.86E-05	species.yr	37.78%	0.56%	0.03%	1.26%	23.72%	1.56%	35.09%
Terrestrial acidification	3.46E-06	species.yr	91.42%	1.56%	0.29%	0.87%	1.71%	1.92%	2.24%
Freshwater eutrophication	2.85E-06	species.yr	97.68%	1.80%	0.03%	0.30%	0.18%	0.00%	0.01%
Terrestrial ecotoxicity	8.82E-08	species.yr	57.67%	1.82%	0.58%	1.37%	7.19%	1.85%	29.52%
Freshwater ecotoxicity	4.99E-08	species.yr	93.85%	3.22%	0.14%	0.05%	1.53%	0.38%	0.83%
Marine ecotoxicity	6.27E-09	species.yr	89.60%	2.80%	0.21%	0.43%	2.96%	0.67%	3.33%
Human carcinogenic toxicity	1.95E-04	DALY	90.05%	0.99%	0.22%	0.66%	5.15%	0.42%	2.51%
Human non-carcinogenic toxicity	1.99E-02	DALY	98.06%	1.84%	0.01%	0.00%	0.05%	0.02%	0.03%
Land use	1.57E-04	species.yr	98.03%	1.91%	0.06%	0.00%	0.00%	0.00%	0.00%
Mineral resource scarcity	1.98E+00	USD2013	13.15%	0.21%	0.16%	84.42%	1.37%	0.37%	0.32%
Fossil resource scarcity	5.36E+02	USD2013	35.22%	0.53%	2.03%	24.27%	14.21%	1.92%	21.83%
Water consumption, Human health	9.65E-03	DALY	0.09%	0.00%	0.03%	0.02%	99.86%	0.00%	0.00%
Water consumption, Terrestrial ecosystem	5.87E-05	species.yr	0.09%	0.00%	0.03%	0.02%	99.86%	0.00%	0.00%
Water consumption, Aquatic ecosystems	2.63E-09	species.yr	0.09%	0.00%	0.03%	0.02%	99.86%	0.00%	0.00%
per 1000 kg of table eggs at market gate			Contribution Analysis						

TABLE 5-6. CROP PRODUCTION- MIDPOINTS RESULTS OF CROP PRODUCTION IN EGG VC (ZAMBIA) - RECIPE 2016 ENDPOINT (H).

Absolute impacts are expressed per functional unit, 1000 kg of table eggs, at market gate. Relative contribution to overall impacts is also provided (relative contribution is painted in red if >50%, in orange if 20-50%, in yellow if 5-20% and green if lower than 5%.

The most significant activity is Crop Cultivation, particularly Land Use and Humana Non-Carcinogenic activities. Fertilizer Production and Irrigation are also important. Pesticides, Energy and Transport are remaining activities with significant impacts.

5.8.4 Egg VC: focus on egg farm

Table 5-7 presents the analysis for Human Health, Ecosystems Quality and Resources Depletion

Endpoint indicators in Zambia for egg production activity per se. Egg Farm combines all egg production phases after parent.

	Table Egg Production System ZM		Parent Farm	Egg Farm Phase 1	Egg Farm Phase 2	Egg Farm Phase 3	Egg Farm Phase 4	Egg Farm Total	Packaging	Waste Management
Human Health	6.53E-01	DAILY	20.71%	2.01%	10.39%	10.76%	56.06%	79.21%	0.03%	0.05%
Ecossystems	4.78E-03	species.yr	21.00%	0.61%	9.77%	11.53%	57.05%	78.96%	0.01%	0.03%
Resources	9.59E+03	USD2013	19.60%	7.21%	11.19%	9.83%	52.07%	80.30%	0.08%	0.02%
	per 1000 kg of table eggs at market gate		Contribution Analysis							

TABLE 5-7. EGG FARM - ENDPOINTS RESULTS OF EGG TABLE PRODUCTION (ZAMBIA) - RECIPE 2016 ENDPOINT (H).

Absolute impacts are expressed per functional unit, 1000 kg of table eggs, at market gate. Relative contribution to overall impacts is also provided (relative contribution is painted in red if >50%, in orange if 20-50%, in yellow if 5-20% and green if lower than 5%.

Figure 5.5 provides further details about egg table production impacts connection to endpoints.

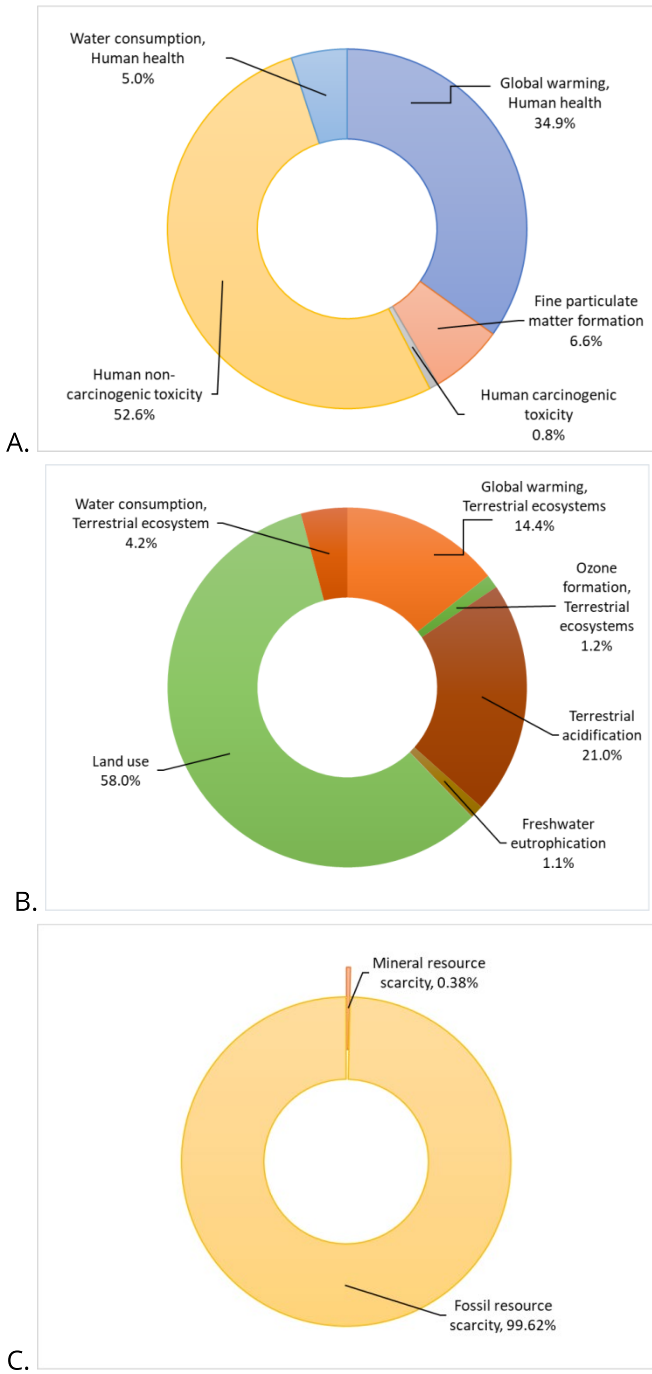


FIGURE 5.5. EGG FARM - RELATIVE IMPORTANCE OF MIDPOINTS TO DAMAGE CATEGORIES OF EGG TABLE PRODUCTION (ZAMBIA) - HUMAN HEALTH (A), ECOSYSTEMS QUALITY (B) AND RESOURCES DEPLETION (C) - RECIPE 2016 ENDPOINT (H).

Human non-carcinogenic activities (53%) and global warming (35%) are main issues when regarding Human Health indicator. Human non-carcinogenic activities are connected with the potential presence of metals (namely Zn) in soils. The main source of this potential contamination is located in the hen layer period (Phase 4) (57%), but the parent farm phase is also significant (21%).

Regarding Ecosystem Quality indicator, the Land Use midpoint contribution (58%) is caused by crop production, mostly related to maize (65%) and soybean (29%). Terrestrial Acidification signifies another important contribution (21.0%), being caused by manure management and related nitrogen ammonia emissions. Around 53% of ammonia emissions occur during the hen lay phase and 20% of emissions result from the parent farm phase, while pullets contribute with 13%. It should be noted that ammonia compounds are responsible for 93% of all emissions pressures towards Terrestrial Acidification. Resources Depletion is driven exclusively by Fossil Resource Scarcity (99%), which is related with fuel consumption in the egg production facilities.

Table 5-8 presents the absolute and relative impacts of each midpoint category regarding the egg production industry (Egg Farm).

				Egg Farm						
			Parent Farm	Egg Farm Phase 1	Egg Farm Phase 2	Egg Farm Phase 3	Egg Farm Phase 4	Total	Packaging	Waste Management
Global warming, Human health	2.27E-01	DALY	20.59%	2.37%	10.29%	10.83%	55.77%	79.25%	0.04%	0.13%
Global warming, Terrestrial ecosystems	6.86E-04	species.yr	20.59%	2.37%	10.29%	10.83%	55.77%	79.25%	0.04%	0.13%
Global warming, Freshwater ecosystems	1.87E-08	species.yr	20.59%	2.37%	10.29%	10.83%	55.77%	79.25%	0.04%	0.13%
Stratospheric ozone depletion	1.52E-03	DALY	21.05%	0.28%	10.00%	11.34%	57.26%	78.87%	0.00%	0.07%
Ionizing radiation	6.37E-06	DALY	19.89%	1.60%	10.81%	9.94%	53.70%	76.04%	3.95%	0.12%
Ozone formation, Human health	4.06E-04	DALY	20.35%	3.23%	14.29%	9.87%	52.13%	79.53%	0.04%	0.08%
Fine particulate matter formation	4.32E-02	DALY	17.79%	17.60%	12.19%	8.51%	43.68%	81.97%	0.20%	0.04%
Ozone formation, Terrestrial ecosystems	5.82E-05	species.yr	20.34%	3.25%	14.29%	9.87%	52.13%	79.53%	0.04%	0.08%
Terrestrial acidification	1.00E-03	species.yr	21.00%	0.96%	7.62%	13.81%	56.58%	78.96%	0.01%	0.03%
Freshwater eutrophication	5.49E-05	species.yr	20.58%	2.22%	12.99%	10.24%	53.92%	79.37%	0.05%	0.00%
Terrestrial ecotoxicity	2.19E-06	species.yr	18.46%	12.86%	9.66%	9.52%	49.36%	81.39%	0.14%	0.01%
Freshwater ecotoxicity	1.13E-06	species.yr	21.04%	0.36%	10.76%	11.03%	56.69%	78.84%	0.11%	0.01%
Marine ecotoxicity	1.37E-07	species.yr	20.74%	1.69%	10.87%	10.80%	55.70%	79.05%	0.20%	0.01%
Human carcinogenic toxicity	5.27E-03	DALY	20.84%	1.06%	10.81%	10.48%	56.65%	79.00%	0.15%	0.01%
Human non-carcinogenic toxicity	3.42E-01	DALY	21.12%	0.01%	10.18%	10.93%	57.75%	78.87%	0.00%	0.00%
Land use	2.77E-03	species.yr	21.12%	0.00%	10.19%	10.94%	57.74%	78.87%	0.01%	0.00%
Mineral resource scarcity	3.66E+01	USD2013	21.03%	0.20%	10.08%	10.79%	57.65%	78.72%	0.25%	0.00%
Fossil resource scarcity	9.55E+03	USD2013	19.60%	7.23%	11.20%	9.83%	52.05%	80.30%	0.08%	0.02%
Water consumption, Human health	3.27E-02	DALY	21.13%	0.01%	10.79%	11.42%	56.64%	78.86%	0.01%	0.00%
Water consumption, Terrestrial ecosyster	1.99E-04	species.yr	21.13%	0.01%	10.79%	11.42%	56.64%	78.86%	0.01%	0.00%
Water consumption, Aquatic ecosystems	8.89E-09	species.yr	21.13%	0.01%	10.79%	11.42%	56.64%	78.86%	0.01%	0.00%
per 1000 kg of table eggs at market gate			Contribution Analysis							

TABLE 5-8. EGG FARM - MIDPOINTS RESULTS OF EGG PRODUCTION (ZAMBIA) - RECIPE 2016 ENDPOINT (H). Absolute impacts are expressed per functional unit, 1000 kg of table eggs, at market gate. Relative contribution to overall impacts is also provided (relative contribution is painted in red if >50%, in orange if 20-50%, in yellow if 5-20% and green if lower than 5%.

The most significant activity considering all middle point indicators is Egg Farm (Phase 4), which comprises hen layers processes (always with a contribution to midpoints impact categories between

43 and 58%. Parent Farm activities are relevant also, in general reaching around 20%. It should be noted that manure land disposal is not within Waste Management because is reused, thus emissions from manure are a key point in egg layer production (occurring at Egg Farm Phase 4), as it will be discussed later in the Discussion section.

5.8.5 Inventory Data Quality Assessment

Data quality assessment was carried out according to ILCG Handbook methodology, as described in this study, Section 5.5. The rating of LCA inventory data is presented in Table 5-9.

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Flux	Indicator / Component						DQR	DQL
	TER	GR	TiR	C	P	M		
Plant Production /Fertilisers (inorganic)	1	1	2	2	3	2	2,3	Basic quality
Plant Production /Fertilisers (organic)	1	1	2	2	3	2	2,3	Basic quality
Plant Production /Pesticides	1	1	2	2	3	2	2,3	Basic quality
Plant Production /Irrigation	2	1	2	2	3	2	2,4	Basic quality
Plant Production /Seeds	1	1	2	2	3	2	2,3	Basic quality
Crop Production	2	1	2	2	3	2	2,4	Basic quality
Milling	2	3	2	2	4	2	3,1	Data estimate
Animal Feed	1	3	2	2	3	2	2,5	Basic quality
Animal Production /Parents	2	2	2	2	3	2	2,5	Basic quality
Animal Production /Layers	1	1	2	2	2	2	1,8	Basic quality
Food\Egg Production	1	1	2	2	2	2	1,8	Basic quality

TABLE 5-9. EGG VC LCA (ZAMBIA) - DATA QUALITY RATING

Layer production and egg processing are the best rated in terms of data quality despite being within the Basic Quality frame. The effort in collecting data during the field visits and further contacts with egg production companies explains this result. On the contrary, milling processes are the most doubtful, being classified as Data Estimate only. This degree of knowledge seems fair enough to drive significant LCA conclusions and recommendations on the egg value chain from a policy perspective, the ultimate goal of the VCA study. Nevertheless, data quality could be improved if more time was allocated to such long and complex value chain, but a reasonable compromise was attained.

5.9 Discussion

The table egg production value chain is a complex system when a cradle to market approach is applied. The LCA study of Egg VC in Zambia confirmed this perspective regarding technological processes and potential environmental impacts spread along the value chain, as noted in the previous section of this chapter.

Considering how the Egg VC impacts on Human Health, Ecosystems Quality and Resources Depletion, the most relevant environmental aspects are evident from the hotspot analysis provided in Table 5-10. Each Table Egg Stage Production activity's impact is shown as a relative contribution to endpoints.

		Crop Production	Milling	Feed Production	Parent Farm	Egg Farm	Eggs at farm gate	Eggs Distribution	Heavy Metals field emission (soil and water)	Pesticides field emission (soil ad water)	P field emission (water)	Nitrate field emissions (air)	Ammonia field emissions (air)	CO2 field emissions (air)	NO2 field emissions (air)
Human Health	Global warming, Human health	16,0%	0,1%	0,0%	0,2%	1,1%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	11,4%	5,5%
	Stratospheric ozone depletion	0,1%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,1%
	Ozone formation, Human health	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
	Ionizing radiation	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
	Fine particulate matter formation	2,1%	0,2%	0,0%	0,1%	0,9%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
	Human carcinogenic toxicity	0,4%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,3%	0,0%	0,0%	0,0%	0,0%	0,0%
	Human non-carcinogenic toxicity	26,2%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	26,2%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
	Water consumption, Human health	2,4%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
Ecosystems	Global warming, Terrestrial ecosystems	6,6%	0,0%	0,0%	0,1%	0,4%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	4,7%	2,3%
	Global warming, Freshwater ecosystems	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
	Ozone formation, Terrestrial ecosystems	0,5%	0,0%	0,0%	0,0%	0,1%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
	Terrestrial acidification	6,2%	0,0%	0,0%	0,9%	3,4%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	9,7%	0,0%	0,0%
	Freshwater eutrophication	0,5%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
	Terrestrial ecotoxicity	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
	Freshwater ecotoxicity	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
	Marine ecotoxicity	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
	Land use	29,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
	Water consumption, Terrestrial ecosystem	2,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
	Water consumption, Aquatic ecosystems	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
Resources	Mineral resource scarcity	0,2%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
	Fossil resource scarcity	44,0%	0,4%	0,0%	0,4%	4,9%	0,0%	0,1%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%

relative contribution to endpoints

0%	] 0% - 1%]	] 1% - 10%]	]10% - 20%]	> 20%

TABLE 5-10. SUMMARY OF HOTSPOTS IN EGG VC SYSTEM (ZAMBIA) - RECIPE 2016 ENDPOINT (H).

From the hotspot analysis the following aspects may be highlighted regarding the Egg VC in Zambia and the areas of protection Human Health, Ecosystems Quality and Resources Depletion:

Human health impacts are driven by:-

- the heavy metal emissions to soil from zinc and cadmium due to field application of fertilizers and pesticides for crop production;

- the dinitrogen monoxide emissions to air from field application of fertilizers, as well as carbon monoxide and particulate matter emitted to the air from fuel combustion associated to crop production;
- the water consumption due to irrigation for crop production.

Ecosystem impacts are driven mainly by:-
- the occupation of arable land due to the cultivation of maize, soybean and wheat;
- the terrestrial acidification due to ammonia emission to air arising from field application of fertilizers and from poultry rearing;
- the global warming due to the dinitrogen monoxide and carbon monoxide emitted to the air from field application of fertilizers and from fuel combustion associated to crop production;
- the water consumption, driven by irrigation water used to cultivate the wheat, maize and soybean.

Resource scarcity impact is driven largely by the extraction of fuel required to power transport vehicles as well as crop farm machinery and egg farm equipment.

Other environmental considerations based on the LCA findings relating to grain production, chicken manure and transport of crop inputs and layer feed are detailed below:

Grain production related emissions

Soil fertility and structure – Large quantities of fertilizers are used in maize and wheat production for layer feed in Zambia because tropical soil structure is inherently fragile. This was evident from LCA impact assessment and endpoint damage indicators. In addition, contaminants present in chicken manure can accumulate in soil and pose a human health/ecosystems quality risk in the long term. Well integrated crop-manure management is required to prevent negative environmental tradeoffs.

Groundwater and surface water – Potential runoff and subsurface flow contamination effects are associated with wastewater/wastes discharges from table egg production facilities, from manure/fertilizer/pesticides disposal in soils or just from waste spills. In this case, human and animal health risks are associated with drinking water contamination or indirect contact. Pesticides and trace elements (e.g. zinc, cadmium) may also endanger human health and ecosystems. Other compounds, namely antibiotics, hormones and other xenobiotic, have a low-level concentration that are difficult to assess/quantify if exact feed composition is not known. Considering that these dangerous substances are out of the scope of the current LCA, a long-term monitoring is recommended in order to protect potentially endangered ecosystems.

Atmosphere – Direct impacts include those on human health (caused by nitrogen oxides and air particulates but also odour-causing compounds) and contribution to global warming (due to carbon dioxide and nitrous oxide emissions) from manure management, the egg production process and other related activities such as feed production and transport of finished products. Volatilized ammonia can be re-deposited and may contribute to damage terrestrial ecosystems. Resources Depletion has less carbon dioxide emissions than one could expect. These emissions are represented on Global Warming midpoint and, the interesting point, is that the energy mix in Zambia is represented by a significant hydropower offer.

Chicken manure processing, transport and disposal approaches

As already stated, a critical determinant of emissions is chicken manure management. Manure application to soils is the most common disposal method in Zambia. This method requires limited additional investment or technical know-how (compared to alternatives such as bio-gas or formulation of feeds for beef or dairy cattle). There is further room for improvement in manure management, both environmental and economic. This is a key area from the environmental pollution control perspective. Governmental guidance and any regulations and inspection should be clear regarding chicken manure application schedules and loads in soils.

Egg production facilities should avoid or mitigate noxious emissions related to manure management. Concerns over air emissions from manure bioconversion processes that occur during housing, storage, transport and land spreading are related to nitrogen losses - ammonia (NH_3) and nitrous oxide (N_2O) - and methane (CH_4) to a lesser extent. In addition, manure transport to final destination is a GHC emission trigger due to vehicle fuel combustion. These issues are discussed below.

Application of manure to cropland is positive from the point of view of nutrient recycling, reducing mineral fertilization needs[92]. Chicken manure is rich in nutrients like nitrogen, phosphorus and potassium, all of which are needed for plant growth. A drawback is related to potential aquifer contamination by nitrates due to over-application rates or metal contamination, namely zinc. Moreover, a serious concern has emerged more recently about the fate of endocrine disruptors and contaminants in animal sludge (antibiotics, metals) revealed in LCA toxicity impact category in wastewater treatment plants[93]. Given the amount of manure generated per year and the limited nutrient soil and plant absorption capacity in Zambian soils, concerns on manure application overloading are unavoidable. In order to guarantee public health, as well as soils and ecosystems protection, water monitoring programmes should be reinforced, including appropriate chemical analysis. Governmental regulations on applied loads and time/season of application should be prescribed (for instance, application of manure during times of heavy rain increases contamination risks).

Until now, only one large-scale egg producer in Zambia has invested in organic fertilizer manufacturing, Chicola™ fertilizer. Biological composting and pelletization of dried manure is an interesting market option, in particular for medium/smaller egg producers. Pelletization stabilizes the organic material and allows it to be easily handled and increase the acceptability of the product as organic fertilizer, providing an alternative source of nitrogen during times of high commercial fertilizer prices. Therefore, investments in supplemental drying and pelletization may be profitable given the

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[92] Mkhabela T.S. (2004). *Substitution of fertiliser with poultry manure: is this economically viable?* Agrekon, 43, 3, 347-356.

[93] Lorenzo-Toja Y, Alfonsín C, Amores MJ, Aldea X, Marin D, Moreira Mt, Feijoo G (2016). *Beyond the conventional life cycle inventory in wastewater treatment plants*. Science of the Total Environment 553, 71–82.

growing recognition of the value of manure in increasing soil organic matter, capacity to retain water and slow release of nutrients. The content of manure pellets should be well controlled by producers and authorities in order to guarantee a healthy and safe soil amendment. In this regard, all measures to prevent manure contamination will be opportune to provide better compost quality. A side benefit of manure pelletization is fertilizer import reduction, thus reducing manufacturing and transport environmental impacts.

When manure production is very significant (e.g.: Goldenlay, Quantum, Zambeef) biogas production (methane) is a profitable option for producing electricity (allowing co-digestion of animal excreta with crop wastes also)[94]. Biogas systems (biomethanization) are based on anaerobic processes engineered for wastewater/sludge treatment-valorisation. Methane is a valuable energy carrier that can be used in internal combustion engines. Thus, biogas will contribute to replace electricity needs, avoiding GHG emissions from fuel oil generators used to mitigate hydropower disruptions in Zambia. In addition, if biogas plants are placed next to egg layer facilities, they mitigate the impact of manure transport to final disposal sites. Anaerobic biological processes will mineralize input organic matter and will yield only 10-15% of bio-solids, which can be further composted and easily applied for soil amendment. Biomethanization or/and pelletization minimise the environmental impact of manure transport and other negative impacts (e.g. air pollution, noise, dust and general traffic risks).

While the investment costs of biogas technologies for electricity production are significant, the pay back period could be rather short (less than 7 years). This option deserves attention from international funding organisations or/and commercial banks in order to support such investments. Biogas operation will require appropriate training to be put in place.

Odour abatement (e.g. sulphide or ammonia volatilization) prior to biomethanization or composting processes requires appropriate measures because the odour may be offensive to neighbouring residential areas. Nitrogen conservation may be improved via several strategies. Best practices on manure management will minimize nitrogen losses both at the time of excretion and during storage and application. Farmers training and education on nitrogen management and odour control techniques are necessary.

Transport of fertilizers and pesticides

Road transport costs from South Africa through Zimbabwe or Botswana to Zambia are critical for ensuring access to fertilizers at competitive prices (effective transport road time is 8 days[95]). If marine with road transport are compared in the same base, the first is an environmentally more efficient method of transport than the former (CO_2 emissions per metric ton-mile are 0.1139 kg and marine ship are 0.0161 kg only). As a rule, road transport of fertilizer from the arrival port to Lusaka has a higher environmental impact than the marine transport to an African port. A competitive

[94] Hansupalak N, Piromkraipak P, Tamthirat P, Manitsorasak A, Sriroth K, Tran T., (2016). *Biogas reduces the carbon footprint of cassava starch: a comparative assessment with fuel oil*. Journal of Cleaner Production, 134 (2016) 539-546.

[95] https://www.cma-cgm.com/static/eCommerce/Attachments/CMACGM-intermodal-africa-transit-times.pdf

environmental option may be the port of Beira in Mozambique, which was recently upgraded and is able to handle bulk fertilizers. Therefore, logistics, bureaucracy and proper roads should be improved in order to reduce transit time between Beira and Lusaka, which remains the same 8 days as Durban-Lusaka (actually, it is 4 days is for road transport in itself, while 4 days is spent in port handling). Dar es Salaam port delivery and transport time to Zambia is even worst (13 to 14 days). Nevertheless, marine transport distances should be kept as low as possible in order to reduce navigation risks and air emissions. Thus local/regional near-by fertilizers/pesticides manufacturers should be preferred when price is competitive.

Feed composition

It is known that an important environmental issue in egg industry is feed composition and feed conversion efficiency in breeder flocks, pullet rearing and laying flocks. Obtaining the exact details of feed composition is difficult because of proprietary formulations. Specific feed formulations are typically geared to the requirements of different stages of physiological development, and particular chicken breeds. Some adaptations to feed formulations are made by local Zambian producers in order to fit demand requirements (or to lower costs).

A detailed analysis of this issue is out of the scope of this LCA, but the subjects are known from the technical and scientific literature. Thus, governmental regulation should be strict regarding formulation and should promote content transparency (e.g. regarding priority substances and dangerous substances, as mentioned in the EU Water Framework Directive and related directives).

Small scale egg producers

Egg producing systems seems to raise similar environmental impacts disregarding the scale of production and type of industrial processing according to literature (Pelletier et al., 2013; Ghasempour and Ahmadi, 2016; Pelletier, 2017). For instance, Pelletier, 2017, assessed several housing technologies - somehow corresponding with different scales/modes of production - and results were rather similar regarding life cycle inventory and impact assessment. Indeed, quite similar levels of environmental performance among all non-organic systems were identified. The reason is because main environmental impact driver of egg production industry is related with feed production and the use in pullet and layer facilities. In this regard, the commercial agriculture requirements for feed formulation are rather independent of scale, only the organic mode use different inputs. Having said that, the single potential difference among the large-scale egg production systems and the remaining ones may concern manure management (Ghasempour and Ahmadi, 2016). Chicken manure produced by deconcentrated egg production systems may be spread over a large (disperse) area with better nitrogen use efficiency and with lower emissions of nitrous oxides. In addition, lower mineral fertilizer requirements may be expected in those places. This potential is more probable to occur in micro-production (less than 100 hens) and not so much in the remaining small-scale producers.

5.10 Conclusions and recommendations

5.10.1 Conclusions

Environmental LCA TOR regarding the sustainability of the egg value chain in Zambia addresses **three core impact questions: human health, ecosystems quality and resources depletion**. The answer to these questions are summarised below:

What is the potential impact of the value chain on human health?

- The evidence obtained indicates a very <u>low environmental impact</u> but there are risks which need to be minimised. The risks are related to pesticides application on crops (required to feed the birds) and chemicals present in feed formulations that are excreted after intake by chicken population.
- In general, the impact of these on human health are not significant, tend to be localised and may be reversible. Moreover, feasible mitigation measures are available, including health standards, environmental regulations, and best practices/environmental management systems. These measures are either mandatory in the food industry and agriculture practices and require effective enforcement. For instance, adoption of relevant environmental management systems need to be encouraged in Zambia. Additionally, awareness campaigns (through local leadership) and advisory services provided through public extension services and by agri-businesses may contribute to effectiveness.

What is the potential impact of the value chain on ecosystem quality?

- There is a <u>medium environmental impact</u>, in particular regarding chicken manure disposal and potential groundwater contamination and emission of nitrous oxides into the air emissions (when manure is stocked or there is overloading of manure disposal on land).
- These problems occur more at the level of large-scale egg producers. The impacts may be significant but usually local in scale and may be reversible. Mitigation measures are available in the environmental protection technology market and are already mainstreamed in many countries. However, environmental technologies may require significant investments and skilled operation.
- Manure treatment-valorisation processes is linked to core question number 3 considering energy (biogas) recovery and/or organic compost production (please see below).

What is the potential impact of the value chain on resources depletion?

- There is a <u>very low environmental impact</u>, namely in non-renewable resources consumption required for fertilizers/pesticides production and energy carriers in feed production, egg production facilities and transportation (transports at regional and trans-boundary scale).

- The impacts are not significant, but may have a diffuse regional scale. If organic loads provided by manure disposal in land are higher than crop requirements, or if the water table is high, soil and groundwater quality may be jeopardized. Nitrogen emissions from manure bio-denitrification processes may be significant too, but can be minimised if properly managed, an issue already mentioned above.
- Additional but minor mitigation measures are possible regarding energy and materials conservation, although they are rather difficult to apply in practice. An exception may be adjustments in transportation paths of fertilizers/pesticides, aiming at minimisation fuel/oil consumption and vehicle conservation (e.g. to increase the use of Beira Port in Mozambique as an optional gate).

In addition, the following points should be highlighted. Most of these points are related to the aforementioned core questions:

- Manure disposal is the most significant issue in large-scale egg production in Zambia. It should be perceived as an opportunity not as a problem. Bioenergy (biogas) production derived from anaerobic treatment of manure is a potential process with the benefits of reducing external dependence on fuel, capturing emissions and improved treatment of manure. The financial feasibility of bioenergy recovery from manure deserves assessment, particularly for corporate egg producers.

  Composting is a suitable technology for medium and small-scale egg producers, and also for large-scale producers if biogas projects are not applied. Compost application in land will minimise macronutrients requirements by crops, saving mineral resources and will restore organic soil structure and properties. A large-scale egg producer in Zambia that is currently producing compost from chicken manure provides a good example of this option. Because manure composting is a low cost technology for soil conservation and resources recovery, other egg producers should follow the concept.

- It should be noted that the current LCA study didn't assess the presence of heavy metals or endocrine disruptors in manure

  - Groundwater contamination in the vicinity of mining industries (Copperbelt region) is an emerging problem in some locations and may negatively affect the quality of groundwater used in egg production facilities, especially in the Copperbelt.

- Efforts to increase food production by smallholder farmers should encompass the water and energy nexus in order to reinforce positive social and environmental impacts in rural areas. This strategy will require appropriate but simple onsite sanitation technologies connected to small-scale biogas or composting facilities (e.g. urine diversion toilets, biogas digesters and composting reactors). This issue was not covered in the LCA study but deserves mention.

5.10.2 Recommendations

The present document is expected to encompass recommendations addressing resource use efficiency and emissions mitigations in the Zambian egg value chain. The driving force for such recommendations is the EU mainstream policy towards supporting environmental performance with economical and social benefits. LCA study provided insights on egg value chain performance regarding environmental impacts and mitigation potential of specific interventions. The study provides a baseline that can be leveraged and used to compare sectorial performance to other ones and to take action to improve environmental sustainability in Zambia. However, opportunities need to be considered within the current economic constraints of the egg value chain. Moreover, technical assistance may be needed to identify precise specific opportunities and how to implement required actions to address these opportunities. In this framework, the main recommendations are listed below:

i) Policy perspective

- **To improve and benchmark the environmental LCA of the egg value chain**
  In order to promote LCA as a decision-making tool, both for industry and for government policy, more robustness, reliability and representativeness are needed. Thus, because identical methods are being used, it is strongly recommended that **this project be benchmarked with similar LCA studies being undertaken by the VCA4D project** and, if possible, with additional egg value chain studies in other regions;
- **To encourage agro-products volunteer labeling**
  There are several labeling options considering egg producing and associated crop farming. Labeling will definitely promote the adoption of best (and sustainable) management practices. However, again, it is important to consider the diversity of conditions within the industry in Zambia when identifying and promoting activities towards increasing environmental performance (e.g.: organic soya is a known product in Zambia). Governmental and non-governmental institutions have a role to play in order to advance with labeling;
    - Promoting practices that will contribute to reduce environmental (and social) impacts, while improving farmers/co productivity or income (value-added), is the most important path in order to reduce environmental impacts either in maize, soybean and wheat and on-farm activities in egg producing facilities.

ii) Technological perspective

- **To promote better manure management**
  In order to guarantee public health, as well as soils and ecosystems protection, **water monitoring programmes should be reinforced**, including appropriate chemical analysis. Monitoring is a priority where medium-large scale facilities dispose off manure and when groundwater abstractions may exist for drinking water supply. As a side effect, industry-level initiatives focused on optimizing feed composition and nutrient cycling that minimizing losses

of nitrogen and phosphorus may potentially induce significant improvements in the overall environmental profile of Zambia egg industry;
In addition, monitoring programs are mandatory also to obtain further knowledge on possible presence of priority/dangerous substances, namely in soils and water bodies;

- **Investments in supplemental manure drying and pelletization may be profitable** given the growing recognition of the value of manure in increasing soil organic matter, capacity to retain water and slow release of nutrients. An adjacent benefit of manure pelletization is fertilizer import reduction, thus inducing lower manufacturing and transport impacts. However, when manure production is very significant (e.g.: Goldenlay, Quantum, Zambeef) and the applied load in soil is being higher than plant nutrient requirements, **biogas production (methane) will be a profitable option for producing electricity** in corporate livestock industries (allowing co-digestion of animal excreta with crop wastes also)[96]. It should be highlighted that **biogas operation is simple but requires skills that are not available now: an appropriate training process should be in place**. Biogas processing or pelletization has another positive side effect: manure transport is minimised and fuel consumption and other negative impacts (e.g.: air emissions, noise, dust and general traffic risks) are cut down;
- Availability of capital to provide proper investments can pose barriers that may need to be overcome to allow the implementation of the aforementioned technologies.

- **To reduce logistics impacts**
  - Time and proper roads should be improved in order to reduce environmental constraints (emissions, vehicles maintenance). Transit between South Africa and Lusaka may be have an option if Beira Port (Mozambique), which was recently upgraded and is able to handle bulk ships. Anyhow, local/regional fertilizers/pesticides manufacturers, as well as other service providers, should be preferred when price is competitive.

- **To foster technical capacitation at local level**
  - Farmers training and education on best practices and innovations is required in Zambia. Among the topics it is suggested farm management and control (including machinery maintenance), manure management regarding nitrogen management and odour control techniques regarding facilities near peri-urban areas, fertilization and pesticide application, general waste management and recycling, transport logistics;
  - In Copperbelt region, technical support to local egg producers may be advisable in order to protect water sources and to prevent possible contamination by mine operation if necessary. Capacitation on water treatment processes may be required also;

[96] Hansupalak N, Piromkraipak P, Tamthirat P, Manitsorasak A, Sriroth K, Tran T., (2016). *Biogas reduces the carbon footprint of cassava starch: a comparative assessment with fuel oil*. Journal of Cleaner Production, 134 (2016) 539-546.

- Stronger relations between farmers and egg producers associations with research centres and universities of Zambia are highly advisable in order to foster innovation and competitiveness of egg value chain.

6. SUMMARY OF CONCLUSIONS AND RECOMMENDATIONS

6.1 Overview of the egg value chain

This study assessed the egg value chain in Zambia focusing on the following issues: its contribution to economic growth in the country; the extent to which growth is inclusive; whether the value chain is socially sustainable; and whether it is environmentally sustainable. The growth performance of the poultry industry as a whole has been very impressive in recent years, especially when contrasted with the erratic growth in the agricultural sector. Between 2011 and 2015, the egg value chain expanded nearly 4 times, with the population of in-lay hens peaking at 3.5 million in 2015 and producing about 1.216 billion eggs during that year. Very sharp spikes in the prices of the main feed ingredients – maize and soya – in 2016 triggered a severe downturn, shrinking by almost 20%. However, in 2017 a recover begun as cost of the feed ingredients fell as a result of significant surplus production.

Growth in the chain is driven by two main factors. These are dynamics in the domestic market, where stability of wholesale/retail prices for table eggs has made it the cheapest animal protein source in the country. Kapenta (dried fish), which is the closest substitute, is more expensive (retails at over 40% per kilogramme) than eggs and the price tends to be far more volatile. Consequently, egg consumption is rising very steeply in the relatively poor urban households where it is generally being eaten with Nshima (traditional maize meal) for dinner. Growth in this market is anticipated to be sustained even when per capita incomes in urban areas increase as consumers will, as is currently the trend, switch from egg consumption at dinner to eating more of it at breakfast and as snacks. However, this dynamic is not replicated in rural areas, partly because most of the households rather get the eggs hatched and then rear "village chicken", which is sold into urban markets. Vegetable proteins and kapenta are rather consumed more, even though the latter is more expensive in rural areas than in towns and cities.

Demand in regional markets is the other driver of growth in the egg value chain. Between 20-25% of eggs produced in Zambia is exported into regional markets such as DR Congo. Also emerging are markets in Angola and it is anticipated that Zambian exports into the Great Lakes Region is likely to grow in the medium term. Per capita consumption in these markets, especially in DR Congo, is well below the level in Zambia. It is, therefore, projected that if it should rise to about 60% of the level in Zambia then table eggs exports can almost double. Informality of the trade and political tensions appear to be the main bottlenecks hindering further expansion in eggs export to DR Congo. It is instructive however that many large-scale egg producers are locating in the Copperbelt to be able to exploit the DR Congo market, where Zambian eggs are considered not only price competitive but also relatively fresh, compared to supplies from South Africa.

6.2 Contribution of egg value chain to Zambia's economy

In 2015 the total value added in the egg value chain in Zambia was about ZMW 1.71 billion (equivalent to €151.7 million), representing 13.6% of agricultural GDP in the country. This figure is almost double the contribution of fisheries and aquaculture and 1.2 times the contribution of forestry and logging. The chain also generated foreign exchange from export of table eggs estimated at ZMW 205.1 million (€18.2 million). It appears this contribution is perceived as rather marginal as BOZ does not even report foreign exchange proceeds from export of table eggs in its annual report for 2016. However, it is evident from Table 3-7 that foreign exchange generation by the egg value chain is higher than other more recognised non-traditional agricultural export products such as horticultural products. The egg value chain contributed a modest ZMW 102.4 million (approximately €9.1 million) to Zambia's public finances in 2015 in the form of direct taxes, VAT and council levies. No subsidies are provided directly to any of the egg producers as well as suppliers and traders. This contribution is relatively low, only 0.3% of overall domestic revenue generated by GRZ.

Large-scale egg producers dominate the chain, altogether accounting for about 87% share of the market. This dominance is reflected in its contribution to value added in the chain as well as its share of income generated (as discussed in Chapter 3). As a result of this dominance, egg prices are set by the lead producer, which has a market share in excess of 20%. Their wholesale price per tray, which was ZMW 23 per tray in 2015, is benchmark not only for all other producers but also for other players such as wholesalers and retailers. A very positive outcome of this situation is, as mentioned above, eggs becoming the cheapest animal protein source and therefore driving up domestic demand.

Though the above situation creates the impression that the chain is not inclusive, we find evidence of inclusiveness at the trading level. This segment of the chain receives over 17% of the total income generated. This income is well-spread among a large number of "wholesalers" (mainly small-to-medium-scale middlemen) and over 18,000 micro-retailers. The "wholesalers" are not the typical relatively well-capitalised traders in other commodity and consumer items trade. Start-up capital for these range from ZMW 7,500 (€665.00) to ZMW 11,250 (close to €1,000.00) and is often generated through micro-retailing of various produce in the main urban markets. The "wholesale" trade, just as egg production, is dominated by men but women predominate egg retailing.

Though benchmark prices are largely determined by the large-scale producers, medium and small-scale producers are able to compete due to proximity to the large informal market players. They do so by capitalising on what constitutes the main distribution margin for the large-scale producers, which is about ZMW 2-3 per tray. Their buyers are compensated by avoiding the higher cost of transport when they buy from intermediaries in the main markets, who are linked to large-scale producers. Though the market structure implies tight margins for most producers at the lower end of the scale, evidence reported in Table 3-1 shows that egg production by all categories of producers is profitable. The margins range from 5.2% for the small-scale producers to over 20% for large-scale producers. These margins are not dependent on any forms of subsidies from GRZ.

At the small-scale end, the average annual earnings of ZMW 4,662.01 (or €416.33) tends to be seen as supplementary to household income as it well below the average annual minimum wage of €714.16[97] and even far lower than the annual living wage in Zambia, which is estimated at €3,403.20 (or €283.60 per month[98]). At the lower end of medium-scale egg production, the net annual income of €2,577.86 for egg production is only 24% below the annual living wage. However, when producers reach the scale of production of about 1,750 in-lay birds (still within medium-scale production) and are able to invest in on-farm feed formulation of feed the net income generated is able to support the average family.

Margins in the egg trade are very tight, a reflection of the level of competition in the chain. However, analysis in this report in Section 3.2, shows that middlemen in the urban markets can obtain egg trade-related income which is more than double the annual living wage in Zambia (€3,403.20). This implies that the households who are dependent on this trade can sustain their livelihood. Community-based middlemen even do better as their margins are close to 65% more than what is obtained by the market wholesalers. The net earnings generated for community-based micro-retailers is estimated at €242.24 per annum. This is despite the rather high return on turnover of 12.5%, the highest within the egg trade. To put this figure in context, it can actually make a difference in terms of household income in poor urban households in Zambia, where an estimated 60.5% of the population is below the national poverty line estimated in 2011 by the World Bank at US $1.90 a day or €581.30 per annum. The contribution from retailing eggs therefore constitutes about 42% of the income threshold. This is important, considering that the households involved in the trade often sell other essential food items, including especially nutrient-rich vegetables.

6.3 Social sustainability of the egg value chain

This is assessed in relation to issues such as food and nutrition security in households, which turned out to be one of the most relevant to the Egg VC. Over the past decade, due to relatively stable prices for table eggs, the value chain has provided increasing numbers of lower income urban households with an affordable, sustainable and reliable source of quality protein, which is relatively convenient and widely accessible. With regard to general equality, while men tend to dominate informal egg trading with small proportions of female egg traders, this appears to be more by choice than by specific gender roles, though men state that egg trading is more physically demanding. Women tend to dominate informal trading in broilers, which apparently involves different skills and labour requirements which are linked to gender.

Urban households in higher density locations appear to have benefited more in terms of egg consumption, whilst in peri-urban households one of the main benefits has been the creation of employment opportunities on egg farms as many of the egg farms are situated close to large urban populations. Primary data from household interviews conducted in Mpongwe and triangulated with national level surveys indicate that in rural areas eggs are less important in the diet. Commercialisation

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97 Source: Government of republic of Zambia Statutory Instrument no. 46 of 2012.

98 Source: Wage Indicator Foundation, 2016.

of "village chickens" appears to be one of the factors discouraging egg consumption in rural areas. Households rather opt to raise chicken from the eggs and sell in order to buy other sources of protein.

There is an ongoing trend toward vertical integration by large-scale egg producers. However, initiatives such as the soya outgrower scheme piloted by NGHL and GLL (Box 2.2) offers scope for involvement of smallholder producers of soya. Such schemes can be beneficial as indicated by some of the farmers consulted. They cite, for example, that in a year when inputs are available on time, the weather is favourable and the price for soya is "good", soya farmers can invest part of their net earnings in improved housing (e.g. burning bricks, buying cement and iron roofing sheets) and/or for meeting expenses relating to education or health. When the converse situation occurs, the farmers tend to be at risk of indebtedness, spiralling poverty and greater dependency on programmes of agricultural subsidy and social safety nets. This therefore makes smallholder soya production risky.

Other issues which emerged from the social profile analysis of actors in the egg value chain are summarised below and include, in particular, small-scale grain producers and urban consumers:-

- Small-scale farmers lack influence on the terms of contracts and are in a very weak bargaining position with regard to grain prices, and moreover lack the capacity (both physical and financial) to store soya and maize after harvest and wait for prices to increase. This situation of price volatility has been made more volatile now that Zambia is producing consistent surpluses of both soya and maize, which tends to drive down the farm gate price which otherwise might be influenced by consideration of import parity pricing.
- There are greater risks of indebtedness and food security, particularly for new entrants to small-scale soya production. This is because new entrants lack the hands-on knowledge and skills relating to soya production which results in lower yields, and because new entrants are more likely to depend on inputs supplied on credit (which may come late in the season which compromises timely planting) and which have to be repaid shortly after harvest.
- Limited quality and breadth of technical advice currently being offered to small-scale soya producers by both public and private extension providers impacts most on new entrants, who do not have the benefit of prior hands-on experience to draw on. The tendency is to provide "blanket recommendations to all small-scale farmers, rather than to tailor the advice to the farmer's circumstances (e.g. soil type, labour supply, access to draft power, cash availability) and climatic events. The narrow focus of extension advice on soya production, and neglect of advice on household utilisation and value addition options, is a further limitation for small-scale farmers.
- Variation between areas in the availability, quality and timeliness of input supply for soya production (particularly inoculum and improved seed) is an issue. Timely and easy access to the best adapted soya varieties and good quality inoculum are very important for viable small-scale soya cultivation for the market. The high cost of certified soya seed is also an issue particularly when prices are low, as seed is the most expensive cash input.
- With regard to longer term land security for rural households, low and uncertain profitability of small-scale farming can encourage sale of family land by older family heads to newer settlers. This

limits the amount of land available for the next small-scale farming generation from these families, who then will either have to rent land locally or re-locate to another area where land is available.

- There is limited use of both eggs and soya products to improve the nutritional quality of infant diets and diets of vulnerable adults in both rural and urban areas. This is because both eggs and soya did not feature in dishes "traditionally" prepared for infants and vulnerable adults.
- Difficulties/barriers for new entrants to egg farming include: high and variable feed costs, low egg prices, high cost of borrowing for capital investment, limited social capital and weak cooperation between egg farmers. As confirmed by the financial analysis in Chapter 3, smaller egg producers face the smallest profit margins, making entry into this enterprise relatively risky.
- The longer term trend of increased automation and mechanisation in the large egg farms and in the related stock feed industries means that employment opportunities on these farms and stock-feed plants will not keep pace with the increased output of these enterprises.
- The employment opportunities for youth are limited in some segments of the value chain. Apart from some opportunities on egg farms and linked enterprises for youth with intermediate levels of education (e.g. secondary school leavers) most of the opportunities are for casual seasonal employment and working as self-employed egg traders.

6.4 Environmental sustainability of the egg value chain

The outcome of the application of the life cycle analysis (LCA) framework in the study of egg VC produced the following outcomes:

Human health impacts are driven by:-

- the heavy metal emissions to soil from zinc and cadmium due to field application of fertilizers and pesticides for crop production;
- the dinitrogen monoxide emissions to air from field application of fertilizers, as well as carbon monoxide and particulate matter emitted to the air from fuel combustion associated to crop production;
- the water consumption due to irrigation for crop production.

Ecosystem impacts are driven mainly by:-

- the occupation of arable land due to the cultivation of maize, soybean and wheat;
- the terrestrial acidification due to ammonia emission to air arising from field application of fertilizers and from poultry rearing;
- the global warming due to the dinitrogen monoxide and carbon monoxide emitted to the air from field application of fertilizers and from fuel combustion associated to crop production;
- the water consumption, driven by irrigation water used to cultivate the wheat, maize and soybean.

Resource scarcity impact is driven largely by the extraction of fuel required to power transport vehicles as well as crop farm machinery and egg farm equipment.

Other environmental considerations based on the LCA findings relating to grain production, chicken manure and transport of crop inputs and layer feed are summarized below:

Grain production related emissions

Soil fertility and structure – Large quantities of fertilizers are used in maize and wheat production for layer feed in Zambia because tropical soil structure is inherently fragile. This was evident from LCA impact assessment and endpoint damage indicators. In addition, contaminants present in chicken manure can accumulate in soil and pose a human health/ecosystems quality risk in the long term. Well integrated crop-manure management is required to prevent negative environmental tradeoffs.

Groundwater and surface water – Potential runoff and subsurface flow contamination effects are associated with wastewater/wastes discharges from table egg production facilities, from manure/fertilizer/pesticides disposal in soils or just from waste spills. In this case, human and animal health risks are associated with drinking water contamination or indirect contact. Pesticides and trace elements (e.g. zinc, cadmium) may also endanger human health and ecosystems. Other compounds, namely antibiotics, hormones and other xenobiotic, have a low-level concentration that are difficult to assess/quantify if exact feed composition is not known. Long-term monitoring is required to protect ecosystems endangered by these contamination risks.

Atmosphere – Direct impacts include those on human health (caused by nitrogen oxides and air particulates but also odour-causing compounds) and contribution to global warming (due to carbon dioxide and nitrous oxide emissions) from manure management, the egg production process and other related activities such as feed production and transport of finished products. Volatilized ammonia can be re-deposited and may contribute to damage terrestrial ecosystems. Resources Depletion has less carbon dioxide emissions than one could expect. These emissions are represented on Global Warming midpoint and, the interesting point, is that the energy mix in Zambia is represented by a significant hydropower offer.

Chicken manure processing, transport and disposal approaches

A critical determinant of emissions is chicken manure management. Manure application to soils is the most common disposal method in Zambia. This method requires limited additional investment or technical know-how (compared to alternatives such as bio-gas or formulation of feeds for beef or dairy cattle). There is further room for improvement in manure management, both environmental and economic. This is a key area from the environmental pollution control perspective. Governmental guidance and any regulations and inspection should be clear regarding chicken manure application schedules and loads in soils.

Egg production facilities should avoid or mitigate noxious emissions related to manure management. Concerns over air emissions from manure bioconversion processes that occur during housing, storage, transport and land spreading are related to nitrogen losses - ammonia (NH_3) and nitrous oxide (N_2O) - and methane (CH_4) to a lesser extent. In addition, manure transport to final destination is a GHC emission trigger due to vehicle fuel combustion. These issues are discussed below.

Application of manure to cropland is positive from the point of view of nutrient recycling, reducing mineral fertilization needs. Chicken manure is rich in nutrients like nitrogen, phosphorus and potassium, all of which are needed for plant growth. A drawback is related to potential aquifer contamination by nitrates due to over-application rates or metal contamination, namely zinc. Moreover, a serious concern has emerged more recently about the fate of endocrine disruptors and contaminants in animal sludge (antibiotics, metals) revealed in LCA toxicity impact category in wastewater treatment plants. Given the amount of manure generated per year and the limited nutrient soil and plant absorption capacity in Zambian soils, concerns on manure application overloading are unavoidable. In order to guarantee public health, as well as soils and ecosystems protection, water monitoring programmes should be reinforced, including appropriate chemical analysis. Governmental regulations on applied loads and time/season of application should be prescribed (for instance, application of manure during times of heavy rain increases contamination risks).

Until now, only one large-scale egg producer in Zambia has invested in organic fertilizer manufacturing, Chicola™ fertilizer. Biological composting and pelletization of dried manure is an interesting market option, in particular for medium/smaller egg producers. Pelletization stabilizes the organic material and allows it to be easily handled and increase the acceptability of the product as organic fertilizer, providing an alternative source of nitrogen during times of high commercial fertilizer prices. Therefore, investments in supplemental drying and pelletization may be profitable given the growing recognition of the value of manure in increasing soil organic matter, capacity to retain water and slow release of nutrients. The content of manure pellets should be well controlled by producers and authorities in order to guarantee a healthy and safe soil amendment. In this regard, all measures to prevent manure contamination will be opportune to provide better compost quality. A side benefit of manure pelletization is fertilizer import reduction, thus reducing manufacturing and transport environmental impacts.

When manure production is very significant (e.g.: Golden Lay, Quantum, Zamchick) biogas production (methane) is a profitable option for producing electricity (allowing co-digestion of animal excreta with crop wastes also). Biogas systems (biomethanization) are based on anaerobic processes engineered for wastewater/sludge treatment-valorisation. Methane is a valuable energy carrier that can be used in internal combustion engines. Thus, biogas will contribute to replace electricity needs, avoiding GHG emissions from fuel oil generators used to mitigate hydropower disruptions in Zambia. In addition, if biogas plants are placed next to egg layer facilities, they mitigate the impact of manure transport to final disposal sites. Anaerobic biological processes will mineralize input organic matter and will yield only 10-15% of bio-solids, which can be further composted and easily applied for soil amendment.

Biomethanization or/and pelletization minimise the environmental impact of manure transport and other negative impacts (e.g. air pollution, noise, dust and general traffic risks).

While the investment costs of biogas technologies for electricity production are significant, the payback period could be rather short (less than 7 years). This option deserves attention from international funding organisations or/and commercial banks in order to support such investments. Biogas operation will require appropriate training to be put in place.

Odour abatement (e.g. sulphide or ammonia volatilization) prior to biomethanization or composting processes requires appropriate measures because the odour may be offensive to neighbouring residential areas. Nitrogen conservation may be improved via several strategies. Best practices on manure management will minimize nitrogen losses both at the time of excretion and during storage and application. Farmers training and education on nitrogen management and odour control techniques are necessary.

Transport of fertilizers and pesticides

Road transport costs from South Africa through Zimbabwe or Botswana to Zambia are critical for ensuring access to fertilizers at competitive prices. If marine with road transport are compared in the same base, the first is an environmentally more efficient method of transport than the former (CO_2 emissions per metric ton-mile are 0.1139 kg and marine ship are 0.0161 kg only). As a rule, road transport of fertilizer from the arrival port to Lusaka has a higher environmental impact than the marine transport to an African port. A competitive environmental option may be the port of Beira in Mozambique, which was recently upgraded and is able to handle bulk fertilizers. Therefore, logistics, bureaucracy and proper roads should be improved in order to reduce transit time between Beira and Lusaka, which remains the same 8 days as Durban-Lusaka (actually, it is 4 days is for road transport in itself, while 4 days is spent in port handling). Dar es Salaam port delivery and transport time to Zambia is even worst (13 to 14 days). Nevertheless, marine transport distances should be kept as low as possible in order to reduce navigation risks and air emissions. Thus local/regional near-by fertilizers/pesticides manufacturers should be preferred when price is competitive.

Feed composition

It is known that an important environmental issue in egg industry is feed composition and feed conversion efficiency in breeder flocks, pullet rearing and laying flocks. Obtaining the exact details of feed composition is difficult because of proprietary formulations. Specific feed formulations are typically geared to the requirements of different stages of physiological development, and particular chicken breeds. Some adaptations to feed formulations are made by local Zambian producers in order to fit demand requirements (or to lower costs). A detailed analysis of this issue is beyond the scope of this LCA, but the subject is known from the technical and scientific literature. Thus, governmental regulation should be strict regarding formulation and should promote content transparency (e.g.

regarding priority substances and dangerous substances, as mentioned in the EU Water Framework Directive and related directives).

6.5 Recommendations for inclusive, socially and environmentally sustainable growth

This study has provides ample evidence to justify inclusion of the egg value chain in areas to be prioritised by GRZ in its efforts to promote export-oriented agricultural sector development which is also inclusive and sustainable. Growth dynamics within the value chain make it a good candidate to sustain its contribution to sector and overall GDP growth in the medium-term. This is driven by rising domestic demand as well as potential growth in the regional export market. Growth in the chain will increase its capacity to absorb surplus soya and therefore ensure sustained growth in soya production. Furthermore, the positive impact of growth in egg production on household nutrition security, especially in urban poor households has been demonstrated. It is also evident that most producers, especially those in the medium-scale and large-scale categories are well aware of prospects in the value chain and anticipate investment in capacity expansion in the short to medium term. To realise the growth prospects and, especially, to ensure that it is inclusive not only at the domestic trading level but also at the level of production, the recommendations below are outlined.

6.5.1 Recommendations emerging from functional, financial and economic analysis

Exchange rate risks, in particular as regards volatility and appreciation of the local currency, are unlikely to impact very much on the overall viability of egg production in the country. This is principally because of the low level of utilisation of imported intermediate goods. However, appreciation of the local currency can impact negatively on foreign exchange inflows generated by the chain and adversely affect the capacity of players who have used competitively-priced offshore financing to scale up production and/or improve production technology. A notable example is the market leader, GLL. Hence, macroeconomic stability and effective exchange rate management to avoid sharp currency appreciation should be seen as part of the required enabling environment for sustained growth in the egg value chain.

Severe spikes in the price of feed ingredients, mainly maize and soya, has been shown (in Section 2.2 of this report) to exert significant growth-reducing effects on the chain. Some large-scale producers are attempting to mitigate this risk by means of backward integration involving cultivation of maize and soya. This may lead to exclusion of smallholder soya producers. However, GLL (Golden Lay) has been part of a pilot outgrower scheme under which it can procure soya produced by smallholder farmers. The main drawback of the scheme are the delivery terms for the participating smallholder farmers, who are required to fully repay inputs credit immediately after harvest when output prices have bottomed out.

To address this we propose inventory collateralisation under ZAMACE in a system which allows soya marketing to be better managed to the benefit of producers and without putting the interests of inputs credit providers and soya users at risk. The case of the harvest 2017 harvest season is cited to demonstrate that such a system can produce tangible income benefits to producers (close to 30% income gain for producers). Further evaluation of this system involving ZAMACE and exploring the potential to significantly scale up and also service medium-scale egg producers should be undertaken. Active involvement of local financial intermediaries in providing inventory finance can catalyse uptake of the system by both grain producers and buyers. However, anecdotal evidence from managers of ZAMACE suggests limited internal capacity within the banks in terms of providing such facilities. Hence, collaboration with ZAMACE to provide training in inventory finance for banks and other non-bank financial intermediaries needs to be explored, especially for the benefit of medium-scale egg producers.

One of the main challenges facing producers is how to reach retailers in the communities on a cost-efficient basis. The outcome of the BOP model piloted by GLL has been successful as proof of concept and can be taken up by other large-scale producers. However, replication does not need to be subsidised as viability has already been demonstrated. Furthermore, subsidising large-scale producers to undertake this will undermine competition between them and medium/small-scale producers whose main competitive advantage lies in the proximity to buyers in high density urban communities.

Access to finance for capital investments in improved housing and cost-efficient production technology as well as working capital is a challenge for most players in the egg value chain. Not only are interest rates high in the domestic money market and the existing capital market is too thin to become a major vehicle for mobilising equity capital. Banks are also averse lending to players in agriculture because of risk perceptions which are borne out by evidence on the quality of loans advance by banks in the country. The ability of GLL to secure financing the AAF has proved critical in expansion programme but also demonstrated that chain plyers have the potential to effectively manage such resources. It can therefore open up opportunities for other large-scale, well-run egg producers.

However, for most medium-scale producers, who need to be prioritised in order to ensure inclusiveness at the level of production this does appear to be a viable option. It is for this reason that we stress the need to develop and inventory credit scheme which will ensure that they can access feed ingredients on a cost-effective basis. Furthermore, for capital investment by these players, BOZ and GRZ may explore the possibility of replicating the innovative financing package piloted by the government of Nigeria – that is the Nigeria Incentive-based Risk Sharing System for Agricultural Lending (NIRSAL). Under that scheme government offers loan guarantees to encourage lending but is tied to appropriate insurance and provision of interest rebates which kick-in only when borrowers repay loans. To improve prospects for effective access to cost-effective finance by medium-scale egg producers we further recommend improved availability of quality business advisory services. It is apparent that the support provided under TAF proved pivotal in the ability of GLL to secure finance from AAF. Consideration may be given to the development of the business advisory services within PAZ.

6.5.2 Recommendations to enhancing social sustainability and inclusion

The following interventions are suggested in order to improve social inclusion and sustainability of the egg value chain in Zambia:

- Improve the support to small-scale farmers either growing soya or in locations suited to soya production. The improved support should be channelled through the relevant agencies, with the aim of improving levels of mutual trust and building sustainable business relations between these agencies and participating farmers. The services (technical advice, supply of inoculum and seed, credit packages as part of contract arrangements, marketing support) need to be more carefully tailored, taking account of the variation[99] within the small-scale farming sector. The aim should be to reduce the current risks faced by small-scale farmers growing soya, and improve the opportunities (including value addition at village level) for sustained small-scale production of soya which is profitable and also improves household food security and nutrition.
- Increased focus on interventions to promote appropriate and more widespread use of both soya products and eggs (as more affordable sources of high quality protein and key vitamins and minerals) in the diet of infants and vulnerable adults, to improve human nutrition both in rural and urban areas,
- Specific initiatives targeting the youth, to improve their inclusion in the Egg VC, including vocational training in rural areas for employment in egg farms and the agencies servicing these farms, and setting up viable small-scale enterprises in rural areas to add value to the soya produced, and to increase the local production of eggs from chickens reared by households.
- Strengthening of egg producer organisation/s, with a specific focus on supporting the medium scale egg farmers and new entrants, so that this sector is not further marginalised and squeezed out of production by the large players, with the attendant negative consequences for employment (not only on smaller egg farms but also the enterprises servicing them).

    - Interventions to improve the participation of the medium and smaller egg farmers in PAZ, and in particular to improve key services for new entrants, such as business advice and technical advice on DOC rearing, vaccination, feed formulation, and egg production and marketing, should reduce barriers to entry for this category.
    - There is potential for production by small and micro-scale egg producers to be boosted if per capita demand in rural poor households rise. This may not impact significantly on overall production in the chain but can produce major positive nutrition benefits. Considering that eggs are the cheapest animal protein source in the country, there is need for research to understand the socio-cultural as well as economic factors which discourage consumption in

99 This includes variation between farmers in terms of levels of resource ownership and access, current levels of indebtedness, health situation, knowledge and capability to manage risks.

poor rural households. The outcome of such studies can guide actions to promote rural egg consumption just as was done in the case growing “village chicken” for urban markets.

6.5.3 Recommendations to improve environmental sustainability of egg value chain

To support the environmental sustainability of table egg production, the following “mitigating measures" are proposed:

Policy perspective: In order to promote LCA as a decision-making tool, both for industry and for government policy, more robustness, reliability and representativeness are needed. Thus, because identical methods are being used, it is strongly recommended that this project be benchmarked with similar LCA studies being undertaken by the VCA4D project and, if possible, with additional egg value chain studies in other regions. Voluntary labeling can definitely promote the adoption of best (and sustainable) management practices. However, again, it is important to consider the diversity of conditions within the industry in Zambia when identifying and promoting activities towards increasing environmental performance (e.g. GMO free soya is a known product in Zambia). Governmental and non-governmental institutions have a role to play in order to advance with labeling. Promoting practices that will contribute to reduce environmental (and social) impacts, while improving farmers/co productivity or income (value-added), is the most important path in order to reduce environmental impacts either in maize, soya and wheat on-farm activities in egg producing facilities.

Technological perspective:

- To promote better manure management: In order to guarantee public health, as well as soils and ecosystems protection, water monitoring programmes should be reinforced, including appropriate chemical analysis. Monitoring is a priority where medium-large scale facilities dispose off manure and where groundwater abstractions may exist for drinking water supply. As a side effect, industry-level initiatives focused on optimizing feed composition and nutrient cycling that minimizing losses of nitrogen and phosphorus may potentially induce significant improvements in the overall environmental profile of Zambia egg industry.

In addition, monitoring programs are mandatory also to obtain further knowledge on possible presence of priority/dangerous substances, namely in soils and water bodies. Investments in supplemental manure drying and pelletization may be profitable given the growing recognition of the value of manure in increasing soil organic matter, capacity to retain water and slow release of nutrients. An adjacent benefit of manure pelletization is fertilizer import reduction, thus inducing lower manufacturing and transport impacts. However, when manure production is very significant (e.g. Golden Lay, Quantum, Zamchick) and the applied load in soil is being higher than plant nutrient requirements, biogas production (methane) will be a profitable option for producing electricity in corporate livestock industries (allowing co-digestion of animal excreta with crop wastes also). It should be highlighted that biogas operation is simple but requires skills that are not available now: an appropriate training process should be in place. Biogas processing or pelletization has another positive side effect: manure transport is minimised and fuel consumption and other negative impacts (e.g.: air emissions, noise, dust and general traffic risks) are cut down. Availability of capital to provide proper investments can pose barriers that may need to be overcome to allow the implementation of the aforementioned technologies.

- To reduce logistics impacts: Time and proper roads should be improved in order to reduce environmental constraints (emissions, vehicles maintenance). Transit between South Africa and Lusaka may be have an option if Beira harbour (Mozambique), which was recently upgraded and is able to handle bulk ships. Anyhow, local/regional fertilizers/pesticides manufacturers, as well as other service providers, should be preferred when price is competitive.
- To foster technical capacitation at local level: Farmers training and education on best practices and innovations is required in Zambia. Among the topics it is suggested farm management and control (including machinery maintenance), manure management regarding nitrogen management and odour control techniques regarding facilities near peri-urban areas, fertilization and pesticide application, general waste management and recycling, transport logistics. In Copperbelt region, technical support to local egg producers may be advisable in order to protect water sources and to prevent possible contamination by mine operation if necessary. Capacitation on water treatment processes may be required also. Stronger relations between farmers and egg producers associations with research centres and universities of Zambia are highly advisable to foster innovation and competitiveness of the egg value chai

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7. Annexes

7.1 Annex 1: Appraisal of egg & soya consumption patterns in lower income areas of Lusaka

Alistair Sutherland[100] – October 2017

Contents:

1.0 Background

A rapid appraisal was undertaken as part of the social analysis component of the EU funded egg value chain study in Zambia. The purpose was to address a gap in information which was identified when searching the available literature and other secondary sources on the extent and pattern of consumption of table eggs and also of soya products in the lower income urban households.

Urban consumers, were identified during the Egg VC study as one of the primary beneficiary groups of the value chain, in terms the nutritional benefits provided through the consumption of eggs and soya products to lower income households, including the more vulnerable members such as children under 5[101].

Given the limited time and resources available, Lusaka was selected as a good place to undertake the appraisal. Lusaka is by far the largest and most ethnically diverse urban concentration in Zambia. Its population of about 2.4 million includes all the main ethnic groups and exceeds the combined population of the other nine main urban centres.

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[100] The valuable contribution of others to the formal survey design, implementation and data analysis is acknowledged. Particular thanks are due to Mwamba Chishimba. Mwamba reviewed the draft questionnaire, made improvements to it, loaded it onto tablets and arranged for software needed for this, extracted the data collected and helped to clean it for analysis in SPSS, and gave guidance on the analysis. Thanks also to Joshua Mabeta, who ably led a small team of enumerators to undertake the formal survey in Kalingalinga and Kanyama while at the same time undertaking the informal interviews.

[101] The literature review and fieldwork also indicated that eggs and soya products are NOT very important to the household diet in rural areas, in spite of the fact that all rural households keep some poultry, and many grow soya for sale. For example, in Eastern Province, where small-scale farmers have been growing soya as a cash crop for at least 20 years, very small amounts of the crop are retained for household use, compared with other crops such as maize, sunflower and groundnuts (Analysis of the **Soya** Bean **Value Chain** in **Zambia's**. **Eastern Province** by. Mary Lubungu, William J. Burke, and Nicholas J. Sitko. IAPRI Working Paper 74. May 2013)

The wider context is that both eggs and soya products had been identified by the team as relatively "affordable" sources of protein for lower income households, and for this reason the egg value chain potentially provides significant social benefits for poorer households in terms of nutrition, including food for the more vulnerable household members (under 5s and the sick). Soya is a major ingredient in the feed used to produce eggs, and is also a potentially significant and affordable source of protein for lower income households, including urban households.

The main focus was on the following aspects of consumption of these products:-

- Proportions of lower income households consuming eggs and soya products,
- The frequency of consumption among households that do consume eggs and soya products
- The daily pattern of consumption of eggs and soya products in households that do consume these,
- The use of eggs and soya products in the diet of young children under 5 years old,
- The general trend in the frequency of consumption of eggs and soya products over the past year
- Some of the stated reasons why individual choose to consume eggs and soya products.
- For households not consuming eggs and soya products, the main reasons for not consuming these,
- Access: where people in higher density lower income locations usually buy their eggs and soya products

2. Methodology

The rapid appraisal combined a formal questionnaire with closed questions (Annex i) with informal interviews using a checklist of more open-ended questions to provide context (Annex ii).

The formal questionnaire was administered, using hand-held tablets. Interviews were completed with 151 participants interviewed in public places, in two high density areas of Lusaka; Kalingalinga (78) and Kanyama (73) during early August 2017[102].

These two areas of Lusaka were selected because they are known to have established populations made up of a diversity of ethnic origins, including a large number of people who were born and raised in these areas, and were seen as fairly typical of lower income urban areas in Lusaka.

All interviews were undertaken over two weekdays (Tuesday and Wednesday) during the daytime in both locations, in areas close to the local markets, but not close to any stalls selling either eggs or soya products. An effort was made in interview individuals representing both genders and a range of ages, with a minimal target of least two respondents from each age and each gender category in each location.

A small team of male and female enumerators, undertook the formal questionnaire, with each enumerator approaching and interviewing a member of the public of their own gender. The lead enumerator also undertook informal interviews with members of the public.

102 The two selected wards were reasonably representative in terms of poverty levels in higher density areas. According to the Lusaka Poverty Data from the 2010 census, Kalingalinga Ward in Munali constituency had a population of 8,356 and a poverty headcount of 15%, while Kanyama Ward in Kanyama constituency had a population of 35,682 and a poverty headcount of 22%. Both wards had the highest poverty headcount within their respective constituencies. Other wards with high density housing in Lusaka, had a poverty headcount ranging from 28% (Lima Ward in Matero) at the highest end to 12% at the lowest end (Munali Ward in Munali).
https://www.google.co.uk/search?q=kanyama+constituency+population&rlz=1C1CHZL_enZM755ZM755&oq=kanyama+pop&aqs=chrome.2.69i57j0l2.6789j0j8&sourceid=chrome&ie=UTF-8

All the questions were closed, with options which the enumerators selected based on the respondents answer to the questions. Some of the questions allowed for more than one option to be selected.

To supplement the formal questionnaire data, informal semi-structured interviews were held with 15 individuals. These interviews covered more general preferences relating to the types of relish preferred, as well as open ended questions about egg and soya consumption. The results are presented separately.

The data from the formal questionnaire was recorded on tablets, and analysed using SPSS, while the responses to the informal survey were recorded on copies of the checklist used and analysed manually.

The findings from both the informal survey and the formal questionnaire are reported below, starting with the informal survey.

3. FINDINGS OF INFORMAL SURVEY

Informal semi-structured interviews were held with 15 members of the public around the markets in Kalingalinga (7 females and 3 males) and Kanyama (3 females and 2 males). The age range of the females was 28-52 and of the males was 15-47. The people selected had occupations which were fairly typical of lower income urban areas in Zambia. None of those interviewed had a salaried job. All apart from one female said interviewed said their occupation was "business" (i.e. micro-enterprises buying and selling), and the other female stated she did not have an occupation. Three of the men also said their occupation was business two were self-employed artisans, and one stated he did not have a source of income. The interviews were brief and guided by a checklist (Annex ii).

The interviews covered more general preferences relating to the types of relish preferred, as well as open ended questions about egg and soya consumption.

Favourite Relish and why? A range of different favourite relishes were identified. Five people (4 female and one male) said beef was their favourite relish, because it tasted good. Beef is also the most expensive meat relish. Two people (both female) said fresh fish was their favourite relish, because it tasted good and a further two (one male and one female) said dried fish was their favourite relish also because it tasted good. Two more (one male and one female) said vegetables was their favourite relish because of the good taste (one mixed with groundnuts and the other preferring pumpkin leaves and okra). The youngest male said eggs were his favourite because of the good taste, a younger female said that both chicken and beef were her joint favourites because of the taste, an older male said his two favourite relishes were soya pieces and beans, and a younger female said goat meat was her favourite for health reasons.

How the family saves money spent on relish during hard times: A range of different alternatives to the favourite relish were identified in order of frequency of mention as follows: plain vegetables/rape (7), eggs (3), beans (3), okra (2), soya pieces (2), kapenta (2), pumpkin leaves (1), sweet potatoes (1), and fish (1 case which is the fish they sell as a business). Plain vegetables, which is usually rape, was most frequently mentioned because they provide the cheapest form of relish as they only require salt (other additions such as cooking oil, tomatoes and onions can be omitted to save money). The other alternatives mentioned are relatively more expensive, and would indicate that the family is less pressed in terms of saving money.

Cheapest type of relish for family that provides protein: A narrower range of options were mentioned and some people mentioned more than one type of relish. The mentions in order of frequency were: eggs (10), beans (5), soya pieces (3), vegetables with groundnuts (1) and chicken pieces (1 mentioned by the person listing beef as her favourite). This indicates that eggs are now widely seen as the cheapest source of protein by lower income families.

Special food used for under 5s in household: A range of options were mentioned and some people mentioned more than one type of food for under 5s. The mentions in order of frequency were: maize porridge with groundnuts (14), rice with groundnuts (3), boiled eggs (3), soya porridge (2), delight porridge (2),maize porridge with egg yoke (1), maize porridge with powdered milk (1), maize porridge with pounded kapenta (1), rice with soup (1) and nsima with soup (1). What stands out is the current importance of groundnuts (pounded) followed by eggs in the diet of under 5s and the relative infrequency with which soya powder is mentioned. Also notable is that almost all under 5 meals are prepared from scratch, with negligible use of pre-packaged products; "Delight"[103] porridge was mentioned only twice.

Frequency of feeding under 5s in household: The most common response was "3 times a day" (7), followed by "2 times a day" (6), "3 or 4 times a day" (1) and "4 times a day" (1). It was clear also that these were specific times to feed the youngest children, who also were included in the main family meals (usually around midday and in the evening). Some of the women interviewed had a specific pattern each day, for example the pattern for the mother feeding 3-4 times per day was porridge with groundnuts for breakfast, nsima with soup for lunch (which could be part of the family lunch), and boiled egg in the afternoon. Another said she fed her child three times a day with porridge and groundnuts followed by a boiled egg on each occasion.

How common is the use of eggs in under 5 dishes – Of the fifteen people interviewed, the majority 11 said it was common for eggs to be used in under 5 dishes. The reasons given for it being common indicated that this question was is some cases understood to include the main meals which under 5s took part in. The reasons given for it being common were; "eggs are less expensive" (2 cases), "so they (children) become healthy", "a source of protein", "because the mother can afford eggs", "I always serve before the main meal", "eggs are the cheapest source of protein", "easy to prepare boiled eggs", "eggs satisfy children between meals". Four people said it was "not common" and the reason given were financial; "can't afford", "due to lack of money", "eggs are expensive family would use money to buy buns for the whole family". This suggests that more eggs would be used for feeding under fives if families in the lowest income bracket could afford to do so. One person said they had no idea if it was common or not

How common is the use of soya in under 5 dishes – Just over half (8) of the fifteen people interviewed said it was common for soya to be used in under 5 dishes. The reasons given for it being common were: "because it is cheaper than eggs", "source of protein, local school gives pupils soya porridge on the morning,", "soya powder is used to make porridge," "soya powder is a source of protein", "soya pieces are healthy and affordable", and "fried soya pieces are eaten with eggs".
Five people said it was "not common" for soya to be used in under 5 dishes. Three of these gave reasons as follows; "soya products are not readily available", "we always have mealie meal but have to buy soya on a regular basis", and "lack of money". The other two of said they did not know the reason. Two people said they did not know if it was or was not common for people to use soya in under 5 dishes.

General trend in the use of eggs and why
Just over half (8) people said the general trend was an increase in the use of eggs, 3 said there had been no change, and 4 said there was a decline. The reasons given for the perceived increase were:

- "a long time ago people never used to eat eggs, now they are relatively cheaper (female aged 52)", "because of increase in supply and it is no longer a taboo for children to eat eggs" (male aged 45), "increase in supply, when eggs are delivered in the local market they usually don't last (female aged 37),
- "prefer eggs to peanut butter, especially for breakfast" ,(female aged 37)
- "lack of alternative relish sources" (male aged 45),
- "they are cheaper and convenient, easy to prepare" (male aged 37),

[103] The ingredients of this product were not established

- “people are now eating eggs for breakfast which never used to be the case” (female aged 28).
- The reasons given for the perceived decline in use of eggs were:
- “decline since they have become expensive” (female aged 30),
- “decline since price of a tray of eggs has increased from K23 to K30” (female aged 25)
- “decline due to lack of money” (male aged 47)
- “decline, as I don’t like them” (female aged 45)

The phrasing of the first two reasons suggest decline referred to is very recent, in response to a recent price increase. The third response suggest the person is referring to their own difficult financial circumstances as the reason. The fourth relates to personal preference.

Two people reporting no change in the trend in use of eggs gave reasons which suggested that their use of eggs had not changed: “no change, boiled, fried as relish with tomato, fried plain with nsima”, and “same – boiled, fried with soup, on bread sometimes”.

General trend in the use of soya and why

Just under half (7) people interviewed said the general trend was an increase in the use of soya, 4 said there had been no change, and 4 said there was a decline. While the main reasons for changing trends in the use of eggs related to affordability, the main reasons for soya related mainly to issues of availability and quality. The reasons given for the perceived increase were:

- “these are now cheaper” (female aged 52)
- “increase in supply, now readily available and affordable” (male aged 45)#
- “a lot of people are buying soya” (female aged 50)
- “increase since soya pieces are easy to prepare (male aged 37)
- “increase since they are cheaper” (male aged 47)
- “increase in use this year due to someone who joined the household that likes soya pieces, fried with tomatoes and onions” (female aged 28)
- “increase since now using soya powder to make porridge” (female aged 52 who does not like eggs)

The reasons given for the perceived decline in use of soya were:

- “decline not readily available, don’t trust quality of soya flour as some sellers mix with maize” (female aged 30),
- “decline soya flour lack of supply in the market” (female aged 35),
- “use to receive free soya flour from the clinic, but no longer do” (female aged 28)
- “Decline, taste not good, there are alternatives porridges for children, Delight” (male aged 15)
- A 45 year old make elaborated his response of no change, implying he now ate less soya, stating “I used to consume a lot when the children were young”.

4. FORMAL SURVEY RESULTS

4.1 Respondent Profile

While it proved easy to include a reasonable number of both male and female participants, it was difficult to engage participants over 40 and particularly those over 50 years old; 86% of the participants were aged between 16 and 40 years. The interview team included both male and female enumerators; male enumerators interviewed men and female enumerators interviewed women. The female enumerators undertook interviews more quickly than the male enumerator, and there was an extra female enumerator on the second day, the overall result being that a larger number of females (91) than males (59) were interviewed; in similar proportions from both Kalingalinga and Kanyama.

Survey Participants by Location and Gender				
		Respo ndent Gender		Total
		Male	Female	
location	Kanyama	29	44	73
	Kalingalinga	31	47	78
Total		60	91	151

Survey Participants by Location and Age Group							
		Respondent age group					Total
		16-20	21-30	31-40	41-50	Above 50	
location	Kanyama	32	18	11	7	4	72*
	Kalingalinga	15	26	24	12	1	78
Total		47	44	35	19	5	150
% in each age group		31%	29%	23%	13%	3%	

**One married male respondent's age was not recorded.*

The minimal targets for gender and age group were met except for the over 50 age group, which was difficult to access in the public spaces. The 16-20 and over 50 age groups were over represented by females, while the 31-40 and 41-50 age groups were over represented by males.

Respondent Gender by Age group						
	Respondent age group					Total
Respondent Gender	16-20	21-30	31-40	41-50	Above 50	
Male	7	18	23	10	1	59
%	15%	41%	65%	53%	20%	39%
Female	40	26	12	9	4	91
%	85%	59%	35%	47%	80%	61%
Total	47	44	35	19	5	150

4.2 Egg Consumption (including under 5s)

Proportions of lower income households consuming eggs

Results indicate that around 90% of low income households do consume eggs, based on the two questions, "do you eat eggs?" and "do other people in your family eat eggs?

Do you eat eggs? * Response by Gender

		Male	%	Female	%	Total	%
Do you eat eggs	Yes	55	92%	81	89%	136	90%
	No	5	8%	10	11%	15	10%
Total		60	100%	91	100%	151	100%

Do other people in your family eat eggs? Response by Gender

		Do other people in your family eat eggs?		Total
		Yes	No	
Respondent Gender	Male	56	4	60
	Female	81	10	91
Total		137	14	151
%		91%	9%	100%

Similar proportions of both male and females reported eating eggs. The effect of age on whether or not a person consumes eggs also appears to be minimal.

Do you eat eggs? Response by age group

		Respondent age group					Total
		16-20	21-30	31-40	41-50	Above 50	
Do you eat eggs	Yes	43	39	32	17	4	135*
	No	4	5	3	2	1	15
% not eating eggs		9%	13%	9%	11%	20%	10%
Total		47	44	35	19	5	150

**One married male respondent's age who eats eggs was not recorded.*

The frequency of egg consumption was assessed by two questions "When was the last time you ate an egg?", and "How often do you usually eat eggs?". The response to the first question indicates that over three quarters of those responding, who ate eggs, had eaten an egg within the last three days, and 19% had eaten an egg that day (probably for breakfast or as a snack).

Responses to the question, "who else eats eggs in the household?", suggest that eggs are usually eaten by most members of the household. Limited weight should be attached to the actual frequency of mention of the different categories of household members, because no data was collected on the actual household composition if each respondent. The pattern of responses suggest that the question was understood as "who in your household eats eggs?" in a large number of cases, because a similar proportion of male adults listed "husband" and female adults "wife", which is suggestive that they were including themselves in their response. The responses suggest that children over 5 are more likely to eat eggs than children under 5. As noted above, without details of the household composition this conclusion would be based on the assumption that the majority of respondents had more younger children in their households because 73% of the females responding were aged 16-30, and 82% of the males were aged 16-40. Grandparents were mentioned less possibly because of there were relatively fewer households interviewed when a grandparent was living.

Who else eats eggs in the household –

	Total	%
Children over 5 years old	109	26%
Husband	92	22%
Wife	91	21%
Children under 5	74	17%
Grandparents	58	14%
Total	423	100%

Frequency of consumption

This was assessed through two questions, “when was the last time you ate an egg?” and “How often do you usually eat eggs?”.

When was the last time you ate an egg? Response by Gender

Respondent Gender	When was the last time you ate an egg?				Total
	Today	Yesterday	The day before yesterday	Longer ago	
Male	9	20	11	14	54
Female	16	31	17	17	81
Total	25	51	28	31	135
%	19%	38%	21%	23%	100%

The response to the second question was broadly consistent with the response to the first, indicating that 79% of the respondents eating eggs ate them at least once a week, and 31% ate eggs most days of the week.

In terms of the effect of gender on the frequency of consumption, the responses suggest that females generally eat eggs more frequently than males.

How often do you usually eat eggs? Response by Gender

Respondent Gender	How often do you usually eat eggs?				Total
	Most days	2-3 times a week	Once a week	Less often	
Male	14	20	5	15	54
Female	28	19	21	13	81
Total	42	39	26	28	135
%	31%	29%	19%	21%	100%

The pattern of daily egg consumption

The pattern of egg consumption in households was assessed through two questions “for which meals do you usually eat eggs?” (with three response to choose from “breakfast”, “snack during the day” and “main meal with Nsima”) and “how many different ways do you eat eggs” (with four responses boiled, scrambled, relish and “other”).

The responses to the first question suggest that about half of the respondents eating eggs usually eat them for breakfast, while the other half usually eat them with the main meal. Qualitative interviews indicated that the people living in the locations regard eating eggs for breakfast as a high status behaviour, while eating eggs with the main meal is mainly for reasons of economy (eggs are cheap). It is possible therefore that some respondents over-reported use of eggs for breakfast and under reported use of eggs for the main meal. It is possible that females were more likely than males to think in this way, hence the differences in responses between the two genders.

In terms of the gender differences, a higher proportion of females reported usually eating eggs for breakfast, while a higher proportion of males reported usually eating eggs with the main meal. None of the men reported eating eggs as a snack, while 5 % of the women did so. Qualitative interviews indicated that many of the women in the locations are engaged with petty trade, often taking babies and small children with them, and reported that they often have an egg for their breakfast while at work, because it is easy to prepare and feed the baby as well. This suggests that eggs provide an affordable and convenient food for younger women with multiple responsibilities and a high level of demand on their time.

For which meals do you usually eat eggs? Response by Gender

Respondent Gender	Breakfast	%	Snack in the day	%	Main meal with Nsima	%	Total	%
Male	24	44%	0	0%	30	56%	54	100%
Female	43	53%	4	5%	34	42%	81	100%
Total	67		4		64		135	
%	50%		3%		47%		100%	

The responses to the second question indicate that eggs are usually eaten either fried or boiled, and less often scrambled, and in a very few cases as an omelette. Qualitative interviews on how households prepare and eat eggs, indicated that the term "fried" is used very often to describe the process of preparing eggs as relish for the main meal, and also that sometimes eggs are also boiled and then added to the relish. Hence the responses should not be interpreted as meaning that most people eat eggs for breakfast or as a snack.

There was little difference between male and female respondents in relative frequency of the difference ways of eating eggs. Only two female respondents reported other ways, which in both cases were "make soup using the yoke". No male respondent reported other ways of eating eggs.

How many different ways do you eat eggs? Response by Gender

	Male	%	Female	%	Total	%
Fried	49	42%	68	42%	117	42%
Boiled	32	28%	56	35%	88	32%
Relish	16	14%	19	12%	35	13%
Scrambled	14	12%	15	9%	29	10%
Omelette	5	4%	1	1%	6	2%
Other	0	0%	2	1%	2	1%
Total	**116**	**100%**	**161**	**100%**	**277**	**100%**

Reasons for eating eggs

Three questions relating to the reasons why individuals might decide to eat eggs rather than another type of food were:-

- What are the reasons you eat more or less eggs?
- What are the advantages of eating eggs?
- What are the disadvantages of eating eggs compared to other foods?

Health reasons were mentioned more frequently than financial reasons for eating more or less eggs.

The main reasons given for eating more or less eggs related in order of frequency mentioned were; health reasons, financial reasons and personal preferences. Convenience was only mentioned by 3% of the respondents to this question. A further 3% of respondents said they ate the same amount of eggs. There was very little difference between male and female responses to this question.

What are the Reasons you eat more or less eggs? Response by Gender

	Male	%	Female	%	Total	%
Health Reasons	24	37%	38	42%	62	40%
Financial reasons	18	28%	26	28%	44	28%
Personal preference	18	28%	22	24%	40	26%
Convenience	3	5%	2	2%	5	3%
Eat the same amount	2	3%	3	3%	5	3%
Total	**65**	**100%**	**91**	**100%**	**156**	**100%**

A similar trend emerged for the main advantages of eating eggs, with health being the most frequently mentioned advantage[104], followed by affordability and taste. Convenience was noted as an advantage by 11% of respondents. Again there was very little difference between male and female responses in the frequency of the main advantages. Two female respondents identified social status as an advantage, but no male respondents did so.

What are the Advantages of eating eggs? Response by Gender

	Male	%	Female	%	Total	%
Eggs are healthy (protein)	50	48%	52	40%	102	44%
Less expensive	24	23%	38	29%	62	27%
Taste	19	18%	23	18%	42	18%
Convenience	11	11%	14	11%	25	11%
Social status	0	0%	2	2%	2	1%
Total	**104**	**100%**	**129**	**100%**	**233**	**100%**

Health/cholesterol was the by far the most frequently mentioned disadvantage by both genders, with a higher proportion of male respondents (93%) identifying this than females (72%). 13% of the female respondents identified allergy as a disadvantage, and 7% of females identified flatulence as a disadvantage. 4% of respondents identified social status as a disadvantage (indicating that eggs are beginning to be seen as a lower status food by a small minority in high density urban areas). 3 females said they no longer trusted the quality of eggs on the market, and two of these made reference to eggs from Chinese egg farmers.

104 This finding came as something as a surprise, because it had been assumed that the affordability of eggs was the main driver of the increase in consumption. A possible reason why health reasons were mentioned more frequently than affordability is that "health" this was the first of the options listed in the options that respondents could choose from, followed by financial reasons. Had the order been reversed then the relative frequency of mention could have been different.

Are there Disadvantages of eating eggs compared to other foods? Response by Gender

	Male	%	Female	%	Total	%
Health/Cholesterol	40	93%	52	72%	92	80%
Allergy	0	0%	9	13%	9	8%
Social status	2	5%	3	4%	5	4%
Gas/flatulence	1	2%	5	7%	6	5%
Quality not trusted	0	0%	3	4%	3	3%
Total	**43**	**100%**	**72**	**100%**	**115**	**100%**

The use of eggs in the diet of children under 5

The frequency of use of eggs by households in the diet of children under 5 was assessed through the question "**If there are young children under 5 years old, how often do they eat eggs**?" The responses suggest that nearly 60% of the respondents who eat eggs reported regular (either "most days" or "2/3 times per week") use of eggs for children under five, while just over 40% who eat eggs reported that under 5s have eggs infrequently (once a week or less often). Qualitative interviews in the two locations indicated that people regard eggs as a very convenient source of food for under 5s, either fed as a snack, or mixed with porridge, eating. The people interviewed indicated that special food is prepared for under 5s, and that this usually given to them between 2-3 times per day, usually in addition to the main household meal. The responses therefore suggest that there is significant scope for increasing the use of eggs in the diet of under 5s, provided the eggs are available, affordable and there is knowledge on how to use them for infant feeding.

If there are young children under 5 years old, how often do they eat eggs? Response by Gender

Respondent Gender	Most days	2-3 times a week	Once a week	Less often	Total
Male	12	27	1	15	55
Female	18	24	13	27	82
Total	30	51	14	42	137
	22%	37%	10%	31%	

The general trend in the frequency of consumption of eggs over the past year

The general trend in the frequency of use of eggs by households was assessed through the question "**Do you eat more or less eggs now than a year ago**?" The responses suggest that nearly half (47%) of the respondents who eat eggs reported eating more eggs while over a third (37%) reporting eating less eggs. The responses did not differ very much by gender, although more weight could be attached to the responses from females who typically buy and prepare household food.

This suggests, overall, a modest increase in the consumption of eggs in lower income areas. The survey did not include a question about the reasons why people eat more or less eggs than a year ago. However, qualitative interviews did provide information to suggest that the reasons for changing patterns of consumption of eggs include:-

- Improved household income enabling families to eat more eggs for breakfast,
- Declining household income leading families to eat more eggs with the main meal, as a more affordable type of relish,

- Increases in the prices of alternative sources of relish and related inputs (e.g. Kapenta, Fish, Chicken and beef prices increasing, and price of charcoal increasing which indirectly make beans and dry fish a more expensive relish due to the long cooking time required).

Do you eat more or less eggs now than a year ago? Response by Gender

Respondent Gender	Do you eat more or less eggs now than a year ago?			Total
	More	Less	The same amount	
Male	26	21	7	54
Female	37	29	15	81
Total	63	50	22	135
%	47%	37%	16%	100%

The main reasons for not consuming eggs

The main reasons for not consuming eggs was assessed by two questions; "If you don't eat eggs why not?" and "if your family does not eat eggs, why not?".

As noted above, 90% of individuals and households did consume eggs. For the 10% who did not, the main reason given was "don't like them". Two respondents said they did not eat eggs because they "have gasses" i.e. cause flatulence. The comment about "gases" was also common when respondents were asked to mention any disadvantages of eggs compared to other relish.

If you don't eat eggs - Why not? Response by Gender

Respondent Gender	Don't like them	Other reason -	Total	Describe other reason
Male	5	0	5	Two females said "they have gasses" and one did not give a reason.
Female	7	3	10	
Total	12	3	15	

If your family does not eat eggs why not? Response by Gender

Respondent Gender	Health Reasons	Financial Reasons	Personal Preference	Other(Please specify)	Total
Male	2	1	0	1	4
Female	6	1	1	2	10
Total	8	2	1	3	14

Access: where the family usually buys eggs

The response to the question about where the family usually buys eggs indicates that the majority use either the local market, or local kiosks (Kantemba). Just under a quarter indicated "supermarket", where it is known that eggs are usually sold at a higher price. This perhaps reflects the more recent penetration of smaller supermarkets into the higher density locations in Lusaka, but may also be "over-reporting" because some respondents might have wanted to project a higher social status during the interview.

Where does your family usually buy their eggs? By Location

Where does your family usually buy their eggs?	Kanyama	%	Kalingalinga	%	Total	%
Kantemba	12	19%	28	38%	40	29%
Supermarket	16	25%	15	21%	31	23%
Local market*	35	55%	27	37%	62	45%
Neighbour	1	2%	2	3%	3	2%
Other - "anywhere we find them"	0	0%	1	1%	1	1%
Total	64	100%	73	100%	137	100%

*Local is the market that people can easily walk to from their home, in this case it is the local markets in Kalinglinga and Kanyama.

4.3 Soya Product Consumption (including under 5s)

Proportions of lower income households consuming Soya Products and frequency of consumption

The proportion of households consuming soya products was based on the two questions, "do you eat soya products?" and "do other people in your family eat soya products?

Results indicate that around three quarters (71% of respondents and 77% of their households) of low income households in the lower income locations surveyed do consume soya products; about 15% less than households who consume eggs. The results suggest that age is not a major factor influencing whether or not a person eats soya products.

Do you eat Soya products? Response by Age Group

Do you eat Soya products?	Respondent age group					Total
	16-20	21-30	31-40	41-50	Above 50	
Yes	34	30	26	14	3	107
%	72%	68%	74%	74%	60%	71%
No	13	14	9	5	2	43
%	28%	32%	26%	26%	40%	29%
Total	47	44	35	19	5	150

Do other people in your family eat soya products?

Yes	%	No	%	Total	%
115	77%	34	23%	149	100%

Regarding the effect of gender on consumption of soya products, the responses indicate similar proportions of both male and female respondents do consume these.

Do you eat Soya products? Response by Gender

Do you eat Soya products?	Respondent Gender		Total
	Male	Female	
Yes	43	64	107
%	73%	70%	71%
No	16	27	43
%	27%	30%	29%
Total	59	91	150

Regarding the effect of location on consumption of soya products, the responses indicate that a higher proportion of people in Kalingalinga eat soya products compared with those in Kanyama.

Do other people in your family eat soya products; Response by Location

		Yes	No	Total
location	Kanyama	47	25	72
	Kalingalinga	60	18	78
Total		107	43	150

As with eggs, responses to the question, "who else eats soya products in the household?", suggest that these products are eaten by all categories of household members. While no data was collected on the actual household composition if each respondent, as this was the same sample, it is worth commenting on some differences in the frequency of mention of different categories of household members compared with the same question asked about eggs.

The most notable difference relates to the mention of grandparents, mentioned as eating soya products 98 times, compared with 58 times eating eggs. The pattern of responses suggest soya products are seen as products more likely to be eaten by older and younger household members (grandparents and children), and less likely to be eaten by the husband or wife. This contrasts with eggs, which are seen as more likely to be eaten by older children and the husband and wife, and to a lesser extent by children under 5 and grandparents.

In terms of the social status attached to different types of food, this might imply that soya products are perceived of as a slightly lower status food compared with eggs.

Who else eats Soya products in the household – Response by Gender

	Male	%	Female	%	Total	%
Children over 5 years old	34	21%	64	25%	98	24%
Grandparents	34	21%	64	25%	98	24%
Children under 5	28	18%	48	19%	76	18%
Wife	34	21%	39	15%	73	18%
Husband	29	18%	42	16%	71	17%
Total	**159**	**100%**	**257**	**100%**	**416**	**100%**

The frequency of consumption of soya products

For respondents who indicated that they did eat one or more soya product, their frequency of was assessed through two question: 1) "**When was the last time you ate a Soya Product?**" and 2) How often do you eat it in a week. .

When was the last time you ate a Soya Product; by Location

Location	Today	Yesterday	The day before yesterday	Longer ago	Total
Kanyama	1	12	11	29	53
Kalingalinga	2	12	14	32	60
Total	3	24	25	61	113

How often do you eat the soya products in a week? By Location

Location	Most days	2-3 times a week	Once a week	Less often	Total
Kanyama	3	18	7	25	53
Kalingalinga	11	8	17	24	60
Total	14	26	24	49	113

The pattern of daily soya product consumption

The pattern of soya product consumption in households was assessed through the question "for which meals do you usually eat soya products?" with three response to choose from "breakfast", "midday" and "evening meal". The responses suggest that of the 113 respondents eating soya products, the most common time to eat these is with the evening meal (70%), followed by the midday (23%) and then breakfast (7%). This contrasts with the pattern for eating eggs when breakfast was mentioned an equal number of times as the main meal with Nsima. Qualitative interviews indicated that the some people living in the locations regard eating soya products as more common when the household budget is tight, but some also said they liked the taste. It appears from the data that eating soya products is more common in Kalingalinga than in Kanyama, particularly for lunch. The possible reasons for this difference were not explored in the interviews, but more frequent use of soya products for infant feeding in Kalingalinga may be one of the reasons (see below).

For which meal/s do you usually eat Soya Products? Response by Location

Location	For which meal/s?			Total
	Breakfast	Midday	Evening Meal	
Kanyama	4	9	40	53
Kalingalinga	4	17	39	60
Total	8	26	79	113
%	7%	23%	70%	100%

The use of soya products in the diet of children under 5

The frequency of use of soya products by households in the diet of children under 5 was assessed through the question "**If there are young children under 5 years old, how often do they eat soya products**?" The responses suggest that over half (51%) of whose households feed children under 5 with soya products less than once a week, and only 15% use these products on "most days" to feed children under 5.

In terms of the effect of location, the data suggest that feeding infants under 5 with soya products is commoner in Kalingalinga than it is in Kanyama.

In the context of relatively high rates of malnutrition nationally, including in urban areas, this indicates that there is significant scope for further increasing use of soya products for under 5 feeding.

If there are young children under 5 years old, how often do they eat soya products? Response by Location

Location	Most days	%	2-3 times a week	%	Once a week	%	Less often	%	Total	%
Kanyama	5	7%	11	15%	13	18%	43	60%	72	100%
Kalingalinga	17	22%	12	16%	15	19%	33	43%	77	100%
Total	22	15%	23	15%	28	19%	76	51%	149	100%

The general trend in the frequency of consumption of soya products over the past year

The general trend in the frequency of use of soya products by households was assessed through the question "**Do you eat more or less soya products now than a year ago**?" The responses suggest that nearly a quarter (23%) of the respondents reported eating more of the soya product while over a third (35%) reported eating less, and the remainder said they ate the same amount. There was a major difference between the locations in the response to this question. The majority of respondents in Kalingalinga reported that they ate the same amount, while in Kanyama over 90% reported a change, either more or less. This suggests a more consistent use of soya products is established in Kalingalinga, a hypothesis supported by the higher use of soya products by other family members, for infant feeding, and for the lunchtime meal in Kalingalinga.

Do you eat more or less of this soya product than a year ago?

Location	More	%	Less	%	The same amount	%	Total
Kanyama	20	38%	29	54%	4	8%	53
Kalingalinga	6	10%	11	20%	43	72%	60
Total	26	23%	40	35%	47	42%	113

Asked about the advantages of eating soya productions, a very similar pattern emerged as that noted for eggs, with health being the most frequently mentioned advantage, followed by affordability taste and convenience. As with eggs, there was little difference between male and females in the relative frequency of listing the main advantages of soya products. Three female respondents identified social status as an advantage, and one male respondents did so. This could indicate that healthy eating, or a vegetarian diet, is beginning to be linked with social status in the higher density areas.

What are the Advantages of eating soya products? Response by Gender

	Male	**%**	**Female**	**%**	**Total**	**%**
healthy (protein)	30	33%	42	35%	72	34%
Less expensive	29	32%	31	26%	60	29%
Taste	19	21%	31	26%	50	24%
Convenience	11	12%	12	10%	23	11%
Social status	1	1%	3	3%	4	2%
Total	**90**	**100%**	**119**	**100%**	**209**	**100%**

Health/cholesterol was the by far the most frequently mentioned disadvantage of eating soya by both genders. However, this result should be treated with caution, and should probably be discounted, as the way the option was framed was an error in survey design. The other possibility is that members of the public are not well informed about the properties of soya, and therefore assumed that as this option was listed as a disadvantage, then they agreed with it. Soya is known to be very low in cholesterol and may slightly help to lower cholesterol levels in the blood.[105] Also, as this was the last question on the survey it is possible that the respondent and enumerators were tiring and did not pay close attention. Whatever the reason, this result affirms that a significant proportion of the respondents were sensitive to the importance of health benefits and risks of different types of food.

Are there Disadvantages of eating soya products compared to other foods? Response by Gender

	Male	%	Female	%	Total	%
Health/Cholesterol	25	89%	43	83%	68	85%
Social status	2	7%	6	12%	8	10%
Taste not good, or not consistency good taste	1	4%	2	4%	3	4%
Allergy	0	0%	1	2%	1	1%
Total	**28**	**100%**	**52**	**100%**	**80**	**100%**

The main reasons for not consuming Soya products

As noted above, the majority (around 75%) of households did consume some soya products.
For the 25% who did not, the reasons were assessed by two questions. The first was; "If you don't eat soya products why not?", with the response options of "don't like them", "my family doesn't like them", "don't know about them" and "other" (specify). The second question was "if your family does not eat soya products, why not?" with different options of: "health reasons", "personal preference", "financial reasons", and convenience and "other" (specify).

The main reason selected by individuals for not consuming soya was "don't like them, followed by "my family doesn't like them". This was mirrored in the reason given why the respondent's family does not eat soya; "personal preferences" being the most common reason, followed by "health reasons". The health reasons were not elaborated during the formal survey. "Finance" was given by individual as a reason in two cases (possibly because it was mentioned in the qualitative interviews that soya products used to be distributed free by clinics). "Convenience" was listed in two cases by female respondents, possibly related to limited local availability, or because soya takes more time to prepare compared with eggs.

If you don't eat Soya products why not? Response by Gender

Respondent Gender	Don't like them	My family doesn't like them	Don't know about them	Other - describe	Total
Male	17	0	0	0	17
Female	17	7	2	1 – "no reason"	27
Total	34	7	2	1	44

105 See for example http://www.mayoclinic.org/diseases-conditions/high-blood-cholesterol/expert-answers/soy/faq-20057758 and https://www.webmd.com/cholesterol-management/features/soy-and-cholesterol#1

If your family does not eat Soya products why not? Response by Gender

Respondent Gender	Personal Preferences	Health Reasons	Financial Reasons	Convenience	Other (specify)	Total
Male	12	3	1	0	1 "live alone"	17
Female	6	6	1	2	1 "gases" 2 "no reason"	18
Total	18	9	2	2	1	35

Access: where the family usually buys soya products

The response to the question about where the family usually buys soya products indicates that the majority use either the local market (60%), or local kiosks (Kantemba). Only 15% indicated "supermarket", where products are usually sold at a higher price than in local markets. In Kalingalinga local kiosks were cited more than twice as much as in Kanyama, perhaps because a more established pattern of household use of Soya in Kalingalinga has resulted in more kiosks selling this product.

Where does your family usually buy their Soya products from? By Location

Where does your family usually buy their Soya products from?	Kanyama	%	Kalingalinga	%	Total	%
Kantemba	7	13%	18	29%	25	17%
Supermarket	10	19%	7	11%	17	15%
Local market	34	64%	36	57%	70	60%
Neighbour	1	2%	2	3%	3	3%
Other (describe)	1	2%	0	0%	1	1%
Total	53	100%	63	100%	116	100%

5. GENERAL CONCLUSIONS FROM INFORMAL AND FORMAL SURVEYS

General preferences for "relish": these vary from one individual and household to another, although meat (particularly beef) and fish (fresh or dried) tend rank higher than chicken, eggs or soya. However, some individuals do prefer vegetable relishes to those made from animal protein sources.

Trends: While data gathered on trends in the frequency of use over time was quite limited, the responses in both the formal and informal surveys indicate that there is an overall trend of increasing importance of both eggs and soya products in the diets of lower income households in Lusaka.

Drivers of changing consumption patterns: While health reasons were mentioned most often in the formal survey, responses to the informal survey suggest that a major driver of the increase use of eggs is the availability and affordability of eggs in the markets of lower income urban areas. Other drivers are the convenience of preparing eggs as a food, the lapse of traditional food taboos relating to eating of eggs by children and women, and the general acceptability of eggs as a tasty food for all categories of household members.

As with eggs, the main drivers of increased use of soya are the availability and affordability of soya products, relative to other sources of household relish and infant foods. Factors which appear to make soya less used than eggs by this category of households include irregular supply/local availability, concerns about product quality, personal tastes (while some people say they like the way soya tastes others say they don't like the taste – whereas with eggs most people seem to like the taste). There may also be a social status factor, because while eating eggs for is now something to aspire to for lower income families, soya is associated with free school meals and free handouts at local clinics.

Importance in household diet; Eggs are now a very important element of the diet for lower income households in Lusaka. 90% of the individuals interviewed said they eat eggs, 60% said they eat eggs at least 2 or 3 times a week and 91% said their household eats eggs. Soya products, particularly soya pieces and soya flour/powder (for use in making porridge), are also important in the diet of lower income urban households, but to a lesser extent than eggs. 70% of the individuals interviewed said they eat soya products,40% said they eat these products at least 2 or 3 times a week and 77% said their household eats soya products.

Importance in Under 5s diet. Both eggs and soya are used in preparing meals specifically for under 5s in the household, but this is not as common as preparing porridge from maize meal and groundnuts, which is by far the most commonly cited meal given to under 5s. The lower income households able to afford eggs buy them specifically as a meal for younger children. The lowest income households still perceive this option as unaffordable.

When eaten: In lower income households, both eggs and soya products are most commonly eaten as part of the evening meal, as relish with nsima, rather than for breakfast or with a midday meal. Both eggs and soya are also perceived by lower income households as relatively more affordable sources of relish during times when the family cannot afford more expensive options such as meat and fish. When times are good, families who can afford them like to eat eggs for breakfast.

Reasons for eating or not eating: Health factors were cited quite often as reasons for eating, or not eating, both eggs and soya products, and in some cases it is possible that there are beliefs which may not be supported by current research. For example, both eggs and soya were associated with beliefs about the risks associated high cholesterol, while more recent research suggests that the cholesterol in eggs is not harmful and recent research on soya products indicates that they are either slightly beneficial or neutral in lowering levels of harmful cholesterol. This suggests that there is scope for further public health information on both eggs and soya products. Other reasons given for eating or not eating were taste preferences, produce quality concerns (mostly soya), and cost (for lowest income). With regard to the cost of eggs, 10 of the 15 people interviewed in the informal survey said that eggs were the cheapest form of protein which can be used for relish, which indicates that cost is certainly one of the drivers behind increasing consumption of eggs in urban higher density areas.

Where purchased. Both eggs and soya products are usually sourced from local markets or kiosks by the people covered in the survey, rather than from supermarkets. Comments indicate that eggs are widely available in local markets and kiosks, but soya products are less reliably available from these sources.

Annex i : Formal Questionnaire Template

Date:

1. Location:
2. Respondent Gender: Male/Female
3. Age Group (circle): 16-20, 21-30, 30-40, 40-50, 50 plus

EGGS

4. Do you eat eggs yes/no

If yes continue, if "No" go to Q 12 :

5. When was the last time you ate an egg? (today, yesterday, the day before yesterday, longer)
6. How often do you usually eat eggs? (most days, 2-3 times a week, once a week, less often)
7. For which meals: breakfast, snack in the day, main meal with nsima
8. How many different ways do you eat eggs? (tick those that apply): boiled, fried, scrambled, omelette, relish, other ways (describe)
9. Which is you favourite way of preparing eggs and why?
10. Do you eat more or less eggs now than a year ago?: More, Less, the same amount
11. If more or less, why? (health reasons, financial reasons, personal preferences, convenience, other (please specify)
12. If you don't eat eggs - Why not? (don't like them, too expensive, my family never eat eggs, other reason - describe
13. Do other people in your family eat eggs? Yes/no

If yes, continue if "No" go to Q21

14. Who else eats eggs (tick categories that apply): husband, wife, grand-parent, children over five, children under 5
15. How many times a week does your family usually eat eggs? (most days, 2-3 times a week, once a week, less often)
16. If there are young children under 5 years old how often do they eat eggs?: (most days, 2-3 times a week, once a week, less often)
17. What are the advantages of eating eggs? (convenience, less expensive, health/protein, taste, social status, other (please specify)
18. Any disadvantages of eggs compared to other foods? (Allergy, health/cholesterol, social status, other (please specify)
19. Where does your family usually buy their eggs? (Ntemba, supermarket, local market, neighbour, other (describe)?

20 .If your family does not eat eggs – why not?

SOYA PRODUCTS

20. Do you eat Soya Products yes/no

If yes continue, if "No" go to Q 25:

21. Which soya products do you eat: soya chunks/pieces, soya mince, soya flour, soya sausages, soya samosas, soya milk, soya strips, soya burger, other – please specify
22. When was the last time you ate the Soya product? (today, yesterday, the day before yesterday, longer)
23. How often do you eat Soya products? (most days, 2-3 times a week, once a week, less often)
24. For which meals: breakfast, midday, evening meal
25. More, Less, the same amount

If more or less, why? (record the reason/s

26. If you don't eat Soya chunks- Why not? (don't like them, my family doesn't like them, don't know about them, other reason - describe
27. Do other people in your family eat Soya Chunks? Yes/no

If yes, continue, if "No" go to Q33

28. Who else eats Soya chunks (tick categories that apply): husband, wife, grand-parent, children over five, children under 5
29. What are the advantages of eating Soya products? Allergy, health/cholesterol, social status, other (please specify)
30. Any disadvantages of Soya products compared to other foods? (Allergy, health/cholesterol, social status, other (please specify)
31. Where does your family usually buy their Soya products? (Ntemba, supermarket, local market, other (describe)?
32. What would encourage your family to eat more Soya chunks?
33. If your family does not Soya chunks – why not?
34. Does your family eat any other products made from Soya? (if yes list these).

Annex ii: checklist – open ended questions to complement quantitative data

Respondent Details

Age Gender .... Occupation......................... Location ....

1. What are your favourite relishes to eat with nsima and why?

2. When times are hard, how does your family reduce the amount spent on relish?

3. What is the cheapest type of relish which provides a family with protein

4. For families with babies and young children under 5, what types of special food is used for them?

5. When and how often is this food usually fed to the under 5s in the home?

6. In this area, is it common for mothers to include eggs in dishes prepared for under 5s (explore reasons why it is common or not common)

7. In this area, is it common for mothers to include soya flour, soya milk, or soya mince in dishes prepared for under 5s (explore reasons why it is common or not common)

8. In this area, what is the general trend in how families use eggs and why (explore reasons for the trend)

9. In this area, what is the general trend how families use soya products and why (explore reasons for the trend)

Annex 1b – Notes on representativeness of Rural and Urban Households interviewed for Social Analysis of Egg VC – Zambia

Soya Producers Interviewed Overview

The small-scale producers of soya interviewed during a rapid appraisal exercise undertaken during the second country visit were located in Mpongwe District, Copperbelt Province, where the largest egg producers are situated.

As this was a rapid appraisal exercise with a specific focus on the small-scale soya segment of the Egg VC, rather than a structured formal survey, questions on potentially sensitive socio-economic aspects were not included. The household interviews followed a checklist. The questions focused on specific aspects of soya production and postharvest operations, including soya utilisation. The interviews also covered production and use of eggs from village chickens.

Mpongwe has a population of commercial farmers on the western side and a substantial population small-scale farmers living in villages and scattered settlements in the eastern side. Mpongwe District has been a focal area for rural development projects, including agriculture, mainly funded by the European Union, since the mid-1980s. Mpongwe one of the operational areas covered by the TAFF funded support to small-holder soya production for supply to Golden Lay, which is implemented through NWK, an established agribusiness organisation providing services to small-scale farmers. An NWK manager arranged for one of the NWK aggregators living close to Mpongwe District to facilitate interviews with small-scale farmers in her operational area. She selected the farmers interviewed based on criteria (at least two female headed and two male headed households growing soya). Three of the farmers she selected were recruited by her and provided with inputs from NWK, the others were not recruited by her but were known to her. Due to limitations with the experience of this aggregator in translating and undertaking farmer interviews, a local female extension officer also known to the farmers agreed to assist with the interviews.

The interviews with small-scale soya producers were undertaken within a 5km radius of Mpongwe District headquarters which is a market centre, and within 1km of the main road servicing the District. This is a relatively densely settled part of the district, because households with more limited resources prefer to live close to services and roads. Mpongwe is largely populated by people of Lamba ethnicity, but with a significant proportion of people of other ethnicities who have settled from other parts of Zambia. The Lamba have a matrilineal kinship system, the most common kinship system in rural Zambia. Local people are able to access land through kinship connections with other local people or the local chief. The size of arable land holdings is relatively small in the area around the district centre (ranging 2-5 hectares) covered, which limits the opportunities for earning significant income from crops and/or livestock. There are a significant number of people from other ethnic groups living in Mpongwe District. A large proportion of the people of different ethnicity have accessed land through the local chief or local family heads, and are settled in areas away from the main road and centres where there is less for land, and they can access larger areas of land for cultivation (from 10 hectares upwards) and grazing.

Five household heads were interviewed in relation to soya production in Mpongwe. Four of the household heads interviewed were of Lamba ethnicity and one was a widow of Shona ethnicity. 3 of the household heads were females, and two of these were widows. All three were aged over 50 with adult children and grandchildren. The other 2 household heads were married males monogamously married with children, including some younger children. One of the two male household heads was interviewed with his wife (the wife of the other had gone to help her sister organise a wedding in town). All of the households interviewed derived their main income from agriculture, and none of them had salaried employment. All of the female headed households interviewed had access to family owned oxen for cultivation, while none of the three male households interviewed had such access; they hired oxen and/or relied on hand hoe cultivation. Such a pattern of access to animal draft power is not untypical in matrilineal settings, which enable older women to inherit or control cattle accumulated. As marriage is often "matrilocal" (with the man moving to live in the village of the wife) younger married men are less likely to be in a position to own or access draft power.

Four of the five farming households interviewed grew soya, and had reasonable access to family labour to assist with the more laborious tasks. The fifth did not grow soya her explanation being that she did not have access to family labour as she stayed alone. All four used herbicides on their soya crop, foliar booster fertilizer. Three of the five had received inputs for soya cultivation on loan from NWK, including improved seed, and sold their soya crop to pay off the loan. All four farmers growing soya made a loss on their soya production. Two using Dina seed from NWK, and sold their soya to NWK to make up the cost of the loan. The other sold to local briefcase buyers at a loss, keeping some of the harvest for replanting next season. The fourth farmer decided not to sell any soya but to keep some of the harvest for seed, and to mix the remainder with maize, at a ratio of 1:5, to provide a higher protein diet for his family, which included 5 young children.

In addition to the five household head interviews, a focused group discussion was held with a group of local farmers living in the same area. The aim of the focus group was to further validate findings and fill gaps in information from the household interviews, including aspects of gender decision making. Four of the six household heads interviewed (two females and two males) attended the focus group discussion and in addition 6 other local female farmers and 7 other local male farmers attended. The ages of other farmers attending was estimated at ranging from between 30 and 55 years old for the female farmers and between 35 and 50 years old for the male farmers.

The focus group discussion focused on aspects constraints to soya production, utilisation, seed management, household decision making in relation to crop choice when planning, soya production and sale, herbicide use and access to land,

Egg and Soya Product Urban Consumers Interviewed Overview

Two areas with high density housing in Lusaka were selected; Kalingalinga Ward on the eastern side and Kanyama Ward on the western side of the city. Both these Wards of Lusaka are known to have established populations made up of a diversity of ethnic origins, and including a large number of people who were born and raised in these areas. They were felt to be reasonably typical of lower income urban areas in Lusaka, both Wards having the highest poverty headcount within their respective constituencies.

Apart from gender and age category, the consumption surveys did not collect socio-economic data on the respondents (such as ethnicity, marital status, size of family, income, house type/ownership). It was felt that asking questions about personal circumstances would raise suspicion unnecessarily, could influence the responses to key questions on consumption, and would prolong the interviews.

Semi-structured interviews of 15 members of the public: 10 female and 5 male. These were drawn from two high density urban locations in Lusaka, close to, but not inside, the informal markets in these areas. The ages of the 10 females interviewed were: 52, 50, 45, 37 (2) 35, 30, 28 (2) and 25. Nine of the females stated that their occupation was "business" which typically means a micro-enterprise buying and selling small quantities of various commodities locally. This is the most common type of livelihood for urban women who are less educated and not in regular employment. The youngest woman, aged 25 stated that she did not have an occupation, but was at home with her children. The ages and occupations of the five males interviewed were 47 (bricklayer), 45 (2 men in business), 37 (plumber) and 15 (business). They were all self-employed, rather than in regular paid employment, which is also the most common type of livelihood for urban men who are less educated.

Structured interviews with 151 members of the public: 91 female and 60 male. These were drawn from two high density urban locations in Lusaka, close to, but not inside, the informal markets in these areas. Further details regarding the number of males and females in each age category is summarised in the table below. The target at the outset was to interview at least four females and four males in each age category. This target was not achieved for males over 50, but was achieved for all other age categories. The above 50 age category were very difficult to target in the interview locations; most probably they were in their homes or elsewhere during the day. Respondents were not asked their occupations.

7.2 Annex 2: Annexes to the environmental analysis

Annex 2.1 – Crops

Maize, soybean and wheat cultivation in Zambia requires intermediate inputs in the form of irrigation, seeds, fertilizers, pesticides, field operations, transports and drying as well as direct inputs from nature in the form of land, sunlight and carbon. The cultivation, *i.e*. primarily the application of organic and mineral fertilizers, generates emissions into air (nitrogen oxides, carbon dioxide, dinitrogen monoxide and ammonia), into water (heavy metals, nitrate, phosphorus and phosphate) and soil (heavy metal and pesticides). Heavy metal uptake by the seeds is not considered.

The following sections explain the data sources and computations applied to determine all inputs and outputs associated with the cultivation of an average hectare of maize, of soybean and of wheat fresh matter in 2015 in Zambia, for a large vertical integrated egg producer (Goldenlay).

Yields

Yields related to maize, soybean and wheat cultivation in Zambia

Crop	Yield (mt/ha)	Source
Maize	4.8	Average yield from large/commercial producers in Zambia (period 2010-2016)
Soybean	2.8	Average yield from large/commercial producers in Zambia (period 2010-2016)
Wheat	6.6	Average yield from large/commercial producers in Zambia (period 2010-2014)

2.1.1 Inputs from technosphere

Mineral fertilizer

Mineral fertilizer application rate in maize, soybean and wheat cultivation for an average hectare in a reference commercial farm

Crop	Fertilizer materials	N %	P_2O_5 %	K_2O %	S %	Application rate (kg/ha)
Maize	Yara Mila Power with B & Zn	10	20	18	5.4	350
	YaraVera Midas	40	-	-	5.6	250
Soybean	Hi K Power Soya Basal	6.2	18	24	7	250
Wheat	PC Start Basal Vigo	13	25	5.1	11.9	200
	Yara Mila Winner	15	9	20	1.8	100
	Urea	46	-	-	-	200
	Nitrabor	15.4	-	-	-	50
	AS Fines	21	-	-	24	200
	SOP WS	-	-	50	18	20

Fertilizer use by fertilizer product in a reference commercial farm

Fertilizer materials	Products with N, P, K	Average Proportion (%)	Used dataset (Agri-footprint 3.0)[106]
Yara Mila Power with B & Zn	1.Ammonium chloride 2. Potassium nitrate 3. Ammonium dihydrogenorthophosphate 4. Potassium dihydrogenorthophosphate	3.5 37.9 34.6 3.9	1. Ammonium chloride (NPK 25-0-0), at plant/RER Mass 2. Potassium nitrate (NPK 14-0-44), at plant/RER Mass 3. Mono Ammonium Phosphate, as 100% (NH3)2HPO4 (NPK 11-52-0), at plant/RER Mass 4. Potassium Dihydrogen Orthophosphate compound (NPK 0-52-34), at plant/RER Mass
YaraVera Amidas	1. Ammonium sulfate 2. Urea	22.8 75.5	1. Ammonium sulphate, as 100% (NH4)2SO4 (NPK 21-0-0), at plant/RER Mass 2. Urea, as 100% CO(NH2)2 (NPK 46.6-0-0), at plant/RER Mass
Hi K Power Soya Basal	1. Potassium chloride 2. Potassium dihydrogenorthophosphate 3. Ammonium sulphate	20.4 34.6 29.2	1. Potassium chloride (NPK 0-0-60), at plant/RER Mass 2. Potassium Dihydrogen Orthophosphate compound (NPK 0-52-34), at plant/RER Mass 3. Ammonium sulphate, as 100% (NH4)2SO4 (NPK 21-0-0), at plant/RER Mass
PC Start Basal Vigo	1. Potassium dihydrogenorthophosphate 2. Ammonium sulphate 3. Diammonium hydrogenorthophosphate 4. Ammonium nitrate	15.0 25.0 30.2 3.18	1. Potassium Dihydrogen Orthophosphate compound (NPK 0-52-34), at plant/RER Mass 2. Ammonium sulphate, as 100% (NH4)2SO4 (NPK 21-0-0), at plant/RER Mass 3. Di ammonium phosphate, as 100% (NH3)2HPO4 (NPK 22-57-0), at plant/RER Mass 4. Ammonium nitrate, as 100% (NH4)(NO3) (NPK 35-0-0), at plant/RER Mass
Yara Mila Winner	1. Ammonium nitrate 2. Potassium nitrate 3. Potassium chloride 4. Potassium sulfate 5. Ammonium dihydrogenorthophosphate 6. Ammonium chloride 7. Potassium dihydrogenorthophosphate	23.2 30.1 2.4 4.5 2.0 2.0 9.0	1. Ammonium nitrate, as 100% (NH4)(NO3) (NPK 35-0-0), at plant/RER Mass 2. Potassium nitrate (NPK 14-0-44), at plant/RER Mass 3. Potassium chloride (NPK 0-0-60), at plant/RER Mass 4. Potassium sulphate (NPK 0-0-50), Mannheim process, at plant/RER Mass

[106] modified whenever original N:P:K ratio datasheet needed to be adapted.

Fertilizer materials	Products with N, P, K	Average Proportion (%)	Used dataset (Agri-footprint 3.0)[106]
	8. Ammonium sulphate 9. Diammonium hydrogenorthophosphate	4.5 4.5	5. Mono Ammonium Phosphate, as 100% (NH3)2HPO4 (NPK 11-52-0), at plant/RER Mass 6. Ammonium chloride (NPK 25-0-0), at plant/RER Mass 7. Potassium Dihydrogen Orthophosphate compound (NPK 0-52-34), at plant/RER Mass 8. Ammonium sulphate, as 100% (NH4)2SO4 (NPK 21-0-0), at plant/RER Mass 9. 0 Di ammonium phosphate, as 100% (NH3)2HPO4 (NPK 22-57-0), at plant/RER Mass
Urea	Urea	100	Urea, as 100% CO(NH2)2 (NPK 46.6-0-0), at plant/RER Mass
Nitrabor	Nitric acid, ammonium calcium salt	95	Calcium ammonium nitrate (CAN), (NPK 15.4-0-0), at plant/RER Mass
AS Fines	Ammonium sulphate	100	Ammonium sulphate, as 100% (NH4)2SO4 (NPK 21-0-0), at plant/RER Mass
SOP WS	Potassium sulfate	100	Potassium sulphate (NPK 0-0-50), Mannheim process, at plant/RER Mass

Obs.The average proportion is calculated using the most recent Safety Data sheets from Yara Omnia

Organic fertilizer

Organic fertilizer application rate in maize, soybean and wheat cultivation for an average hectare in a reference commercial farm

Type	Application rate (mt/ha)	Composition (%)		
		N	P_2O_5	**K_2O**
Chicken manure	10.0	1.2	0.6	0.6

Lime

Lime is applied at a rate of 1250 kg/ha, regardless of the crop.
Agri-footprint 3.0 process *Lime fertilizer, at regional storehouse/RER Mass* was used as a proxy.

Pesticides

<u>Maize</u>

Pesticides used in maize cultivation and the dataset (compound class) used for its representation

Pesticide	Application rate (kg/ha)	Used dataset (Agri-footprint 3.0)
CHEMICAL, HERBICIDE: (2,4-D AMINE; -)	0.30464	2,4-D, at plant/RER Mass
CHEMICAL, HERBICIDE: (ALACHLOR; 15972-60-8, 15792-50-8)	0.23540	Alachlor, at plant/RER Mass
CHEMICAL, HERBICIDE: (ATRAZINE; 1912-24-9)	0.35996	Atrazine, at plant/RER Mass
CHEMICAL, HERBICIDE: (BENTAZON; 25057-89-0)	0.38772	Bentazone, at plant/RER Mass
CHEMICAL, INSECTICIDE: (CARBOFURAN; 1563-66-2)	3.80952	Carbofuran, at plant/RER Mass
CHEMICAL, HERBICIDE: (SIMAZINE; 122-34-9)	0.16907	Chlorotriazine herbicides, at plant/RER Mass
CHEMICAL, HERBICIDE: (CYANAZINE; 21725-46-2)	0.31722	Cyanazine, at plant/RER Mass
CHEMICAL, HERBICIDE: (GLYPHOSATE; 1071-83-6)	0.45696	Glyphosate, at plant/RER Mass
CHEMICAL, HERBICIDE: (METOLACHLOR; 51218-45-21)	0.16617	Metolachlor, at plant/RER Mass
CHEMICAL, INSECTICIDE: (ENDOSULFAN; 115-29-7)	0.08159	Organochlorine insecticides, at plant/RER Mass
CHEMICAL, INSECTICIDE: (MONOCROTOPHOS; 6923-22-4)	0.17483	Insecticide, at plant/RER Mass
CHEMICAL, INSECTICIDE: (PIRIMIPHOS-METHYL; 29232-93-7)	0.05333	Insecticide, at plant/RER Mass
CHEMICAL, INSECTICIDE: (DELTAMETHRINE; 52918-63-5)	0.31722	Pyrethroid ester insecticides, at plant/RER Mass
CHEMICAL, INSECTICIDE: PERMETHRIN; 52645-53-1)	0.01000	Insecticide, at plant/RER Mass
CHEMICAL, HERBICIDE: (EPTC; 759-94-4)	0.75668	Thiocarbamate herbicides, at plant/RER Mass
CHEMICAL, HERBICIDE: (DICHLORMID; 37764-25-3)	0.14265	Chloroacetanilide herbicides, at plant/RER Mass
CHEMICAL, INSECTICIDE: (IMIDACLOPRID = 129099)	0.05250	Insecticide, at plant/RER Mass

Soybean

Pesticides used in soybean cultivation and the dataset (compound class) used for its representation

Pesticide	Application rate (kg/ha)	Used dataset (Agri-footprint 3.0)
CHEMICAL, INSECTICIDE: (CYPERMETHRIN ALPHA; 67375-30-8)	0.0175	Pyrethroid ester insecticides, at plant/RER Mass

Pesticide	Application rate (kg/ha)	Used dataset (Agri-footprint 3.0)
CHEMICAL, HERBICIDE: (BENTAZON; 25057-89-0)	1.98	Bentazone, at plant/RER Mass
CHEMICAL, INSECTICIDE: (CARBARYL; 63-25-2)	0.85	Carbaryl, at plant/RER Mass
CHEMICAL, INSECTICIDE: (CHLORPYRIFOS; 2921-88-2)	0.384	Phenyl organothiophosphate insecticides
CHEMICAL, INSECTICIDE: (ENDOSULFAN; 115-29-7)	0.5	Organochlorine insecticides, at plant/RER Mass
CHEMICAL, FUNGICIDE (Fentin hydroxide; 668-34-8 (Triphenyltin ion))	0.475	Fungicide, at plant/RER Mass
CHEMICAL, HERBICIDE: (LINURON; 330-55-2)	1.41	Linuron, at plant/RER Mass
CHEMICAL, HERBICIDE: (METOLACHLOR; 51218-45-21)	2.16	Metolachlor, at plant/RER Mass
CHEMICAL, HERBICIDE (TRIFLURALIN; 1582-09-8)	1.0125	Trifluralin, at plant/RER Mass

<u>Wheat</u>

Pesticides used in wheat cultivation and the dataset (compound class) used for its representation

Pesticide	Application rate (kg/ha)	Used dataset (Agri-footprint 3.0)
CHEMICAL, HERBICIDE: (BENTAZON; 25057-89-0)	0.3375	Bentazone, at plant/RER Mass
CHEMICAL, HERBICIDE: (2,4-D AMINE; -)	0.3375	2,4-D, at plant/RER Mass
CHEMICAL, FUNGICIDE: (CAPTAN; 133-06-2)	0.125	Captan, at plant/RER Mass
CHEMICAL, FUNGICIDE: (THIRAN; 137-26-8)	0.125	Dithiocarbamate fungicides, at plant/RER Mass

Seed

Information on seeding rates was obtained from Goldenlay and include losses in germination and emergence. The production process of seeds is identical to this of crop cultivation with the only adjustment of the seed yield at seed production assumed to be 20% less that this of crop yield at farm.

Crop	Seeding rate (kg/ha)
Maize	40
Soybean	110
Wheat	110

Field operations

The infrastructure associated with the field operations and the values on direct energy use were modelled using Agri-footprint 3.0 default values for maize, soybean and wheat crops.

Field operation inputs per type and crop

Crop	Agri-footprint 3.0 Inventory	Unit	Amount
Maize	Energy, from diesel burned in machinery/RER Mass	MJ	12790
Soybean		MJ	3685
Wheat		MJ	6091
Maize	Electricity mix, AC, consumption mix, at consumer, < 1kV/ZM Mass	MJ	3977
Soybean		MJ	954.9
Wheat		MJ	3977
Maize	Basic infrastructure, at farm/GLO Mass	ha	1
Soybean		ha	1
Wheat		ha	1

Irrigation

One of the main drivers for arable crop irrigation in Zambia at present is the wheat and soybean rotation. Grown exclusively by large commercial farmers, wheat requires the installation of irrigation which can later be used to irrigate soybean. Maize is grown as a winter crop and is only irrigated if irrigation is already installed for the summer crop. (Mendes *et al*[107]., 2014)

Centre pivots are the most popular irrigation equipment with large and medium commercial farmers in Zambia. Motorized pumps are the most popular equipment supplied to smallholders. Because operating costs for fossil fuel pumps are more expensive than the cost of electric pumps, this technology is restricted to areas with high-value crops. (Mendes *et al*., 2014).

AusAgLCI - A Life Cycle Inventory database for Australian agriculture[108] is used to model the centre pivot irrigation system. The following AusAgLCI unit processes are utilized:

- *Pumping, irrigation, 40m total pumping head, 100% diesel/AU U*
- *Centre pivot irrigation system, production, per ha/AU U*

Diesel is assumed to be the only source of pumping energy due to known instability in the supply of electricity in Zambia, and to the extent of reference commercial crop fields. The surface of the field covered by one irrigation system is 46.3 ha.

Based on Mayerhofer *et al*.[109] (2010), irrigation water is assumed as:

- 37.6% river water
- 62.4% groundwater

Agri-footprint 3.0 elementary flows *Water, river, ZM* and *Water, well, in ground, ZM* are used.

[107] Mendes, D.M. *et al*. (2014). Zambia: Irrigation market brief. FAO/IFC Cooperation Programme. FAO. Rome, Italy.
[108] http://auslci.com.au/index.php/Home
[109] Mayerhofer, C. *et al*. (2010). Survey on Commercial Farming and Major Industries – Land Use, Groundwater Abstraction & Potential Pollution Sources. Report No.4 Development of a Groundwater Information & Management Program for the Lusaka Groundwater Systems. Lusaka, Zambia.

The amount of irrigation water for each crop is based on Mayerhofer *et al*. (2010). An analysis of the "blue water footprint" (Mekonnen & Hoekstra, 2010)[110] for the three crops in Zambia is also reported.

<u>Maize</u>

According to Mayerhofer *et al*. (2010), irrigated maize consumes 6000 m^3/ha; since only 1.4% is cultivated maize is irrigated maize (dry season maize), irrigation water for maize is assumed to be **84 m^3/ha**. However, according to the "blue water footprint" (Mekonnen & Hoekstra, 2010)[111] the amount of irrigation water for maize in Zambia is 1m^3/t, *i.e*. 4.8 m^3/ha.

<u>Soybean</u>

According to Mayerhofer *et al*. (2010), soybean irrigation is 6000 m^3/ha; since only 10.1% of soybean is irrigated (dry season soybean), irrigation water for soybean is assumed to be **606 m^3/ha**. Mekonnen & Hoekstra (2010) indicate 0 m^3/t as the amount of irrigation water for soybean in Zambia. However, large commercial farms[112] in Zambia may have soybean production irrigated areas of 46%.

<u>Wheat</u>

In Zambia, the cultivation of wheat depends on irrigation. Mayerhofer *et al*. (2010) indicate a value of **6000 m^3/ha** for wheat irrigation water. Mekonnen & Hoekstra (2010) refer 703 m^3/t as the amount of irrigation water for wheat in Zambia (4639.8 m^3/ha, assuming a yield of 6.6 mt/ha)

2.1.2 Inputs from nature

Land use change

Deforestation rate in Zambia is assumed to be 1.5% per year, 90% is transformed into crop land - calculation based on Vynia *et al*.[113] (2011) and supported by documents from Goldenlay[114].

2.1.3 Emissions

Direct field emissions are substances emitted from an agricultural area. The calculation of direct field emissions requires the application of specific models.
Emissions to air are calculated according to the IPCC guidelines[115] (IPCC, 2006), with exception of CO_2 emission from land use change.

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[110] Mekonnen, M.M. & Hekstra, A.Y. (2010). The green, blue and grey water footprint of crops and derived crop products, Value of Water Research Report Series No. 47, UNESCO-IHE, Delft, the Netherlands.

[111] Mekonnen, M.M. & Hekstra, A.Y. (2010). The green, blue and grey water footprint of crops and derived crop products, Value of Water Research Report Series No. 47, UNESCO-IHE, Delft, the Netherlands.

[112] *e.g.* Goldenlay's Kafubu Farm.

[113] Vinya, R., Syampungani, S., Kasumu, E.C., Monde, C. & Kasubika, R. (2011). Preliminary Study on the Drivers of Deforestation and Potential for REDD+ in Zambia. A consultancy report prepared for Forestry Department and FAO under the national UN-REDD+ Programme Ministry of Lands & Natural Resources. Lusaka, Zambia.

[114] Goldenlay (2012). Environmental Impact Assessment for the proposed commercial farming of maize, wheat and soya beans in Kanyenda farming block in Mpwongwe District. Lusaka, Zambia.
Goldenlay (2013). Environmental and Social Impact Statement for the development of Kafubu farm, Ndola District. Lusaka, Zambia.

[115] IPCC (2006). N2O emissions from managed soils and CO2 emissions from lime and urea application (IPCC Chapter 11), 4, 1–54.

Nitrate emissions into water are also calculated according to the IPCC guidelines (IPCC, 2006) but phosphorus emissions follow Agri-footprint 3.0 model.
Heavy metals and pesticides emission models are presented, also.

Emissions to air

Emissions to air associated with the cultivation of one hectare of maize, soybean or wheat

Emission / Elementary flow (Agri-footprint 3.0)	Crop	Amount (kg/ha)	Explanation	Model
Dinitrogen monoxide	Maize	3.77	N2O direct emissions, due to use of manure;	IPCC, 2006
	Soybean			
	Wheat			
Dinitrogen monoxide	Maize	0.80	N2O indirect emissions (leaching and volatilization), due to use of manure;	IPCC, 2006
	Soybean			
	Wheat			
Ammonia	Maize	29.14	Ammonia emissions, due to use of manure;	IPCC, 2006
	Soybean			
	Wheat			
Dinitrogen monoxide	Maize	2.12	N2O direct emissions, due to use of fertilizer;	IPCC, 2006
	Soybean	0.24		
	Wheat	2.87		
Dinitrogen monoxide	Maize	0.69	N2O indirect emissions (leaching and volatilization), due to use of fertilizer;	IPCC, 2006
	Soybean	0.08		
	Wheat	0.93		
Ammonia	Maize	16.39	Ammonia emissions, due to use of fertilizer;	IPCC, 2006
	Soybean	1.88		
	Wheat	22.19		
Dinitrogen monoxide	Maize	0.46	N2O direct emissions from crop residues;	IPCC, 2006
	Soybean	0.47		
	Wheat	0.89		
Dinitrogen monoxide	Maize	0.10	N2O indirect emissions from crop residues;	IPCC, 2006
	Soybean	0.11		
	Wheat	0.20		
Carbon dioxide, fossil	Maize	138.50	Direct CO2 emissions, due to use of urea fertilizer;	IPCC, 2006
	Soybean	0		
	Wheat	146.67		
Carbon dioxide, fossil	Maize	550.00	CO2 emissions from application of calcic limestone to soil	IPCC, 2006
	Soybean			
	Wheat			
	Maize	2,992.10		

Emission / Elementary flow (Agri-footprint 3.0)	Crop	Amount (kg/ha)	Explanation	Model
Carbon dioxide, land transformation	Soybean	1,042.90	CO2 emission resulting from the transformation of forest land into arable land for crop cultivation	LEAP (2015)[116] (Annex 6, Under Conventional Tillage, weighted average)
	Wheat	143.9		

Emissions to water

Emissions to water associated with the cultivation of one hectare of maize, soybean or wheat

Emission / Elementary flow (Agri-footprint 3.0)	Crop	Amount (kg/ha)	Explanation	Model
Nitrate	Maize	159.42857	Nitrate emissions to groundwater, due to use of manure;	IPCC, 2006
	Soybean			
	Wheat			
Nitrate	Maize	179.35714	Nitrate emissions to groundwater, due to use of fertilizer;	IPCC, 2006
	Soybean	20.59286		
	Wheat	242.73000		
Nitrate	Maize	39.15437	Nitrate emissions to groundwater from crop residues;	IPCC, 2006
	Soybean	39.53943		
	Wheat	74.85710		
Phosphorus	Maize	1.30920	Phosphorous emissions to surface water, due to use of manure;	Agri-footprint 3.0, based on Struijs, Beusen, Zwart, & Huijbregts (2010)[117]
	Soybean			
	Wheat			
Phosphorus	Maize	1.52740	Phosphorous emissions to surface water, due to use of fertilizer;	Agri-footprint 3.0, based on Struijs, Beusen, Zwart, & Huijbregts (2010)
	Soybean	0.98190		
	Wheat	1.28738		

[116] LEAP - Livestock Environmental Assessment and Performance (2015). Global database of GHG emissions related to feed crops: A life cycle inventory. Draft for Public Review. FAO. Rome, Italy.

[117] Struijs, J., Beusen, A., Zwart, D., & Huijbregts, M. (2010). Characterization factors for inland water eutrophication at the damage level in life cycle impact assessment. The International Journal of Life Cycle Assessment, 16(1), 59–64.

Heavy metal emissions

Heavy metal emissions (HME) are related to the application of organic and mineral fertilizer and are emitted into agricultural soil and groundwater. The emission of heavy metals is based on the methodology described by Durlinger *et al*.[118] (2017). Heavy metal contents of plant material were obtained from Durlinger *et al*. (2017) - maize and wheat - and Nemecek *et al*.[119] (2015) – soybean. Heavy metal contents of manure from laying hens (litter from belts from laying hens) was obtained from Nemecek *et al*. (2015). Durlinger *et al.* (2017) provided heavy metal contents of fertilizers.

Heavy metal emission related to the cultivation of one hectare of maize, soybean or wheat

Crop	Emission	Unit	Compartment	
			Groundwater	Soil
Maize	Cadmium	mg/ha	43.4	1,298.1
	Chromium		2,0192.0	49,065.8
	Copper		3,537.8	121,526.0
	Mercury		1.2	569.7
	Nickel		-	29,160.3
	Lead		337.1	8,987.6
	Zinc		31,155.4	1,292,278.8
Soybean	Cadmium	mg/ha	40.2	2,091.4
	Chromium		19,763.5	26,364.1
	Copper		3,535.3	63,459.8
	Mercury		1.2	605.0
	Nickel		-	9,842.7
	Lead		274.2	6,911.4
	Zinc		31,102.3	1,179,318.5
Wheat	Cadmium	mg/ha	43.19	3,772.6
	Chromium		20,159.63	42,561.9
	Copper		3,537.90	120,630.6
	Mercury		1.21	604.5
	Nickel		-	31,632.8
	Lead		348.07	14,637.6
	Zinc		31,155.72	1,352,717.2

[118] Durlinger, B. *et al.* (2017). Agrifootprint 3.0 Part 2: Description of Data. Agri-footprint. Gouda, Netherlands.

[119] Nemecek T., Bengoa X., Lansche J., Mouron P., Riedener E., Rossi V. & Humbert S. (2015) Methodological Guidelines for the Life Cycle Inventory of Agricultural Products. Version 3.0, July 2015. World Food LCA Database (WFLDB). Quantis and Agroscope, Lausanne and Zurich, Switzerland.

Pesticide emissions

Pesticide emissions are calculated based on the pesticide inputs listed in Annex 2.1 (Pesticides). The Agri-footprint 3.0 pesticide partition model (between compartments) is followed.

Pesticide emission related to the cultivation of one hectare of maize, soybean or wheat

Crop	Pesticide emission	Unit	Compartment		
			Air	Groundwater	Soil
Maize	2,4-D	kg/ha	0.00916	0.00102	0.09164
	Alachlor		0.01001	0.00111	0.10008
	Atrazine		0.01211	0.00135	0.12106
	Bentazone		0.01678	0.00186	0.16779
	Carbofuran		0.01079	0.00120	0.10794
	Cyanazine		0.02569	0.00285	0.25692
	Deltamethrin		0.00001	1.083E-06	0.00010
	Dichlormid		0.00513	0.00057	0.05125
	Endosulfan		0.00275	0.00031	0.02746
	EPTC		0.02084	0.00232	0.20840
	Glyphosate		0.01566	0.00174	0.15661
	Imidacloprid		0.00148	0.00016	0.01478
	Metolachlor		0.00779	0.00087	0.07793
	Monocrotophos		0.00326	0.00036	0.03256
	Permethrin		0.00028	0.00003	0.00282
	Pirimiphos methyl		0.00150	0.00017	0.01501
	Simazine		0.00558	0.00062	0.05583
Soybean	Alpha-cypermethrin	kg/ha	0.00009	0.00001	0.00089
	Bentazone		0.08569	0.00952	0.85688
	Carbaryl		0.04545	0.00505	0.45446
	Chlorpyrifos		0.00987	0.00110	0.09871
	Endosulfan		0.01683	0.00187	0.16831
	Fentin hydroxide		0.01483	0.00165	0.14827
	Linuron		0.05711	0.00635	0.57109
	Metolachlor		0.10130	0.01126	1.01303
	Trifluralin		0.04313	0.00479	0.43131
Wheat	2,4-D	kg/ha	0.01015	0.00113	0.10152
	Bentazone		0.01461	0.00162	0.14606
	Captan		0.00731	0.00081	0.07313
	Thiran		0.00422	0.00047	0.04220

Annex 2.2. – Milling and Feed Compounding

2.2.1. Milling

Process	Outputs		Allocation[1] (%)	Losses
Maize crushing, from dry milling, at plant/ZM Mass	1 mt	Maize crushed	100	2% transport 21% storage 2% milling processes
Soybean crushing (pressing), at plant/ZM Mass	1 mt	Soybean expeller Crude soybean oil[2]	83.92 16.08	2% transport 6% storage 2% milling processes
Wheat dry milling, at plant/ZM Mass	1 mt	Wheat bran Wheat flour[3] Wheat middlings & feed[3] Wheat germ[3]	11.96 73.59 12.46 1.99	2% transport 6% storage 2% milling processes

1 - Mass allocation, on the basis of dry matter
2 - co-product; 3 – co-products

Inputs and Outputs

<u>Maize</u>
This process describes the production of maize crushed from a maize dry milling process at a chicken feed production factory in Zambia.

The system boundaries of this process are from receiving of maize to delivery of maize crushed at the dry milling factory gate. Considered activities include inputs of maize from farms, transport inputs (see Annex 2.5.), electricity and a non-hazardous final waste flow to landfill. Capital goods are not included.

Electricity requirements for the dry milling of maize were adapted from Agri-footprint 3.0 database (*Maize flour, from dry milling, at plant/Mass*), using Zambia energy grid mix (see Annex 2.4.)

<u>Soybean</u>
This process describes the production of crude soybean oil and soybean expeller from a soybean crushing process at a chicken feed production factory in Zambia.

The system boundaries of this process are from receiving soybeans to delivery of soybean oil, soybean meal and soybean hulls at factory gate. Considered activities include inputs of soybeans and associated transport (see Annex 2.5), electricity, and a non-hazardous final waste flow to landfill. Capital goods are not included.

The process was modelled based on Agri-footprint 3.0 unit process *Soybean expeller, from crushing (pressing), at plant/Mass*. Electricity requirements were adapted using Zambia energy grid mix (see Annex 2.4.)

<u>Wheat</u>
The process describes the production of wheat flour, wheat bran, wheat middlings and feed and wheat germ from a wheat dry milling process at a chicken feed production unit in Zambia.

The system boundaries of this process are from receiving of wheat to delivery of wheat bran and other co-products at the dry milling factory gate. Considered activities include inputs of wheat, transport inputs, water, heat from combustion of fuel oil and electricity and an output of waste water to waste water treatment, plus a non-hazardous final waste flow to landfill. Capital goods are not included.

The process was modelled based on Agri-footprint 3.0 *Wheat bran, from dry milling, at plant/Mass*. Electricity requirements were adapted using Zambia energy grid mix (see Annex 2.4.) and heat generation was modelled as *Process steam from heavy fuel oil, heat plant, consumption mix, at plant, MJ EU-27 S System - Copied from ELCD* (Agri-footprint 3.0)

2.2.2. Feed compounding

Process	Inputs	Value range (%)	Output[1] (%)	Losses
Feed Compounding for LH <17 w/ZM Mass	Maize crushed Soybean expeller Wheat bran Crushed limestone	54-63 16-22 9-14.6 <1.5	87.6	n.s.
Feed Compounding for LH >17 w/ZM Mass	Maize crushed Soybean expeller Wheat bran Crushed limestone	59.3-61 18.2-18.8 4.7-9 9-11	97.2	n.s.

[1] - Does not add to 100% as some minor inputs are neglected. Nevertheless, it is assumed that the modelled flows are representative for the feed mix.

Inputs and Outputs

The processes describe the production of compound feed for laying hens. The feed composition of laying hens <17 weeks and >17 weeks was based on the information provided by Goldenlay.

The system boundaries of this process are from gate to gate. Considered activities include the ingredients (consumption mixes) for the compound feed and the energy required to produce the compound feed.

The compound feed ingredient "Crushed limestone" was modelled using dataset *Crushed stone 16/32, open pit mining, production mix, at plant, undried RER S System - Copied from ELCD* from Agri-footprint 3.0. The energy consumption for the manufacturing of the two compound feeds was based on Agri-footprint 3.0 processes *Compound feed breeding laying hens <17 weeks/NL Mass* and *Compound feed breeding laying hens >17 weeks/NL Mass*. Electricity requirements were adapted using Zambia energy grid mix (see Annex 2.4.) and heat generation was modelled as *Process steam from heavy fuel oil, heat plant, consumption mix, at plant, MJ EU-27 S System - Copied from ELCD* (Agri-footprint 3.0)

Annex 2.3. – Egg Production

The egg production model includes both an egg farm sub-model and parent farm sub-model. The avian development stages considered in each sub-model are presented in the following table

Sub-model	Stage	Age Group	Production cycle duration (days)[1]
Parent farm	Chicks & Pullets	1 – 20 weeks	160
	Breeders	21 – 72 weeks	384
	Hatching eggs	-	-
Egg farm	Chicks	1 – 3 weeks	21
	Pullets	4 – 17 weeks	134
	Laying hens	18 – 81 weeks	484
	Spent hens	-	-

[1] – includes sanitization period (when cages are disinfectedmi99 and left empty, between cycles)

Mortality

Information for Parent stock mortality rate, namely culling rate, is obtained from Lohmann (2017)[120]. Hatching eggs mortality was compiled from literature. Mortality values for stages 3, 4 and 5 are validated by Goldenlay.

Development stage	Mortality (%)	Explanation
Parent stock – Chicks & Pullets	45.0	Includes male culling (initial sex ratio 48 M: 52 F; required sex ratio 9M : 100F)) and a base mortality of 3%
Parent stock – Breeders	9.0	
Hatching eggs	24.0	Includes hairline-cracked/damaged fertilized eggs, embryonic mortality and late mortality
Chicks	50.7	Includes male culling (sex ratio 48M : 52F) and a base mortality of 3%
Rearing pullets	3.0	-
Laying hens	9.0	-

Compound Feed and Drinking Water

Information on Parent stock average food and water intake, per bird, is obtained from Lohmann (2017). Information on Egg farm stock average food and water intake, per bird was provided by Goldenlay.

[120] Lohmann (2017). Lohmann Brown / Lohmann LSL Parent Stock. Lohmann Tierzucht GmbH. Cuxhavenm, Germany.

System	Stage	Average feed intake per bird (kg/production cycle)	Average feed intake per bird (L/ production cycle)
Parents farm	Chicks & Pullets	7.41	22.40
	Breeders	42.00	94.64
Egg farm	Chicks	0.36	1.78
	Pullets	5.59	17.23
	Laying hens	53.36	120.64

Compound feed for chicks and/or pullets corresponds to *Feed Compounding for LH <17 w/ZM Mass* process (cf. 2.2.2). For breeders and hens, *Feed Compounding for LH >17 w/ZM Mass* is used.

For drinking water, Agri-footprint 3.0 *Drinking water, water purification treatment, production mix, at plant, from groundwater RER S System - Copied from ELCD* process is used.

Allocation

Information on Egg farm hens was validated by Goldenlay. Parent farm data for egg per hen and average bird weight (81 weeks old) are based on Lohmann (2017).

Parameter	Parent Farm	Egg Farm
Eggs per hen / production cycle	262	320
Egg weight (g)	61.7	61.7
Weight per spent bird, for slaughter (kg)	Hen : 1.7 Cockerel : 2.3	1.6

As previously mentioned, the sex ratio in the Parent farm is 9 males per 100 females. Mass allocation calculation accounts for this fact as well as for mortality losses.

System	Mass Allocation (%)	
	Eggs	Poultry meat
Parent farm	89.2	10.8
Egg farm	92.5	7.5

Energy

The energy model is based on Durlinger *et al*. (2017) chapter "Laying hens in the Netherlands" complemented with information from literature and data provided by Goldenlay. It includes supply of electricity and heat. Electricity requirements were adapted using Zambia energy grid mix (see Annex 2.4.) and heat generation was modelled as *Process steam from heavy fuel oil, heat plant, consumption mix, at plant, MJ EU-27 S System - Copied from ELCD* (Agri-footprint 3.0)

System	Stage	Electricity consumption (kWh per bird)	Heat Consumption (MJ per bird)
Parents farm	Chicks & Pullets	0.7	1.8
	Breeders	3.9	10.6
	Hatching eggs	-	528.3[1]

Egg farm	Chicks	0.45	0.54
	Pullets	0.45	0.54
	Laying hens	2.3	-

1 – per 1000 eggs for hatching

Emissions

Manure is assumed to be produced without litter and stored in a pit before being carried to the field and applied to the soil. Manure management emissions to air are calculated for methane (biogenic), direct and indirect dinitrogen monoxide and ammonia. All emissions are modelled based on IPCC (2006)[121].

Emissions to air from manure management at bird farm facility and enteric fermentation per 1000 table eggs at farm gate.

System	Stage	CH_4 (kg CH_4/ year)	NO_2 Direct (kg NO_2 /year)	NO_2 Indirect (kg NO_2 /year)	NH_3 Volatilization (kg NH_3 /year)
Parents farm	Chicks & Pullets	0.00910	0.00022	0.00119	0.07566
	Breeders	0.14012	0.00509	0.02802	1.78301
Egg farm	Chicks	0.00024	0.00001	0.00003	0.00200
	Pullets	0.01029	0.00024	0.00134	0.08553
	Laying hens	0.04279	0.00130	0.00717	0.45629

Waste Treatment

Dead birds are incinerated at Goldenlay facility. The information collected was considered insufficient to calculate the emissions associated with the incinerator standard operation. For this reason, the process *Meat and bone meal {TEST}| treatment of, municipal incineration | Alloc Def, U* (Ecoinvent 3.0) is used.

[121] IPCC. (2006). Emissions from livestock and manure management (IPCC Chapter 10), 4.

Annex 2.4. – Energy grid mix

Energy type	Installed capacity (MW)	Energy mix (%)	Used datasets
Hydro	2,255	88.5682	Electricity from hydroelectric power plant, AC, production mix, at power plant, < 1kV RER S System - Copied from ELCD (proxy for Thermal power plant)
Thermal	80	3.1421	
Diesel	11	0.4320	Electricity, diesel, at power plant/US U System - Copied from USLCI
Heavy fuel oil	50	1.9638	Electricity, residual fuel oil, at power plant/US System - Copied from USLCI
Coal	150	5.8915	Electricity, anthracite coal, at power plant/RNA System - Copied from USLCI (50%) Electricity, bituminous coal, at power plant/US System - Copied from USLCI (50%)
Solar	0.06	0.0024	Electricity from wind power, AC, production mix, at wind turbine, < 1kV RER S System - Copied from ELCD (proxy)

Source: Policy Report on the Electricity Sector in Zambia (ESI, 2016)

Energy loss during production and transport was assumed 19.5%.

Annex 2.5. – Transport

Raw material / intermediate input		Mode	Amount	Unit	Used dataset (EI 3.3)
Crops	Crops to milling	Truck		t.km	Transport, Large truck >20t (LC 24 tonnes) | Empty return /GLO Mass
Feed	Feed to egg facilities	Truck	0,01937	t.km	Transport, Large truck >20t (LC 24 tonnes) | Empty return /GLO Mass
Eggs	Egg transport to Tanzania border	Truck	3,9	t.km	Transport, truck <10 metric ton, EURO3 100%LF| Empty return /GLO Mass
	Egg transport to RDC border	Truck	18,8	t.km	Transport, truck 10-20 metric ton, EURO3 100%LF| Empty return /GLO Mass
	Egg transport to Copperbelt/ Lusaka regions	Truck	373,6	t.km	Transport, truck <10 metric ton, EURO3 80%LF| Empty return /GLO Mass
Fertilizer	Urea Fertilizer (marine)	Ship	5,80	t.km	Transport, sea ship, 15000 DWT, 80% LF, long, empty {GLO}| mass
	Urea Fertilizer (terrestrial)	Truck	4519,6	t.km	Transport, Large truck >20t (LC 24 tonnes) | Empty return /GLO Mass
	NPK fertilizer (marine)	Ship	12,48	t.km	Transport, sea ship, 15000 DWT, 80% LF, long, empty {GLO}| mass
	NPK fertilizer (terrestrial)	Truck	10453,6	t.km	Transport, Large truck >20t (LC 24 tonnes), EURO3 100%LF| Empty return /GLO Mass
Pesticides	Marine transport	Ship	162,97	t.km	Transport, sea ship, 15000 DWT, 80% LF, long, empty {GLO}| mass
	Terrestrial transport	Truck	549,8	t.km	Transport, Large truck >20t (LC 24 tonnes), EURO3 100%LF| Empty return /GLO Mass
Manure	Transport to crop field	Truck	3,1	t.km	Transport, truck <10 metric ton, EURO3 100%LF| Empty return /GLO Mass

Annex 2.6. – Environmental impact assessment – general guidelines

Environmental Impact assessment – General guidelines for expert system (adapted from ad-hoc guidelines ICOLD-International Commission on Large Dams)

<table>
<tr><th>Impact criteria</th><th>Impact features</th><th>Mitigation /monitoring considerations</th><th>Impact classification</th></tr>
<tr><td>Cause-effect relation</td><td>Direct</td><td rowspan="7">• Mitigation measures are rather inexistent or very difficult to apply, OR
• Mitigation measures are available but are expensive to apply or operate
• Monitoring is mandatory</td><td rowspan="7">High</td></tr>
<tr><td>Importance</td><td>Very significant</td></tr>
<tr><td>Magnitude</td><td>Maximum</td></tr>
<tr><td>Probability</td><td>Certain</td></tr>
<tr><td>Duration</td><td>Permanent</td></tr>
<tr><td>Territorial dimension</td><td>Regional</td></tr>
<tr><td>Reversibility</td><td>Irreversible</td></tr>
<tr><td colspan="4"></td></tr>
<tr><td>Cause-effect relation</td><td>Direct/Indirect</td><td rowspan="7">• Mitigation measures are available but are expensive/complex to apply or operate
• Monitoring is advisable</td><td rowspan="7">Medium</td></tr>
<tr><td>Importance</td><td>Medium significance</td></tr>
<tr><td>Magnitude</td><td>Medium</td></tr>
<tr><td>Probability</td><td>Certain/Probable</td></tr>
<tr><td>Duration</td><td>Permanent/Temporary</td></tr>
<tr><td>Territorial dimension</td><td>Local/regional</td></tr>
<tr><td>Reversibility</td><td>Reversible</td></tr>
<tr><td colspan="4"></td></tr>
<tr><td>Cause-effect relation</td><td>Direct/Indirect</td><td rowspan="7">• Mitigation measures are available at affordable conditions
• Education or training will hinder impacts</td><td rowspan="7">Low</td></tr>
<tr><td>Importance</td><td>Low significance/ Irrelevant</td></tr>
<tr><td>Magnitude</td><td>Medium/Minimal</td></tr>
<tr><td>Probability</td><td>Certain/Probable</td></tr>
<tr><td>Duration</td><td>Permanent/Temporary</td></tr>
<tr><td>Territorial dimension</td><td>Local/regional</td></tr>
<tr><td>Reversibility</td><td>Reversible</td></tr>
</table>

7.3 Annex 3: List of stakeholders consulted (including workshop participants)

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