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Sustainability Hot Spot Analysis 2.0

A participatory approach to assess the Nile perch & Irish potato value chains in Uganda

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2022

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Seminar für Ländliche Entwicklung | Centre for Rural Development

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Preface

For 60 years, the Centre for Rural Development (SLE, Seminar für Ländliche Entwicklung), Humboldt-Universität zu Berlin, has trained young professionals in the field of German and international development cooperation.

Three-month empirical and solution-oriented research projects conducted on behalf of German or international development agencies form an integrated part of the one-year postgraduate course. In interdisciplinary teams and with the guidance of experienced team leaders, young professionals carry out assignments on innovative topics, providing consultancy support to the commissioning organizations while involving a diverse range of actors from household to national levels in the process. The outputs of this applied research directly contribute to solving specific development problems.

The studies are mostly linked to rural development themes and have a socio-economic focus, such as improvement of agricultural livelihoods or regimes for sustainable management of natural resources. The host countries are mainly developing or transforming countries, but also fragile states. In the latter, themes such as disaster prevention, peace building, and relief are examined. Some studies develop new methodologies, published in handbooks or guidelines. Further priorities are evaluations, impact analysis, and participatory planning. In the future, however, studies may also take place in the Global North, since the Sustainable Development Goals are a global concern.

SLE has carried out more than two hundred consulting projects in more than ninety countries and regularly publishes project results in this series. In 2021, SLE teams completed studies in Germany, Tunisia, Uganda, and Zambia.

The present study analyses "sustainability hotspots" of the Irish potato and Nile perch value chains in Uganda and was conducted in cooperation with a mirror team of five Ugandan researchers from Ugandan universities and institutions. The report is also downloadable from www.sle-berlin.de.

We wish you a stimulating read.

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Executive summary

Value chain (VC) support and development have gained global momentum in international development and poverty reduction strategies. Achieving food and nutrition security and decent livelihoods within the planetary boundaries of our telecoupled world is unthinkable without sustainable food VCs (FAO, 2014a; SWAC & OECD, 2021). Surprisingly, applicable tools for holistically assessing sustainability along food VCs are lacking.

The German Federal Ministry for Economic Cooperation and Development (BMZ) recognised this gap. It stepped up to fund a study to develop and test such a tool in the realm of its special initiative, One World - No Hunger (SEWOH). Co-financed by the BMZ, the authors of the present study, as a subproject of the research project Sustainability of Modern Agri-Food Systems (NAMAGE) at the Centre for Rural Development (SLE), developed a holistic, participatory, and feasible method to assess the sustainability of VCs: the "Sustainability Hot Spot Analysis (SHSA) 2.0".

The SHSA 2.0 was deployed in the Irish potato and Nile perch fish VCs in Uganda, both of which are supported through German development cooperation, and subsequently refined. The tool was successful in identifying a number of sustainability hot spots (SHS) and pointing to potential solutions.

The goals of the present study were, hence, threefold: 1. to conduct an empirical study on the Irish potato and Nile perch VCs in Uganda, 2. to provide policy recommendations for sustainable VC promotion in Uganda using the Irish potato and Nile Perch VC as case studies, and 3. to develop and explore the potential of SHSA 2.0 as a comprehensive and applicable sustainability VC assessment tool for development cooperation at large.

Methodological approach

The methodological framework used is a refined version of the sustainability hot spot analysis (SHSA) originally developed by the Wuppertal Institute. The SHSA is conducted in five steps. First, the VC stages (life cycle phases) are defined. These stages might include raw material extraction, production, aggregation, processing, distribution, consumption, and waste, but are usually limited to four or five phases. Second, the relevance of these categories in each VC stage is assigned as inapplicable (scored 0), low (scored 1), medium (scored 2), or high (scored 3). Third, the impact (i.e., relevance) of the phases are determined against each other on the same scale. Fourth, the ratings of steps two and three are multiplied to identify

sustainability hot spots, which now have a minimum score of six (3x2) or a maximum score of nine (3x3). Fifth, stakeholders and experts review and validate the results. Apart from the stakeholder review, all steps are based on a literature review and occasional individual expert interviews.

In this contribution, we suggest a SHSA 2.0, in which we expand the original SHSA by embracing stakeholder participation and include agroecological principles as suggested by HLPE (2019) and FAO (2018) to outline categories and indicators, which are based on agroecology but are adapted to the local context (see Table 1). Moreover, we include an empirical data collection phase to assess categories and indicators.

We applied a mixed-methods approach involving quantitative, qualitative, and participatory research methods to identify SHS along both VCs. The empirical studies on the Irish potato and Nile perch VCs in Uganda followed a stepwise approach. We started with an exploratory phase using methods such as participatory rural appraisal (PRA), focus group discussion (FGD), and PhotoVoice with potato farmers and fishers, as well as semi-structured interviews with other VC actors and stakeholders. The exploratory phase was conducted by the entire research team for both VCs to develop a joint understanding of the challenges that both VCs face and how these challenges can be addressed methodologically. Thereafter, the research team was split into two groups (five members in the Nile perch team and five in the potato team).

The exploratory phase was followed by a workshop with VC actors and farmers/fisherfolks to score the relevance of our suggested agroecological categories and to identify and rank the selection of related indicators. The participatory development of sustainability indicators was a key element of our research approach as the local context and realities are key for sustainability assessments (Rydin et al., 2003) .

The results of the relevance and indicator scoring were key to design the subsequent data collection for the SHSA 2.0. However, we used different data collection approaches for each VC. Potato farmers were surveyed through quantitative surveys n =135) to supplement and validate existing census data and literature on local farm and farmer profiles (including local farm practices, field sizes, yields, potato prices) that we received beforehand. As this data was unavailable in the fish VC, we followed an explorative, qualitative approach involving semi-structured interviews and FGDs with fishers (n = 49). Concerning both VCs (potato and Nile perch), VC actors and other stakeholders were interviewed through expert interviews (n=46 in sum).

The collected qualitative and quantitative data was transcribed and analyzed and, along with secondary data, formed the bases for the assessment of the indicators selected by industry stakeholders during workshops. The joint results of the indicator assessment (through mainly primary data) and the relevance scoring from the workshops informed the SHSs. The SHSs were presented to stakeholders during results and validation workshops, who gave feedback and discussed possible solutions and recommendations for the identified SHSs along the VCs.

Potato value chain and sustainability hot spots

Irish potato is cultivated by an estimated 335,000 Ugandan, mostly smallholder, farmers (IFDC, 2019b) on an area of roughly 39,300 ha (FAOSTAT, 2017c). In Uganda, potato serves as a dual-purpose crop for both home consumption and income generation (Gildemacher et al., 2009). Most of these farmers live in the cool highlands in the southwestern region (Kigezi) and fewer in the eastern parts of the country (Mount Elgon region, our study region) (Ugandan Bureau of Statistics, 2020). The crop is characterized by a short growing season of three to four months and is generally grown bi-annually under rainfed cultivation from March to July and from September to January (Gildemacher et al., 2009).

Although recent estimates indicate that the overall production of Irish potatoes has increased 200 % in the past decade (Ugandan Bureau of Statistics, 2020), this was mainly achieved through extensification rather than intensification of production (Parker & Wauters, 2021). Also, domestic production only meets about one-third of the national potato demand (National Agricultural Advisory Services, n.d.). Thus, the Irish potato production in Uganda currently solely serves the domestic market (Gildemacher & Rappoldt, 2019) and the country imports potatoes for French fry and potato chip production, e.g., from Egypt and Kenya (precise data is not available).

In our research area around Mt. Elgon, Irish potatoes are grown mainly in the Kapchorwa, Kween, and Mbale districts, which are located 1,500 – 3,000 m above sea level. The average potato plot size of potato-producing households in the Mt. Elgon region is 0.7 acres (0.3 hectares) per household (IFDC, 2021). Our results have shown a great on-farm diversity, that is, farmers crop 11 different crops, on average. Land is usually owned by the male household head (rather than leased) with family as well as hired seasonal laborers caring for it. While potato represents an integral part of farmers' daily diets, being among the three most important crops grown for home consumption in the study area, potato sales nominally supplement farming families' cash income and may improve their access to land and livestock, school services, and improved housing conditions.

In our study we found that farmers sell 70 – 90 % of their harvest and consume the remainder (10-30 %). The majority of the produce is sold to middlepersons from the surrounding area or traders at the farmgate on a cash basis. In addition, potatoes are occasionally sold to other farmers and rarely directly to processors. The vast majority of the potatoes aggregated by middlepersons is sold to traders who in turn sell to processors. In the Eastern region, the processing stage is dominated by small-scale processors with no industrial processing plant in the area.

Sustainability hot spots in potato value chain

Following the methodological approach explained above, we identified a total of 12 SHS in the potato VC, that is, a combined category/indicator impact score with 6.0 or higher. The majority was found in the production stage (7/12) and the environmental dimension (6/12), with fewer in the social (3/12) and economic (3/12) dimension.

The SHS identified in the **environmental dimension** are soil health (production), input use (production), and food loss and food waste (production, aggregation, processing, and distribution). **Soil health** was found to be affected by the medium uptake of composting and the low uptake of mulching, especially important for hilly regions with a high risk of soil erosion. In regard to **input use**, the production and use of high-quality seeds was identified as a key constraint, given that most farmers use saved seeds which are often compromised in quality, due to the lack of availability and access to high-quality seeds and information. **Food loss and food waste** represents an almost all-encompassing constraint, identified as a hot spot in all VC stages, apart from consumption. At the production stage, inadequate post-harvest management practices and a lack of adequate storage options cause substantial losses. Downstream VC actors also reported the lack of adequate storage facilities to be a key constraint, responsible for losses up to 12 %.

The SHS identified in the **social dimension** are fairness (processing), co-creation of knowledge (production), and agency (production). Due to the precarious working conditions in the processing stage dominated by informal small-scale producers who pay salaries below the absolute poverty line (and living wage) and do not offer social security benefits to employees, **fairness** was identified as a SHS at the processing stage. **Co-creation of knowledge** has been identified as a SHS due to the control group's limited access to extension services, farmers' neutral satisfaction levels with the available extension services, and the lack of post-harvest management and marketing content in current extension curricula, and. Despite a high level of participation in organized groups (mainly farmer and savings groups), **agency** was also identified as a SHS because of the above issues in combination with lack of access to market price information and high levels of dependency on potentially biased middlepersons.

The SHS identified in the **economic dimension** were economic resilience (distribution), connectivity (production), and economic benefits for all stakeholders (production). The lack of availability of suitable and affordable insurance options for distributors alongside the lack of formal agreements made **economic resilience** a SHS at the distribution stage. Given that farmers mainly sell their potatoes to middlepersons at the farmgate, the links between intermediaries and processors as well as direct consumers are considered weak. Though around 10 % of farmers reported selling directly to consumers, only one third of them reported having return customers; hence, **connectivity** is identified as a SHS. With an average annual net income of $86.6 US ± $72.4 US (with a high variation) from potato sales and monthly total savings (all income sources combined) of $29 US ± $7 US per household, on average, aggravated by the lack of access to financial services other than savings groups, profits and the ability to invest in business opportunities remain limited. Even if production was increased to maximal attainable yields (with production costs increasing proportionally), average net income would still be below poverty line. Hence, **economic benefits for all stakeholders** represents a SHS.

However, positive sustainability trajectories have also been identified. As a rainfed crop which is grown with limited chemical inputs in Eastern Uganda, the environmental footprint of Irish potato production in the region can be considered low. In addition, the contribution to farmers' food security and the widespread participation of farmers in organized structures (e.g., farmers groups) alongside the partly unexploited potential of existing multi-stakeholder platforms contribute substantially to the VC's sustainability potential and represent entry points for improving the potato VC in Uganda.

Nile perch value chain and sustainability hot spots

The Nile perch VC was selected for investigation since it is the economic mainstay of the Lake Victoria region; its fishery sector accounts for 60 % of the overall fisheries′ catch and the GIZ runs a broad development cooperation program on Nile perch in Uganda.

However, Nile perch is not the preferred fish for consumption by Ugandans due to its fishy taste. It is mostly consumed smoked or salted in Uganda. Nile perch is mainly exported from Uganda (around 96 %).

Nile perch is caught with gillnets or longlines with hooks, predominantly on small wooden boats, operating largely with outboard motors. Since 2010, fishers are required to fish with nets of a minimum mesh size of 6 inches, use boats of a minimum length of 28 feet, and own a fishing permit/license. Because of the resulting high equipment and operational costs, many fishers do not own boats themselves and work as crew members instead. The economic pressure on the lake is high which results in declining catches due to overexploitation of the Nile perch stocks, illegal fishing practices, and eutrophication of the lake ecology. To reduce the occurrence of illegal fishing methods, military units have been burning undersized boats and illegal gear, confiscating catches, and arresting fishers fishing without permission since 2017.

Fishers and/or boat owners sell their fish to middlepersons at landing sites who offer advance payments to fishers to meet their trip costs, binding fishers in unwritten contracts. The major share of the landed Nile perch is traded to factory agents, who deliver Nile perch of 50 cm or greater to the fish factories. Factory standards are high due to the requirements set by the export markets (mainly Europe and Middle East). Fish not fulfilling the factories' requirements (in size and quality) is processed and traded in the artisanal VC for the local market. Nile perch by-products (skins, heads, bones, offcuts, fats) are also traded, processed by hand under low hygienic standards, and traded in the local and regional markets. A special by-product is the fish maw (swim bladder) which has developed as an independent VC due to its high economic value. It is mainly exported to China. In 2017, new regulations for maw extraction were introduced to allow artisanal processors to participate in maw extraction. This has led to greater availability of Nile perch in local markets, as the gutted fish produced as a by-product of maw extraction is not accepted by factories which process fish for the export market. Export hygiene regulations require factories to process only whole fish and, therefore, the gutted fish from local maw extractors are rejected and sent to local markets.

Sustainability hot spots in Nile perch value chain

Based on our research we identified 14 SHS along the Nile perch VC.

Within the **environmental dimension**, we identified five SHS, the first being **biodiversity** in the production stage. Breeding grounds are at risk due to inflows from factories, human settlements, agricultural activities as well as illegal fishing methods involving small-meshed nylon nets (monofilaments) which entangle small fish before they reach a reproductive age. The second SHS was also identified within the category biodiversity, but in the processing stage. It is a SHS because the industrial export-oriented processing sector is focused almost exclusively on Nile perch and, consequently, puts pressure on producers to fish despite low stocks. In addition, the artisanal processing sector absorbs undersized, immature Nile perch that has been caught illegally and is rejected by factories.

Water quality in the production stage is the third SHS as eutrophication has been on-going since the 1960s and is responsible for recent fish kills because low oxygen availability can paralyze large fish like Nile perch. Also, microplastic pollution e.g. from the breakdown of plastics from monofilament nets is becoming a concern in the Lake Victoria ecosystem. **Synergy** in the production stage received a high scoring especially due to the water level rise which is most likely caused by the loss of buffer zones around the lake and its catching areas due to population growth, deforestation, and swamp drainage. Another SHS is **equipment** in the production stage due to the use of undersized and monofilament nets which catch immature fish (interrupting reproductive cycles) and leave non-biodegradable microplastics in the lake. They are strictly forbidden, but widely circulate due to low levels of law enforcement.

Another five SHS were identified within the **social dimension**. **Access and use of resources** in the production stage was identified as a hot spot because of fishers' limited access to boats and gear, making them dependent on boat owners. Furthermore, hygienic handling was rated poor especially at landing sites with a low degree of infrastructure. The SHS **social values and diets** in the production stage received a high scoring mainly due to the cultural taboo that prohibits women on or close to fishing boats and their participation in fishing activities. **Fairness** in the production stage is a SHS due to unequal profit distribution in the export industry, putting fishers at a disadvantage. Moreover, corruption is present, especially following the military's interventions in the lake. Additionally, some cases of child labor have been reported.

Agency was identified as SHS in the production stage because of the low level of organization at the landing sites and the strong dependencies identified, disproportionately affecting fishers. These occur primarily as a consequence of the abolition of the Beach Management Units which organized fishing among actors at the landing sites. Dependencies at the production stage have increased since then particularly with the banning of small boats for ecological reasons. Many fishers can not afford bigger boats and now depend on boat owners to offer them employment as fisheries labourers. The **legal framework** is a SHS in the production stage in relation to the execution of laws, lack of clear penalties for illegal fishing, and violent law enforcement by military patrols.

In the **economic dimension Economic resilience** was scored as a SHS in the production stage as well as in the processing stage. Fishers are rarely economically resilient because most rely exclusively on fishing for income in a setting where contracts and insurances do not exist. Factory processing is also characterized by lack of diversification in terms of fish species. Because of their dependency on Nile perch and their need to process immense quantities of fish to cover their fixed costs, factory processors have low economic resilience. **Commercial viability** is a SHS in the processing stage due to the high market concentration in the Nile perch VC by factories and export companies. **Economic benefits** in the production stage is a SHS because of fishers' low income.

Overall, the Nile perch VC has two faces. On the one hand, it is not sustainable due to its impacts on the degradation of the lake ecosystem, the notorious overexploitation of Nile perch stocks, and the high prevalence of illegal fishing methods. On the other hand, Nile perch is an invasive species in the lake and should be limited by appropriate human fishing activities. In addition, it is one of the most profitable food VCs in Uganda and provides livelihoods to millions of people around Lake Victoria. However, value addition must be shifted to the domestic market, awareness of overfishing must be raised, and community-based management approaches for fisheries are urgently needed for a transformation to a more sustainable Nile perch VC.

SHSA evaluation/lessons learned

We conclude that SHSA offers a practical and holistic tool for the assessment of SHS, particularly as an *ex-ante* evaluation of VCs, e.g. for development projects and when data/knowledge on potential target commodities is scarce. Its high degree of transparency and steps involved makes the collected data an ideal baseline for measuring progress of project interventions over a given period.

Moreover, we find that the agroecological principles based on HLPE (2019) and FAO (2018b) provide a suitable ground for developing categories for SHSA 2.0. These principles help establish a comprehensive framework for addressing sustainability challenges, particularly in food production and food system transformation. At times, the complex agroecological terminologies of the HLPE and FAO were hard to understand by academic and non-academic attendees and failed to match local realities. We conclude that the SHSA categories should be adapted to the local context and should be supplemented, if deemed necessary. Ultimately, working with a predefined set of categories within an established framework has the major advantage of accelerating the research process and allowing comparison of results with other studies across space, time, and VCs, when drawn from the same framework.

The SHSA 2.0 method has been shown to be effective in integrating scientific and local knowledge in a participatory fashion. Participation is time consuming and biased and hence inaccurate results might be obtained when time is limited. To tackle the limitation of participatory instruments *per se*, we conclude that they need to be carefully designed and implemented. To this end, local colleagues who have knowledge and understand the local context are key in supporting participatory research processes.

Certainly, access to stakeholders and their mobilization is crucial for a successful SHSA 2.0. Adequate representation and participation of stakeholders from all VC stages ensures a balanced assessment of SHS. Nevertheless, it is important to stress that applying this criterion on the ground can be challenging, as some stakeholders are more difficult to access than others or may show limited willingness to disclose information. Furthermore, to balance a high number of VC stages, categories, and participants within geographic, time, and resource constraints, trade-offs must be made. This refers, for e.g., to the selection of participants representing each VC stage, which is also crucial for reducing potential biases and efficiently collecting data.

Finally, as SHSA 2.0 tries to strike a balance between being neither too limited nor too costly, we recommend conducting *a priori* cost–benefit check of the application of this method considering the quantity and quality of up-to-date literature available on the topic of investigation.

Conclusions and policy recommendations

Both the Irish potato and Nile perch VCs in Uganda face several sustainability challenges. We found a great number of sustainability hot spots in the production stages of both VCs which threaten their contribution to the overall sustainability of food systems. In the potato VC, the main SHSs are a lack of quality inputs and storage facilities, soil health issues, potato loss and waste, and limited economic benefits, particularly for farmers. Likewise, the majority of SHSs in the Nile perch VC are in the production stage (biodiversity, water quality, fishing equipment, access and use of resources, fairness, and economic benefits, among others) while three are in the processing stage.

We conclude that the SHSA 2.0 offers a practicable and rapid tool for the assessment of SHS, particularly as an *ex-ante* evaluation of VCs. It is well-suited for problem assessments, feasibility studies, VC development projects, and when data/knowledge on target commodities is scarce. Yet, access to stakeholders and their mobilization are crucial for successful implementation of the SHSA 2.0. The high stakeholder participation within the SHSA 2.0 allows for co-ownership of the study and co-creation of knowledge between researchers and VC stakeholders, resulting in a higher probability of positive real-world impacts compared to, for example, top-down approaches (Mauser et al., 2013).

In light of the climate/ecological crisis, there is increasing agreement that a global paradigm shift in food systems and VC promotion is needed (Anderson et al., 2021). VC promotion as identified in the presented two case studies do not follow a holistic or strong sustainability approach. Agroecological principles and elements as suggested by HLPE (2019) and FAO (2018b) represent a suitable framework to tackle sustainability challenges, particularly in the production of foods, transformation of food systems, and fair distribution of foods. Yet, the agroecological principles must be adapted to local contexts as culture and local conditions matter. We find that, in the case of potato farming, the adoption of agroecological intensification holds great potential to overcome some of the sustainability challenges (particularly soil health, nutrient cycling, participation, and knowledge exchange), but their labor requirements and costs and benefits require further research.

Policy recommendations for improving the potato VC include training on post-harvest management, marketing, and finance for farmers; establishing contract farming structures between farmers and processors; construction, maintenance, and management of high-quality storage options; and promoting certified seed production. For the Nile perch VC, policy recommendations include the demarcation of breeding grounds to allow Nile perch rejuvenation, stricter standards for gear supply, the establishment of co-management structures at landing sites, and programs for establishing or supporting alternative livelihoods, that is, outside of fishing.

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Abbreviations

AFALU	Association of Fishers and Lake Users of Uganda
AEI	Agroecological intensification
BMU	Beach Management Unit
BMZ	Bundesministerium für Wirtschaftliche Zusammenarbeit und Entwicklung (German Federal Ministry for Economic Cooperation and Development)
CIP	International Potato Centre
DEval	The German Institute for Development Evaluation
DiFR	Directorate of Fisheries Resources
EREPP	Elgon Regional Potato Platform
FGD	Focus group discussion
FPU	Fisheries Protection Units
GAP	Good Agricultural Practice
GHG	Greenhouse gas
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH (German Corporation for International Cooperation GmbH)
IEC	Information, education, and communication material
IFDC	International Fertilizer Development Centre
IUU	Illegal, unregulated and unreported
LVFO	Lake Victoria Fisheries Organization
MAAIF	Ugandan Ministry of Agriculture, Animal Industry and Fisheries
MIFA	Mengya Integrated Farmers Association
NAADS	National Agricultural Advisory Services
NARO	National Agricultural Research Organisation
NaFIRRI	National Fisheries Resource Research Institute
NAMAGE	Nachhaltigkeit Moderner Agrar- und Ernährungssysteme ("Sustainability of Modern Agro-Food Systems")
NDFR	National Directorate of Fisheries Resources
NPMFP	Nile Perch Fishery Management Plan for Lake Victoria
NSSF	National Social Security Fund
PNSP	Promotion of Nutrition-Sensitive Potato

PRA	Participatory rural appraisal
RAP	Rooted apical cuttings
RFBCB	Responsible Fisheries Business Chain Project
SAFA	Sustainability Assessment of Food and Agricultural systems
SEWOH	Special initiative One World - No Hunger by the BMZ
SFS	Sustainable food systems
SFVC	Sustainable food value chain
SHS	Sustainability hot spot
SHSA 2.0	Sustainability Hot Spot Analysis 2.0
SLE	Centre for Rural Development
TBL	Triple bottom line
UAIS	Uganda Agricultural Insurance Scheme
UFFCA	Ugandan fisheries and fish conservation association
UGX	Ugandan Shillings, exchange rate used $1 US = 3,600 UGX
UNWFO	Uganda National Women's Fish Organization
UPP	Uganda Potato Platform
VC	Value chain
WASSWAPPA	Wanale Seed and Ware Potato Producers Association

1 Introduction

1.1 Background and study context

The sustainability of food value chains (VCs) is key to tackling the simultaneous challenges of food systems, namely providing food and nutrition security and decent livelihoods within planetary boundaries (FAO, 2014a; SWAC & OECD, 2021). Within the framework of the One World - No Hunger initiative (SEWOH), the German Federal Ministry for Economic Cooperation and Development (BMZ) promotes food value chains, mainly in sub-Saharan Africa, to create more income and employment, contributing to reduced poverty and improved food security. The German Institute for Development Evaluation (DEval) concluded that, in general and without special focus on SEWOH, German bilateral VC promotion achieves the development objectives of increasing availability and economic access to food. Yet, it may target actor groups with more resources, while chronically poor households and other marginalized groups are often not direct beneficiaries of such project or programme interventions (Kaplan et al., 2016). Furthermore, the DEval study revealed that little attention has been paid to a multidimensional assessment of sustainability, especially regarding the social and ecological dimensions (Kaplan et al., 2016).

In cooperation with the BMZ, through the research project Sustainability of Modern Agri-Food Systems (NAMAGE) of the Centre for Rural Development (SLE), the SLE research team, hereinafter referred to as we/us, developed a holistic and feasible approach to assess sustainability of Irish potato and Nile perch fish VCs in Uganda promoted by SEWOH and implemented by the GIZ[1]. We gathered evidence on sustainability hot spots, trade-offs, and synergies, while also reflecting on the role of (agroecological) principles and innovations for both VCs, so as to provide recommendations to improve the promotion of sustainable VCs.

This report gives details of the research approach used, presents key findings of this study, and provides final policy recommendations.

1 In the NAMAGE structure, a parallel study targeting groundnut and dairy VCs in Zambia was also conducted by another research team. The two SLE research teams jointly developed a common conceptual framework.

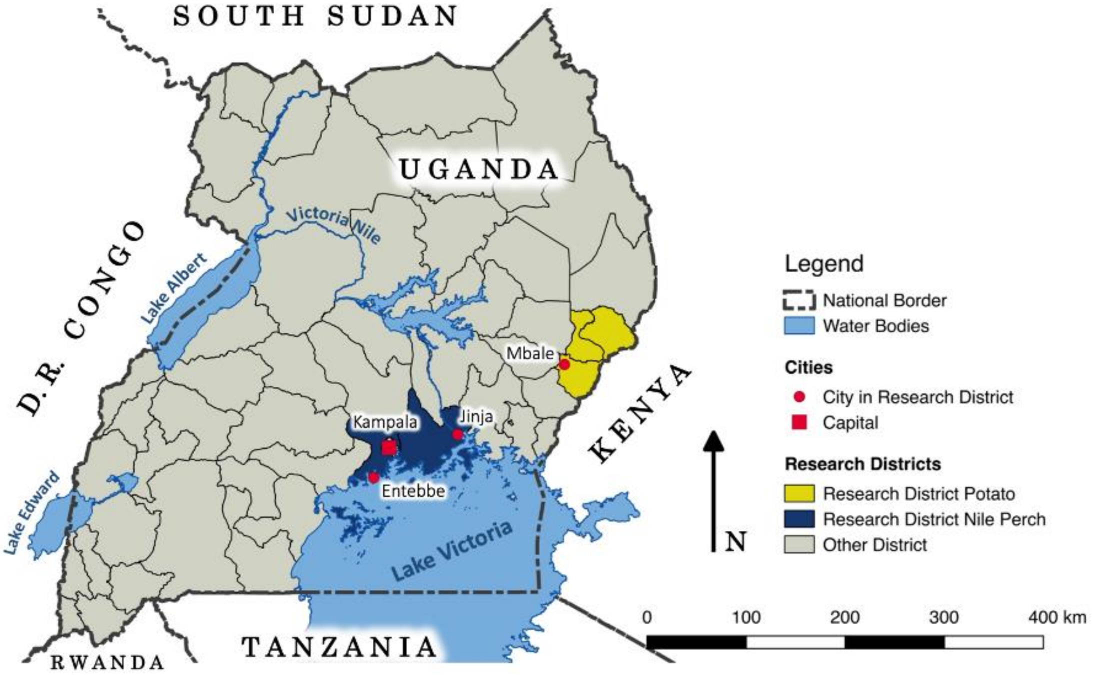

Figure 1: Map of Uganda with the project areas for the potato (Mbale, Kapchorwa, and Kween districts) and fish (Jinja, Wakiso, Mukono, and Kalangala districts) value chains

Source: Own illustration (QGIS)

Farming and agricultural livelihoods in Uganda

Uganda is a landlocked country in East Africa, located at the heart of the Great Lakes region (see Fig. 1). Around 43 % of the country's surface is used as agricultural land (UBOS, 2020). Agriculture, as the largest sector, employs 72 % of the population and contributes about 23 % to GDP (MAAIF, n.d.). Conditions for agriculture in our study regions are excellent: Uganda has among the highest water reservoirs in Africa and our study region receives equatorial, tropical rainfalls (World Bank Group, 2020). In many regions of Uganda, soils are highly fertile. Most Ugandan farmers (70 %) are food self-sufficient (FAO, 2021). However, food availability, access and utilization remain problematic particularly in the drier Karamoja, East Central, and West Nile regions (FAO, 2021).

Yet, even in regions where food availability and security are high, malnutrition remains a key concern in Uganda due to lack of dietary diversity; that is, diets are dominated by starch-based foods (carbohydrates) and deficient in nutrient-rich and nutrient-dense foods (Ngaruiya et al., 2017). Fruits and vegetables are under-consumed in Uganda as they are more expensive than starches (Kiguli et al., 2019).

However, increasingly, there is a simultaneous challenge of obesity and overweight as a form of malnutrition in Uganda, in both urban and rural areas (Kiguli et al., 2019; Ngaruiya et al., 2017). In fact, overweight affects 18 % of the rural population aged 35 - 60 years in Eastern Uganda (Mayega et al., 2012). Fast food consumption and consumption of processed foods has increased rapidly in the past decades, particularly in urban centres (Ayo et al., 2012; Baalwa et al., 2010; Sserwanja et al., 2021). The consumption of highly processed food such as fried foods including chips, crisps, and eggrolls is higher among urban population than in rural areas (Kiguli et al., 2019).

Next to traditional cash crops such as cocoa, coffee, and tea (Latynskiy & Berger, 2016), staple crops such as maize, beans, plantain, peanuts, and potato are more prevalent than livestock and fish, for which relevant investments and productivity have been insufficient in the past decades (MAAIF, 2016; UBOS, 2020; Waiswa et al., 2021; World Bank Group, 2019). Agriculture in Uganda is largely dominated by small-scale farmers[2] (Bamwesigye et al., 2020) who have limited access to land, markets, finance, inputs, and technology and are usually highly affected by price fluctuations of agricultural commodities (Jayne et al., 2010). The Gini coefficient indicates increasing inequality in land distribution in Uganda since 2012 (World Bank Group, n.d.-a). 66.2 % of households farm on less than one hectare (ha), only 13 % on more than two hectares (UBOS, 2020).

In the Mt Elgon area, our study area, an average household farms 1.1 ha (2.7 acre, all crops combined, IFDC unpublished dataset 2021); however, the average household size, sharing a field, in the Mt Elgon area is 7.4 persons (Mason & Weiss, 2021).

It is uncommon for women to own land in Uganda as land is inherited by the oldest sons in the household. Gender disparities in the agricultural sector are high and relate to land tenure, workload, control of production/returns, and access to finance (Chigbu et al., 2019).

As prioritized in Uganda's Vision for 2040 (MAAIF, 2016), investment and development of the country's agricultural sector is guided by the Ugandan Ministry of Agriculture, Animal Industry and Fisheries (MAAIF) within the Agriculture Sector

2 According to the Ugandan Bureau of Statistics small-scale farmers are "those who usually cultivate less than one hectare of land (2.5 acres) in a cropping season, practice labour intensive farming using rudimentary technology [...]" (UBOS, 2014).

Strategic Plan. This plan was adopted in 2016 as a part of the National Development Plan II and, more recently, III. The agriculture sector among other sectors is supported by international assistance – the total ODA Uganda received amounted to 2.1 billion US dollars in 2019 (World Bank Group, n.d.-c). In the agricultural sector, development programmes have attempted to enhance the quantity and quality of food production in Uganda (Pan et al., 2018). For instance, Uganda has successfully developed a sector for organic food production and exportation, and is one of the leading African countries in organic production (e.g., bananas, chillies, coffee, cotton, ginger, passionfruit, pawpaws, and pineapples) (ITC, 2021; Kundermann & Arbenz, 2020).

Two of the agricultural commodities emphasized in national and international development strategies are Irish potato and fish.

1.2 The Irish potato value chain in Uganda

Irish potato was introduced around 1900 in Uganda (PotatoPRO, n.d.-a) and is now cultivated by an estimated 335,000 Ugandan farmers (IFDC, 2019a). It is the third-most consumed tuber in Uganda after sweet potatoes and cassava (Tatwangire & Nabukeera, 2017) and is a dual-purpose crop grown primarily by smallholder farmers, both for home consumption and income generation (Gildemacher et al., 2009). Most of these farmers live in the cool highlands in the southwestern region and fewer in the eastern parts of the country (UBOS, 2020) and contribute around 10 % of the national production (Ferris et al., 2001) . The estimated land under potato cultivation in Uganda was 39,300 ha in 2017 (FAOSTAT, 2017c) with most of the national potato output concentrated in the western regions (87.5 %) (UBOS, 2010). The estimated land under potato cultivation in Uganda was 39,300 ha in 2017 (FAOSTAT, 2017c) with most of the national potato output concentrated in the western regions (87.5 %) (UBOS, 2010). The crop is characterized by a short growing season of three to four months and is generally grown biannually under rainfed cultivation from March to July and from September to January (Gildemacher et al., 2009). The use of irrigation systems in potato production is uncommon in Uganda (UBOS, 2020).

In the eastern region, Irish potatoes are grown on the slopes of Mt. Elgon, mainly in Kapchorwa, Kween, and Mbale districts. Located between 1,500 and 3,000 m above sea level, agricultural zones are distinguished by the presence of deep volcanic soil, moderate temperatures, and generous rainfall (900 – 1,400 mm/year).

The average potato plot size of potato-producing households in the Mt. Elgon region is 0.7 acres (0.3 hectares) per household (IFDC, 2021). Consequently, these producers are characterized as smallholders (FAO, 2012). Potato farmers in the region consume around 30 % of their potato production and sell around 70 % domestically (IFDC, 2021).

Increasing demand for and consumption of potatoes in the country has led to continuous nationwide growth in potato production. However, this growth is mainly met through extensification rather than intensification of production, i.e., an increase of yield per land unit (Parker & Wauters, 2021). On average, potato farmers in Uganda achieve a yield of 3 – 12 tonnes per hectare (t/ha), which is far below the attainable yield of 20 – 30 t/ha (Parker & Wauters, 2021). One of the causes of this yield gap is the use of low-quality seed due to insufficient availability and affordability of quality-controlled/certified seeds (IFDC, 2019b). Farmers commonly use potato seeds from previous harvests or buy them from other farmers in their village or local market. These seeds are often infected by diseases, particularly bacterial wilt and late blight (Parker & Wauters, 2021).

At the production level, farmers face additional challenges including inadequate postharvest handling resulting in substantial losses (~ 10 %) (Tatwangire & Nabukeera, 2017), limited availability of certified agricultural inputs (fertilizers, pesticides, and tools), and hampered access to agricultural training and extension services (UBOS, 2020).

Although recent estimates indicate that the overall production of Irish potatoes has increased by 200 % in the past decade (UBOS, 2020), this meets only about one-third of national demand (National Agricultural Advisory Services, n.d.-b) and represents only a fraction of the potato production in neighbouring Kenya (>1,500,000 tons) and Rwanda (>800,000 tons) (FAOSTAT, 2017b, 2017a). The Irish potato sector in Uganda currently serves solely the domestic market (Gildemacher & Rappoldt, 2019a) and the country imports potatoes for French fry and potato chip production, e.g., from Egypt and Kenya (precise data is not available).

Potatoes in Uganda are consumed as both fresh and processed products. Consumption grew from 9.6 kg/capita/year in 1999 to 15.0 kg/ca/year in 2011 (PotatoPRO, n.d.-a; Witte, 2013). Ferris et al. (2001) estimated consumption of fresh potatoes to be over 500,000 tonnes in urban centers and around 350,000 tonnes in rural areas in 2015, where they are mainly consumed boiled by potato farmers themselves (Tatwangire & Nabukeera, 2017; Witte, 2013).

Processing[3] of potatoes in Uganda mostly involves processing into chips[4], crisps, and egg rolls (Aliguma et al., 2007; Tatwangire & Nabukeera, 2017). While there is a wide range of small-scale processors (restaurants, hotels, and fast-food outlets), there is only one processing plant for chips (currently not operating due to a shortage of suitable potato varieties) and a small number of chip processors (Mbowa & Mwesigye, 2016; Uganda National Potato Platform, n.d.). Yet, in urban centers such as Kampala, chips are the most frequently consumed fast food followed by deep-fried chicken and sausages (Ayo et al., 2012). As evidenced through multiple studies, the increasing demand for potatoes in Uganda is mainly explained by urbanization, changing food habits, and the rapid growth of the fast-food sector, particularly in urban centers (Ayo et al., 2012; UDHS, 2016; Wanyama et al., 2019). It is estimated that over 50 % of all Ugandan potatoes are processed into chips in Ugandan cities and towns (Ferris et al., 2001) commonly offered in restaurants, hotels, and retail centers (Kajunju et al., 2021).

GIZ and potato value chain promotion

In light of rapidly changing consumer preferences coupled with production challenges in the potato value chain, GIZ coordinated a series of interventions in the Mt. Elgon region. As part of the One world - no hunger initiative, BMZ will fund GIZ's Promotion of Nutrition-Sensitive Potato (PNSP) Value Chains in East Africa project from 2016 to 2023. It is budgeted at 9.9 million Euro for its components in Kenya and Uganda. In Uganda, the project is in the Mt. Elgon region (see Fig. 1). The institutional partner is the MAAIF (GIZ, 2018) while the International Fertilizer Development Centre (IFDC) implements the project activities (GIZ, 2021a). Their target group is small-scale farmers, with a focus on female farmers. GIZ gears its interventions to production and marketing, nutrition counseling, and sector coordination and has provided >3,000 farmers with agricultural trainings and >5,000 people with nutrition counseling as of December 2020 (GIZ, 2021a).

The project deploys measures at different stages of the VC, e.g., farmer field and business schools with integrated advisory services on good agricultural practices (GAPs) and a regeneration technique called rooted apical cuttings to produce high-quality seeds, as well as improvement of ware potato storage. The project also offers training and other formats to increase knowledge on family

3 Processing hereby refers to the conversion of ware potatoes into a food product with the aim of sale rather than own consumption (Cucagna & Goldsmith, 2018).

4 In Uganda, the word "chips" refers to French fries and the word "crisps" refers to potato chips. We use the Ugandan names throughout this report.

nutrition, dietary diversity, and health as well as vegetable farming. Furthermore, the GIZ/IFDC provide direct and indirect support to the Uganda Potato Platform (UPP) and the Elgon Regional Potato Platform (EREPP), which are, respectively, a national and a regional multi-stakeholder platform with representatives from various stakeholders and actors in the potato sector such as farmers, input providers, traders, processors, and consumers. The Covid-19 pandemic has represented a major challenge in the project implementation due to recurring mobility and assembly restrictions in Uganda (GIZ, 2021a).

1.3 The Nile perch value chain in Uganda

Although Uganda is a landlocked country, its fishing sector accounts for 3 % of the country's GDP and the greatest share of fishing (58 %) is reportedly done on Lake Victoria, Africa's largest freshwater fishery. Uganda shares Lake Victoria with its neighbours, Kenya and Tanzania, whose economies also boast a large fishing sector (Barratt et al., 2015; LVFO, 2015). In-land fisheries around lakes like Lake Victoria contribute substantially to livelihoods and food security for more than one million Ugandans who are involved in the production, aggregation, trading, processing, or distribution stage of the VC (Fiorella et al., 2014; Odongkara et al., 2009).

The Ugandan fishing sector at Lake Victoria is dominated by three key species, accounting for 95 % of the total catch from the lake: Nile perch (*Lates niloticus*), Nile tilapia (*Oreochromis niloticus*), and silver cyprinid (*Rastrineobola argentea*), locally known as *mukene* (Barratt et al., 2015). The Nile perch VC was chosen for investigation since it is the economic mainstay of the Lake Victoria region and its fishery sector, accounting for 60 % of the overall fisheries catch and being the most profitable fish species in Uganda (Kimani et al., 2018). In addition, the Nile perch VC promoted by the GIZ Global project *Sustainable Fisheries and Aquaculture*, which is our partner for the present research.

Nile perch is widely known as being artificially introduced into Lake Victoria in the 1960s, thereby eradicating various native fish species (Kolding et al., 2014). As such, fishing activities in the area progressively changed from subsistence- and domestic-orientated activities to more commercial and export-based enterprises dominated by the Nile perch (Aloo et al., 2017). The spread of Nile perch in Lake Victoria caused a fishing boom in the 1980s and 90s, particularly in light of internal migration to lake villages across the country (Barratt et al., 2015; Brugere et al., 2015).

A large share of the recorded landed Nile perch in Uganda (~ 95 – 96 %) is bought by export-based companies that process the Nile perch in factories and sell it as premium products in the international market, mainly the EU. The remaining 4 – 5 % remain in the local market. However, because much of the harvest goes unrecorded, the amount of fish, including undersized (below 50 cm) and low-quality fish, absorbed into the local market is unknown. Estimating the proportion of the harvest that stays in the local area is hampered by lack of data on home consumption by fishers as well as unregistered transactions between fishers in the local cash market or with artisanal processors (Kimani et al., 2018).

Due to fluctuations in stocks, the catches and prices of Nile perch vary from year to year. Nile perch export volumes were at their first peak in 2005 with about 3,000 tons of fish harvested per month. The catch then declined for a decade with 2010 harvests of only about 1,300 tons/month. The export business saw increasing volumes (~ 1,700 tons/month) in 2018 and prices for fish filet and maws (swim bladders) increased. Since then, the sector has been facing another depression: in April 2021 only 350 tons were exported (UFPEA, 2021).

The Nile perch VC is a very complex value chain with local, regional, national, and international actors involved at different stages from catch to sale (Kimani et al., 2018). In general, the Nile perch value chain can be divided into four main output products. The largest of which is (1.) industrially processed fish filet for export markets mainly in Europe and Asia. Fish not fulfilling the factories' requirements (in size and quality) is processed and traded in (2.) the artisanal value chain for the local market; (3.) By-products (skins, heads, bones, offcuts, fats) are processed by hand and traded in the local and regional markets. A unique VC and market exists for 4) the fish maw (swim bladder). During the last 10 years, it has developed into an independent sector receiving prices ranging from $50 to $240 US[5] per kg of fresh maw, depending on the size (Bagumire et al., 2018; Kimani et al., 2018). by-products (skins, heads, bones, offcuts, fats) are processed by hand and traded in the local and regional markets. A unique VC and market exists for 4) the fish maw (swim bladder). During the last 10 years, it has developed into an independent sector receiving prices ranging from $50 to $240 US[6] per kg of fresh maw, depending on the size (Bagumire et al., 2018; Kimani et al., 2018). Institutionally, the VC is regulated through the Directorate of Fisheries Resources (DiFR) under the Ministry of Agriculture, Animal Industry and Fisheries (MAAIF). Furthermore, the legal framework for the Nile perch species is harmonized and coordinated

5 Throughout the report, the exchange rate used is $1 US = 3,600 Ugandan Shilings (UGX)

6 Throughout the report, the exchange rate used is $1 US = 3,600 Ugandan Shilings (UGX)

regionally – together with the two other riparian states Kenya and Tanzania – through the Lake Victoria Fisheries Organization (LVFO). The LVFO establishes the fisheries management framework and implements the Nile Perch Fishery Management Plan for Lake Victoria (NPFMP), which is now in its third edition and a powerful directive for the sector (LVFO, 2015).

The Nile perch VC is confronted with a number of constraints. As Nile perch is harvested in capture fisheries, the VC is highly dependent on the reproduction and recovery of stocks (Brugere et al., 2015). Since the boom and following industrialization of the sector in the 1990s, the VC experienced several break-downs due to overexploitation of its perch stocks. Overfishing has been a problem ever since, which has led from traditionally unrestricted access to the lake to strict regulation of fishing practices and entry barriers (NPFMP2, 2015). For instance, the Ugandan administration put in place the Fish (Fishing) Rules in 2010, which regulate licensing, fishing gear, boat size, and movement permits for the catch (Fish (Fishing) Rules, 2010).

However, on-going non-compliance with those regulations (formally known as illegal, unregulated and unreported (IUU) fishing practices) is a major threat to the VC, not only to production, but also at the post-harvest stages (Fish exporters seek ban on local consumption of Nile Perch, 2021). IUU fishing practices intensified upon the release of the second NPFMP (2015-2019), which emphasizes strict control of the resource and formalization of the sector (NPFMP2, 2015). The Ugandan administration's resulting strict regulation enforcement led to a change in the institutional framework that resulted in replacement of community-based Beach Management Units (BMU) with Fisheries Protection Units (FPU) in 2017. Prior to 2017, BMUs were a hybrid collective of community and institutional control units and acted as the main fisheries regulation enforcement authority (NPFMP2, 2015). In contrast, the FPU is a branch of the Ugandan army known for punishing IUU fishing strictly with penalties such as cash fines and imprisonment (Kantel, 2019).

These developments have led to national political conflict and media coverage, with regular headlines about corruption cases (Museveni threatens to withdraw soldiers from the lake over corruption, 2020) and disproportionate use of violence and brutality against fishers by the FPU (Kantel, 2019; RDC orders arrest of fishing enforcer over battering of Kalalangala fisherman, 2020; Army brutality cost Museveni votes from the islands 2021b).

Recently, the issue of how to deal with the recession of Nile perch has become the focus of many public media debates. The processing and exporting industries suggested a ban on local marketing of Nile perch during the review of the Fisheries Bill, arguing that open-air gutting should be illegal. This would highly disadvantage local trade and consumption of Nile perch while securing the supply of Nile perch destined for the international export market (Fish exporters apologize over request to ban local consumption of Nile Perch, 2021; Fish exporters seek ban on local consumption of Nile Perch, 2021).

GIZ fish value chain promotion

The activities of the GIZ in the Ugandan fish VC are part of the Global Programme Sustainable Fisheries and Aquaculture. The particular GIZ project in Uganda is called Responsible Fisheries Business Chain Project (RFBCB). The project started in 2016 and is scheduled to end in 2023 and has a funding allocation of 10.95 million EUR. The implementing partners are the DiFR, processing and export associations, NGOs, and the LVFO (GIZ, 2021b). The target group of the interventions is "workers in small- and medium-sized businesses, whose livelihoods depend on the Nile perch VC" (GIZ, 2021b, p.2). Its objective is to increase local food security and income while fostering sustainable and resource-conserving fishing. In this context, the GIZ promotes artisanal fishing and the reduction of illegal fishing activities.

1.4 Study team and partners

The project team consisted of five junior professionals from the 59th cohort of the postgraduate program at SLE at the Humboldt University of Berlin (Jasmin Ahmed, Lukas Eichelter, Felix Hegeler, Eva Kirmes, Flavia Marà) and their team leader (Dr. Hendrik Hänke). The interdisciplinary team was complemented by four research fellows (Deous Mary Ekyaligonza, Dr. Joanita Kataike, Dr. Violet Kisakye, Muhangane Lauben) from Uganda and a team leader (Dr. Joshua Wesana) (for a more detailed description see Annex 1). Our project's primary partners were NAMAGE (a research group under SLE) and One World - No Hunger (an initiative of the BMZ and GIZ). In addition, we cooperated with key stakeholders from the International Fertilizer Development Center (IFDC), Uganda Potato Platform Limited (UPP), the regional platform EREPP (Elgon Regional Potato Platform), and governmental institutions including district agricultural officers for the potato VC. For the fish VC, GIZ was a project partner as well as the Directorate of Fisheries and Resources (DFiR) and the District Fisheries Offices in the research areas.

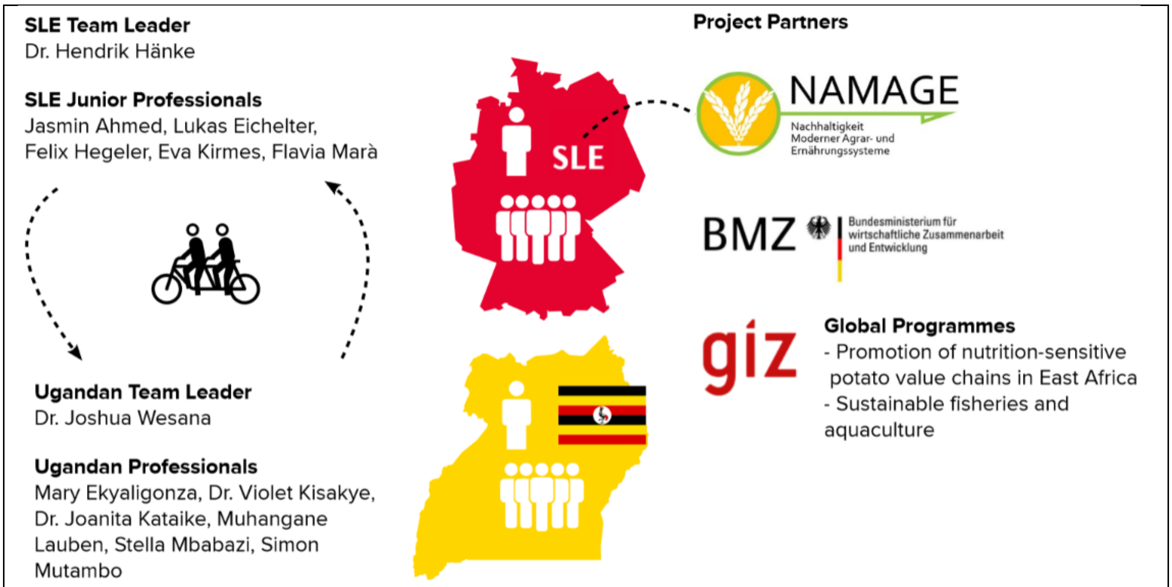

Figure 2: SLE research and mirror team

Source: Own illustration

2 Research framework

2.1 Core problem and research objectives

2.1.1 Core problem

Existing approaches to define and assess sustainability in the context of food VC development are complex and time-consuming. Often, they are neither operational nor participatory, and most agricultural VC assessment tools do not consider all dimensions of sustainability (i.e., they are most often divided into society, environment, and economy) and their interdependencies. Furthermore, there is a growing interest on the part of BMZ to analyze and understand the potential of including agroecology in sustainable food systems and VC promotion as highlighted in its recently published 2030 strategy (BMZ, 2020).

2.1.2 Research objectives

In order to tackle this core problem, a research framework was built around one primary and two secondary outcomes (see Annex 2):

Outcome 1: The BMZ uses study recommendations to improve the sustainability of food VC approaches with special consideration for agroecological principles.

Outcome 2: Local VC stakeholders and policymakers in Uganda consider and act upon the sustainability hot spots, trade-offs, and synergies identified in the Irish potato and Nile perch value chains.

Outcome 3: Local ownership of sustainability-oriented innovations as well as agency to negotiate trade-offs along food value chains are enhanced.

The study aimed to achieve these three outcomes by delivering the following five outputs:

Output 1: Elaborate an overview of the Irish potato and Nile perch value chains in Uganda and identify associated sustainability hot spots.

Output 2: Operationalize holistic assessments of the sustainability of the Ugandan Irish potato and Nile perch VCs through a participatory Sustainability Hot Spot Analysis 2.0 (SHSA 2.0).

Output 3: Analyze the potential roles of agroecological practices in addressing sustainability hot spots along the Irish potato and Nile perch VCs.

Output 4: Discuss trade-offs and synergies along the Irish potato and Nile perch VCs and provide recommendations for their effective negotiation.

Output 5: Provide recommendations for the promotion of sustainable Irish potato and Nile perch VCs in Uganda rooted in a food system approach using agroecological principles.

The contributions provided by these outputs, together with the results delivered by a corresponding study on two VCs in Zambia, fed into a higher level aim:

Higher level aim: NAMAGE synthesizes lessons learned on how to implement a participatory sustainability assessment, based on the results of the two studies in Uganda and Zambia.

2.2 Guiding research questions

Based on the core problem and research objectives, we formulated the following guiding research questions.

1. What do Irish potato and Nile perch VCs look like in Uganda? Who are the key actors and what are the links from farm to fork?
2. How can the SHSA be enriched with participatory elements and agroecological principles to serve as an instrument for improving SFVC promotion?
3. To what extent can the SHSA reflect and capture VC actors' perception of sustainability and multidimensional values?
4. What trade-offs and synergies can be identified along the Irish potato and Nile perch VCs in Uganda? How can these be negotiated among the VC stakeholders?

3 Conceptual framework

3.1 Food systems and food value chains

Food systems comprise a vast range of actors and their diverse activities, i.e., the production, processing, and distribution of food products, embedded in wider social, environmental, and economic contexts (FAO, 2018a; TEEB, 2015), Today's food systems are highly complex and diverse, varying increasingly from local to global scales (HLPE, 2019; TEEB, 2015).

A food systems approach represents a crucial entry point in addressing food security and nutrition (Béné et al., 2019; FAO, 2018a; HLPE, 2019). Due to multiple concerns (e.g., growing pressure on natural resources, climate change, planetary boundaries, equity and power, trade, dietary and health issues), the concept of food systems has gained increasing interest among researchers and policymakers calling for a profound transformation towards sustainability to tackle these challenges (Béné et al., 2019; HLPE, 2019). Béné et al. (2019) analyzed disciplinary narratives used by experts and practitioners seeking to transform food systems. Narratives on sustainable food systems mainly revolve around food security, nutrition, and health, but increasingly include social justice, fairness, democracy, and environmental and agro-biodiversity concerns (Frison, 2016; Mooney, 2017). To that end, agroecology is an emerging narrative shaping the sustainability debate and has been described by HLPE (2019) as a potential driving paradigm in the transition to sustainable food systems (SFS) (see Chapter 3.3).

Transforming food systems cannot take place without systemic changes in VCs, which should be equitable and sustainable (HLPE, 2019). According to FAO (2018), Sustainable Food Value Chains (SFVC) encompass the full range of VC actors and their sequential and coordinated activities that add value to a specific raw agricultural material to transform it into a particular food product sold to consumers. In this definition, the value created along the VC is mostly captured in economic terms, i.e., salaries, profits, tax revenues, or consumer surplus. Moreover, value can also be added by externalities within the VC. These include negative (cost to society) or positive (value to society) effects (see section 3.2).

The main links identified in the VC are (i) production (e.g., farming or fishing), (ii) aggregation, (iii) processing, (iv) distribution, and (v) consumption. Aggregation is particularly relevant for food VCs in rural contexts, where collecting and storing small amounts of products from widely dispersed smallholder farmers remains challenging (FAO, 2014a).

Moreover, a focus on "short VCs" has gained popularity in the SFVC debate in recent years (HLPE, 2019). Supporting short VCs and alternative distribution infrastructures such as farmers markets and local exchange strengthens linkages between producers and consumers, that is, the vertical coordination or vertical integration (Delgado, 1999; Rehber, 1998). This may result in improving farmers' livelihoods and access to local, diverse, and sustainably produced food, e.g., through agroecological practices (Delgado, 1999; Rehber, 1998).

Across the past two decades, international and German development cooperation have increasingly employed food VC promotion to increase food security and reduce rural poverty (Kaplan et al., 2016). However, food security and poverty reduction as sole goals in VC promotion often led to conflicting outcomes (i.e., trade-offs) by, for example, not including environmental concerns (Mausch et al., 2020) or inequalities in target communities; might not be inclusive; and may neglect the poorest and most vulnerable populations in farming communities (Donovan et al., 2020; Stoian et al., 2012)(see section 3.2). The effectiveness of the VC approach must embrace the complexity of needs and realities in which development interventions are situated (Stoian et al., 2012).

3.2 Sustainability and multidimensional value

The most common definition of sustainability as "meeting the needs of the present without compromising the ability of future generations to meet their own needs" provided by the Brundtland report (Brundtland, 1987, p. 16) bases its understanding of sustainability on human needs, neglecting its inherent and complex interdependence with non-human needs (Wu, 2013). This is both argued to be reductionist and anthropocentric, as well as distracting from wider interspecies relationships where sustainability would rest on diversity of life on Earth by recognising their interdependence (Rupprecht et al., 2020).

Figure 3 shows how three dominant conceptualizations of sustainability that put the social, environmental, and economic dimensions into relation. The triple bottom line (TBL) approach (Figure 3a) focuses on how society, environment, and economy interrelate. The weak sustainability approach considers the possibility of one element replacing another, including its interlinkages (Figure 3b), while strong sustainability (Figure 3c) places social and economic systems within planetary boundaries, that is, the capacity of planet Earth to sustain humanity over the long term (Rockström et al., 2009).

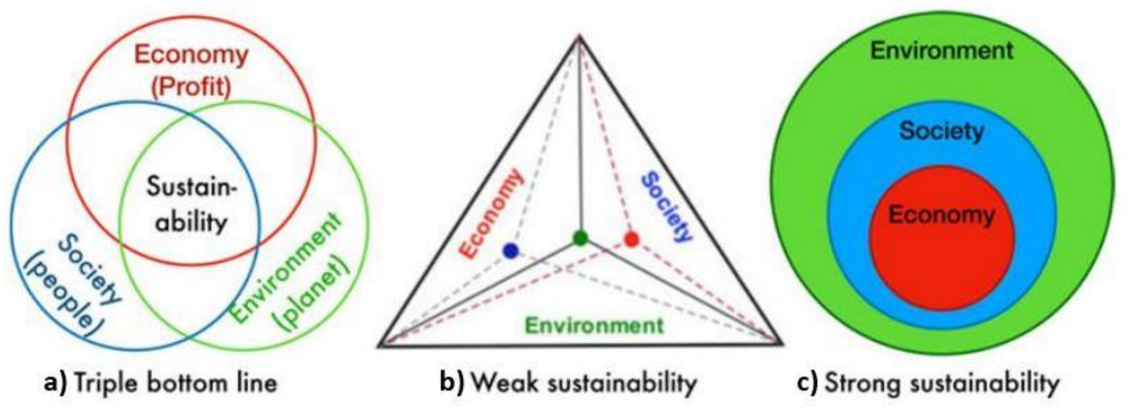

Figure 3: Interrelation of social, environmental, and economic dimensions in different conceptualizations of sustainability

Source: Wu, 2013; Rupprecht et al., 2020

For this study, strong sustainability provides the conceptual underpinning for a comprehensive framing of the multidimensional nature of sustainability in the context of food VCs (see Figure 3c and Chapter 3.2). The development of this approach shows how the depiction of economy has changed from being a distinct element in the TBL to being a societal niche in the conceptualization of strong sustainability. Moreover, the environment is interpreted as a comprehensive dimension and not as interchangeable with the other dimensions. In other words, environmental systems are seen as the basis for functioning social systems; in return, economic systems are embedded within social systems (Berkes et al., 2000). The strong sustainability approach encourages a systems perspective that strives to recognize the intertwined nature existing among dimensions (Rupprecht et al., 2020) and emphasizes the inherent multidimensionality of sustainability within planetary boundaries (Rockström et al., 2009).

Analogue to sustainability, the concept of value within VCs should be multidimensional (TEEB, 2018b). Often, the concept of value is used in a narrowly economic interpretation, mainly referring to stocks, flows, and outcomes that are visible in markets (TEEB, 2015, 2018a). The SFVC concept developed by FAO (2014) represents a starting point for this study (see Chapter 3.1), but it is further complemented by multidimensional value creation. To serve this purpose, the TEEBAgFood Framework (TEEB, 2015) draws on a systems approach to unveil value additions that are highly important but economically invisible and, thus, often overlooked in policy- and decision-making. These invisible values mostly appear as value addition in environmental, cultural, and social flows. Hence, TEEB (2018b) promotes holistic and multidimensional understandings of values whereby the value added to a product or a VC stage is defined as its contribution to overall human wellbeing, which is assessed through the state of ecological, social, and economic systems and their interdependencies/overlaps.

3.3 Agroecology

In recent years, agroecology's contributions to the debate on transitioning to SFS and developing new VCs has gained prominence (FAO, 2018b; Gliessman et al., 2019; Goïta & Frison, 2020; HLPE, 2019; Willett et al., 2019) as outlined in Chapter 3.1 there are multiple definitions of agroecology:

Table 1: Set of 10 agroecological elements (FAO 2018b), 13 agroecological principles (HLPE 2019), and SFS operational principles

Agroecological elements	Agroecological principles	SFS operational principles
a. Recycling	1. Recycling	Improve resource efficiency
b. Efficiency	2. Input reduction	
c. Diversity	3. Soil health	Strengthen resilience
	4. Animal health	
	5. Biodiversity	
d. Synergy	6. Synergy	
e. Resilience	7. Economic diversification[7]	
f. Co-creation of knowledge	8. Co-creation of knowledge	Secure social equity/responsibility
g. Culture and food traditions	9. Social values and diets	
h. Human and social value	10. Fairness	
i. Circular and solidarity economy	11. Connectivity	
j. Responsible governance	12. Land and natural resources governance	
	13. Participation	

Source: Own illustration based on FAO, 2018b; HLPE, 2019

7 According to HLPE (2019) "Economic diversification" is limited to on-farm income. In this study, however, we examine both livelihood as well as income diversification.

The FAO elaborated 10 elements of agroecology to support policymakers, practitioners and stakeholders in the operationalization of agroecology (FAO, 2018b). These elements are interlinked and interdependent and cover a spectrum from diversity and resilience to human and social values (FAO, 2018b). However, the development of such elements has led to criticism from NGOs and social movements for failing to consider the political orientation and transformative nature of agroecology (Anderson et al., 2021). Recognizing the shortcomings of the 10 FAO elements, the HLPE has further developed this framework to define 13 agroecological principles, adding new principles in relation to resilience and social justice/responsibility (see Table 1, HLPE, 2019).

Hence, the 13 agroecological principles developed by HLPE (2019) and the 10 elements of agroecology by FAO (2018b) presented in Table 1 are adopted in this study to build on the categories used in the SHSA to assess the sustainability hot spots in the Irish potato and Nile perch VCs (see chapter 4.2.1). This set of principles and elements is comprehensive and relevant for the present study as it also builds upon the operational principles of SFSs (Wezel et al., 2020) that formulate transition paths towards SFSs for food security and nutrition (see Table 1). In this context, the HLPE report (2019) proposes to include "agency" and "ecological footprint" as important components in the framework to operationalize and assess SFSs.

With its holistic and transformative approach, agroecology is deemed to promote the transition to SFS (Gliessman et al., 2019). This can be classified according to five levels, or phases, of agroecological transition (Gliessman, 2016).The first three levels are oriented towards the agroecosystem level and include: (1.) increase efficiency to reduce inputs, (2.) replace conventional inputs and practices with agroecological ones, and (3.) redesign agroecosystems based on ecological processes. The last two levels address the entire food system and entail: (4.) re-establish more direct connection between producers and consumers, and (5.) create a new global food system based on equity, participation, democracy, and justice.

4 Methodology

4.1 Research Design

Based on this conceptual outline, we (1.) developed a Sustainability Hot Spot Analysis 2.0+ (SHSA 2.0) and (2.) applied it to identifying sustainability hot spots (SHS) and synergies in the potato and fish VCs in Uganda. After (3.) formulating applicable recommendations for sustainable VC promotion, we (4.) refine the SHSA 2.0 with a focus on feasibility in comparable cases.

We used a mixed-method approach and followed a stepwise research design:

Step 1: An exploratory phase using methods including participatory rural appraisal (PRA), focus group discussion (FGD), and PhotoVoice with potato farmers and fisherfolks and semi-structured interviews with other value chains actors and stakeholders.

Step 2: Workshops with value chain actors and farmers/fisherfolks to score the relevance of suggested agroecological categories and to identify and rank the selection of related indicators

Step 3: Quantitative surveys with potato farmers and qualitative semi-structured interviews with fisherfolks

Step 4: Expert interviews with value chain actors and other stakeholders

Step 5: Evidence-based assessments of indicators (both primary and secondary data based to identify sustainability hot spots (SHSs)

Step 6: Validation workshops to receive feedback on the suggested SHSs and discuss possible solutions and recommendations

The exploratory phase was conducted by the entire team working together on potato and Nile perch VCs to develop a joint understanding of the challenges that both VCs face and how these challenges can be methodologically addressed. Thereafter, the research team was split into two groups (five members in the fish team and five in the potato team).

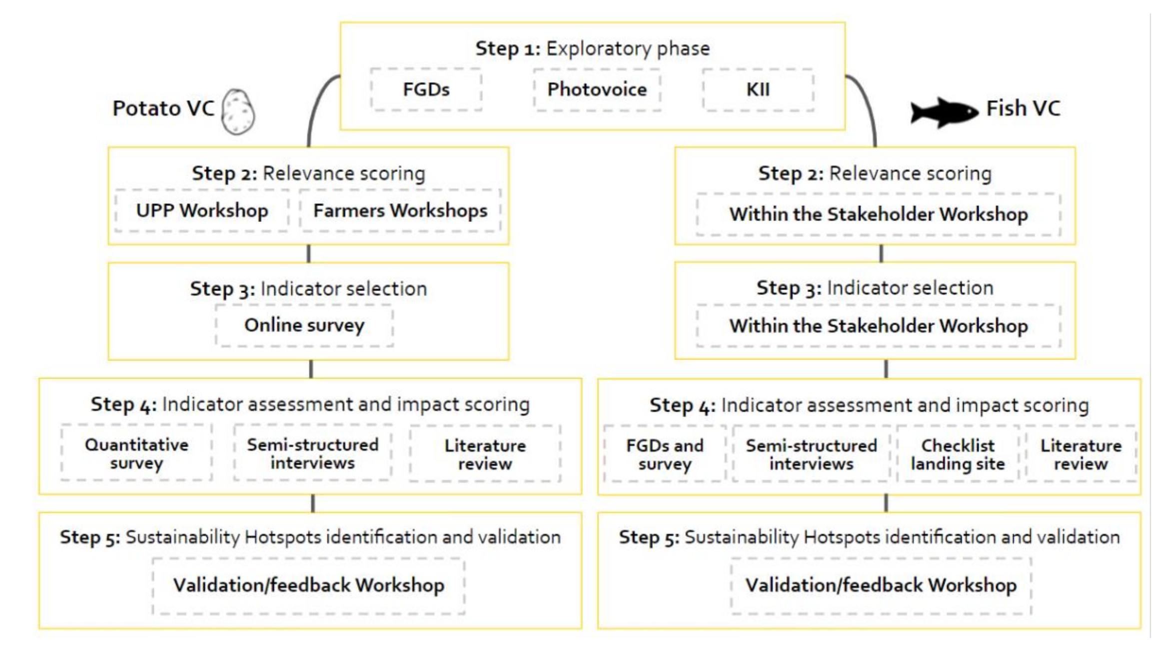

Figure 4: Research approach in the potato VC (left) and Nile perch VC (right)

Source: Own illustration

After Step 1 (see above), the other research steps (2-6, as outlined in Figure 4) were done in the smaller groups with the team leader overseeing both groups. The flowchart in Figure 4 presents the methodological activities in a semi-sequential order conducted by the two research sub-groups.

See section 4.3 Research units and sampling for more details.

4.2 Participatory development of sustainability indicators, value chain assessment and Sustainability Hot Spot Analysis 2.0 (SHSA 2.0)

4.2.1 Participatory development of sustainability indicators: A focus on smallholders and agricultural systems

The purpose of this subchapter is to review different stakeholder-driven/participatory sustainability assessment methodologies with special focus on the involvement of smallholder farmers. As there are limited approaches to assessing sustainability along value chains in literature, this short chapter further highlights key lessons and recommendations.

Lien et al. (2007) conclude that the varying definitions of sustainability alongside the heterogeneous nature of farming systems make it almost impossible to have a unified methodology for farm sustainability assessments. Moreover, researchers have developed numerous lists of sustainability indicators with little or no consistency across case studies. As such, several approaches to sustainability assessment of agricultural production systems have been developed and remain context specific. The approaches vary based on the objective of the assessment, the selection of indicators, the spatial and temporal scale of the assessment as well as the target audience among others (Ssebunya et al., 2018). Moreover, the different dimensions of sustainability, for example the social, environmental, economic or political dimensions, make it rather complex and have led to the development of different assessment methodologies depending on the focal dimension (Franco, 2021; Janker et al., 2019; Lien et al., 2007).

Literature on sustainability assessments can be broadly categorized into two paradigms: (1.) top-down approaches (expert-led) and (2.) bottom-up (conversational) approaches (Reed et al., 2006). Top-down approaches gained popularity partly in response to development agencies' push for quantifiable indicators that allow for regional comparisons. However, Fraser et al. (2006) note that the approach is marred with potential shortcomings (e.g., the alienation of local communities). Hence, bottom-up approaches have become increasingly important, especially in the fields of agriculture and environmental management. Sustainability is also dependent on sociocultural factors, and -as social and economic systems are key features of sustainability- substantiality is dynamic. This realization makes the use of participatory approaches to capture views from diverse stakeholders not only prudent, but necessary (Bell & Morse, 2004; Bosshard, 2000; Reed et al., 2006).

Many researchers have used participatory methods for sustainability assessments, including the selection of appropriate indicators (Belanche et al., 2021; Coteur et al., 2018; Fraser et al., 2006; Lairez et al., 2020; Reed et al., 2006). Community engagement in sustainability assessment procedures assures the selected indicators are relevant and context specific and evolve with the community over time. Participation leads to empowerment and the built capacity of communities to address emerging challenges within their local environment (Fraser et al., 2006).

Lairez et al. (2020) used participatory methods to capture farmer objectives/priorities for and perspectives of sustainability combined with field-level agronomic monitoring to identify locally relevant criteria for a sustainability assessment of farming systems in Laos. Novel participatory methods used included individual card games (to identify farm-level objectives) and group games (for field-level objectives). The authors concluded that games provide more salient information than traditional household interviews. To capture the researchers' perspective, an agronomic diagnosis was performed on farmer plots selected in a participatory manner using focus group discussions. The researchers then integrated the farmer–scientist perspectives into a final set of sustainability indicators. Lairez et al. (2020) conclude that their mixed-method approach allows for the integration of quantitative and qualitative data which provides a more comprehensive view of farm sustainability. They further purport that their approach is useful for understanding farming system sustainability based on local contexts, as informed by science and practice.

Reed et al. (2006) suggest that letting local communities whose customs/beliefs and values might have contributed to prevailing unsustainable conditions be in control of the assessment may render sustainability assessments futile. The authors further argue that while top-down approaches to indicator selection and assessments may lead to objectively variable indicators, they may be irrelevant and unusable to the local communities. Conversely, they suggest bottom-up approaches tend to yield a very long list of indicators which are rather complex and time consuming (Reed et al., 2006). The authors thus propose a hybrid approach they term as "an adaptive learning process" that provides a delicate balance between the top-down and bottom-up approaches. Their proposed methodology starts with a delineation of the systems boundary (scope) and invitation of relevant stakeholders (based on intensive stakeholder analysis). Next is the participatory establishment of community goals and development of strategies to reach the goals using participatory methods such as focus group discussions and participatory planning and multi-criteria decision analysis (MCDA) (for details about MCDA methodology, see Scott, 2005). This is followed by identification and evaluation of sustainability indicators; the authors advise that this should be a task for all stakeholders. They propose a number of participatory tools when engaging with local communities including focus group meetings and MCDA. The evaluation exercise should lead to the identification of the most appropriate indicators. In the next step, researchers apply scientific methods to validate the indicators and refer back to stakeholders for re-evaluation, making the process iterative (Reed et al., 2006).

Summarized, we find that there is no single perfect methodology for stakeholder engagement in sustainability assessments. Both top-down and bottom-up approaches are common and have their own limitations. A hybrid methodology may provide a suitable alternative to overcome the individual limitations of either approaches. However, sustainability, as a normative concept (Renn et al., 2009) and requires participation to be locally, meaningfully adapted. To ensure maximum engagement of stakeholders especially farmers, the sustainability indicators must be easy to comprehend and collect. With regard to the assessment of the SHS along the potato value chain in the Mt Elgon region of Uganda, the research team should thus make a deliberate effort to refine indicators so that they are comprehensible to the farmers. This should involve translation into the local languages so that farmers have a clear understanding in order to actively participate throughout the whole process.

4.2.2 Value chain assessment tools

Driven by sustainability concerns, multiple tools have been proposed to identify the negative environmental and social externalities of VCs beyond the conventional economic vantage point. They include the Material Input Per Service Unit Analysis (Bienge et al., 2009), Environmental Life Cycle Assessment (ISO 14040, 2006) and Social Life Cycle Assessment (UNEP & SETAC, 2009) among others. Yet, there are few tools documented with the explicit goal for sustainability assessments in value chain.

The Sustainability Assessment of Food and Agricultural systems (SAFA) is one of these tools and can identify trade-offs and synergies in agricultural value chain analysis (FAO, 2014b). The SAFA tool categorizes sustainability into four dimensions: environmental integrity, economic resilience, social wellbeing, and good governance. There are a total of 21 themes (categories) and 58 subthemes (indicators) under these dimensions (FAO, 2014b). The main aim of the tool is to standardize sustainability assessment in food and agricultural systems for comparative purposes. However, the reliance on predetermined themes and subthemes limits stakeholder participation. Additionally, SAFA requires high data input. The SAFA guidelines have been operationalized by the Sustainability Monitoring and Assessment RouTine (SMART)-Farm Tool and used in several sustainability assessment studies, particularly on the production aspects of value chains (Kamau et al., 2021; Ssebunya et al., 2018).

ValueLinks 2.0 is another sustainability manual (a collection of tools, concepts and experiences) developed for the GIZ based on the United Nations sustainable development agenda (Springer-Heinze, 2018). ValueLinks 2.0 is an improvement of ValueLinks which had been criticized for inadequately addressing ecological and social aspects (Schoen & Waeltring, 2019). Springer-Heinze (2018, p. 15-16) describes the tool as "a systematic compilation of methodological knowledge, concepts and tools to inform the utilization of the value chain approach in sustainable development". ValueLinks 2.0 uses a systems approach to analyze value chains from a neutral observer's point of view based on the sustainable development agenda. It uses the GIZ experience in demarcating value chain boundaries, analysis of value chain structure, and sustainability. The tool focuses on the economic growth potential of the value chain determined by market demand and competitiveness (Springer-Heinze, 2018). Environmental dimensions are assessed with focus on the whole product cycle. The potential social impacts are assessed mainly on pro-poor business and employment opportunities. Lastly, the enabling environment (the institutional criteria) is assessed (Springer-Heinze, 2018). The tool emphasizes trade-offs through assigning weights to different dimensions and indicators deemed more important along the value chain. However, since the manual is open and was designed for use in agricultural and non-agricultural VCs (Schoen & Waeltring, 2019), it requires knowledge of other VC assessment approaches to be effectively used. Additionally, although the manual is well researched, its application along the entire value chain while maintaining its pro-poor objectives remains to be seen (Donovan et al., 2015). Moreover, we find that the tool is based on a TBL approach, that is, a weak sustainability approach (cf. Rupprecht et al., 2020; Wu, 2013).

4.2.3 The limitation of status quo and its evolution

Why another tool?

As these technical methods require high levels of expertise, resources, and data, the Hot Spot Analysis (HSA) was developed as a quick, simple, and cost-efficient alternative, particularly for corporate use (Rohn et al., 2014). In a qualitative estimation of the social and ecological impacts of a product's life cycle, it is geared toward informing decision-making processes by identifying key priority areas for action (Liedtke et al., 2010). Initially only looking at resource intensity across VC stages (Wallbaum & Kummer, 2006), the HSA has since been broadened to social aspects and is now often labeled Sustainability Hot Spot Analysis (SHSA) (Bienge et al., 2009).

Sustainability Hot Spot Analysis (SHSA)

In its existing version promoted by the Wuppertal Institute for Climate, Environment and Energy (Bienge et al., 2009), the SHSA is conducted in five steps. First, the VC stages (life cycle phases) are defined. These stages might include raw material extraction, production, aggregation, processing, distribution, consumption, and waste, but are usually limited to four or five phases.

Second, the relevance[8] of these categories in each VC stage is assigned as inapplicable (scored 0), low (scored 1), medium (scored 2), or high (scored 3). Third, the impact (i.e., relevance) of the phases are determined against each other on the same scale. Fourth, the ratings of steps two and three are multiplied to identify sustainability hot spots, which now have a minimum score of six (3x2) or a maximum score of nine (3x3). Fifth, stakeholders and experts review and validate the results. Apart from the stakeholder review, all steps are based on a literature review and occasional individual expert interviews.

Limitations of existing SHSA

The SHSA does not include economic, political, or cultural categories. It is limited in its categories and lacks empirical depth as those using the tool rarely collect data, rely mainly on literature review, and only include VC stakeholders in validation, if at all (Bienge et al., 2009; Lam et al., 2013; Liedtke et al., 2010; Rohn et al., 2014). Relevance and impact assessments are often aggregated and amalgamated to entire VC stages, category clusters, or even dimensions, leading to generic and imprecise assessments (e.g., entire VC stages receive a single relevance score, (Rohn et al., 2014)). Positive externalities and synergies (see section 3.2) are blind spots. Moreover, a sustainability assessment through SHSA is not, per se, participatory. To facilitate participation and to include evidence-based indicator assessments based on both primary and secondary data, we suggest the Sustainability Hot Spot Analysis 2.0 (SHSA 2.0).

Suggestion to overcome limitations: Sustainability Hot Spot Analysis 2.0 (SHSA 2.0)

SHSA 2.0 is intended to cover economic, political, and cultural categories. It derives a multitude of categories informed by agroecology (HLPE, 2019) and major existing sustainability assessment tools (UNEP & SETAC, 2009)[9], which are measured through indicators fed by (partly participatory) methods.

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8 The Wuppertal Institute uses the term significance. We decided to use the term relevance instead to avoid confusion with statistical significance. Relevance, i.e. importance, as used in our SHSA, does not refer to the OECD DAC evaluation criteria.

9 To define the categories, NAMAGE built on agroecological principles (FAO, 2018b; HLPE, 2019) but enriched them with elements of VC promotion. For instance, as VC promotion seeks economically sustainable outcomes, the categories "commercial viability" and "economic benefits for all stakeholders" were included in the economic dimension in addition to economic diversification and connectivity. This is also reflected in the decision to integrate "inclusion" as the equity in the distribution of economic value added in the VC in the social dimension as sustainability category. Furthermore, in the social dimension, NAMAGE deliberately added the category "agency" to account for power

The relevance (significance) and impacts are not aggregated but assessed for each individual category at each individual stage of the VC (see Fig. 4). SHSA 2.0 also accounts for trade-offs and potential synergies if they appear in the data or synthesis of our results.

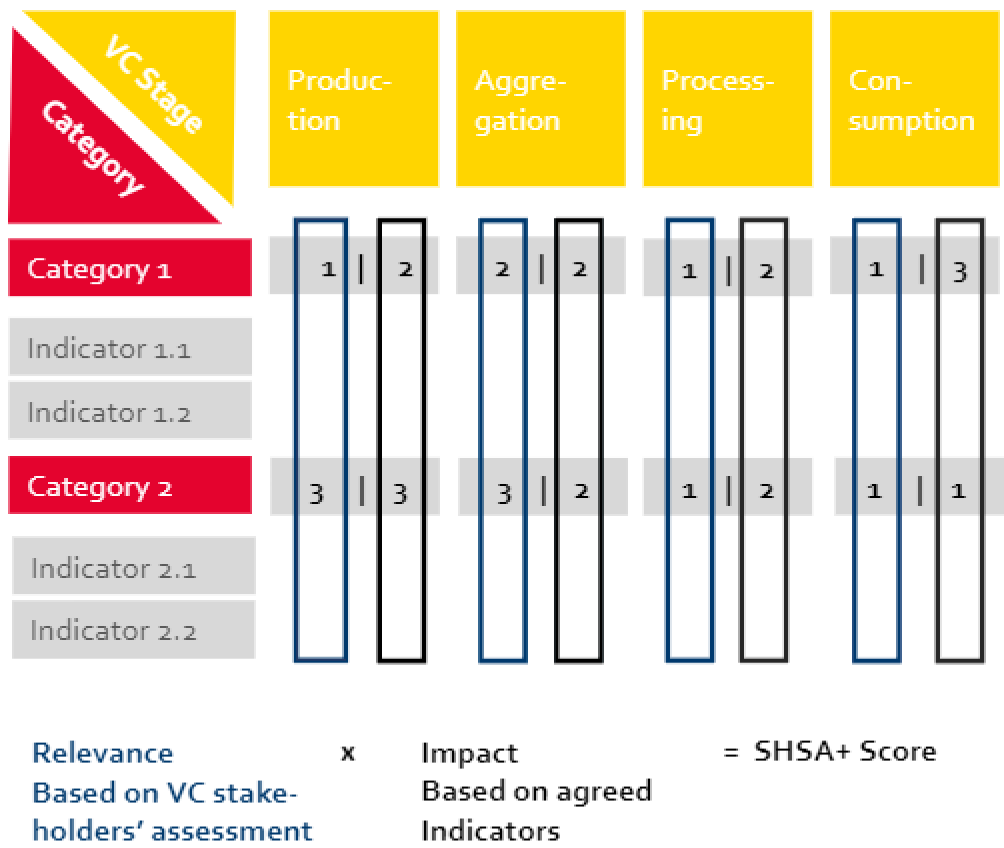

Figure 5: Example of SHSA+ matrix and derivation of score

Source: Own illustration

The research process was mainly participatory. While a list and the definition of categories were provided to stakeholders by the NAMAGE research team (see Annex 3), they were free to add categories and add to the definition. Also, the selection of indicators was done jointly with VC actors and other stakeholders based on a preliminary and comprehensive series of indicators generated by us. This list was informed by literature review and data collected during the exploratory

structures/imbalances in food VCs. In the environmental dimension, two categories were included, i.e., water and carbon footprint, as they cover important sustainability aspects.

phase (for a full list of collected indicators, see Annex 4 for the potato VC and Annex 5 for the fish VC).

SHSA 2.0 looks at more than 20 sustainability categories in three overarching environmental, social, and economic dimensions. Political and cultural categories are integrated in the social dimension.

The categories, which were derived from agroecological principles (see Table 1) and the objectives of VC promotions (for e.g., commercial viability, equity in the distribution of economic value added), could be reduced or new ones could be added by VC actors and other stakeholders implicit in step 2 (see Figure 4). During this step, VC actors and other stakeholders (experts and key informants) individually scored the relevance of the determined categories at each step of the VC (see section 5.3.1 for the scored relevance along the potato VC and 6.3.1 for the fish VC). VC actors and stakeholders agreed on indicators to determine the impact assessment of the category (step 3 in Figure 4).

Subsequently, we decided on appropriate methods to assess the selected indicators and data acquired on them (see section 4.2.2). Data on indicators was condensed to a single impact score for the categories at the selected VC stages (step 4 in Figure 4). Finally, once the SHS were identified, stakeholders validated and gave feedback on findings and suggested recommendations and potential solutions for addressing these hot spots in workshops.

4.3 Research units and sampling

VCs often consist of actors along five stages: production, aggregation, processing, distribution, and consumption (FAO, 2014). In the Irish potato VC, these include seed multipliers/suppliers, farmers, middlepersons, traders, processors, distributors, and consumers. In the Nile perch VC, these include input providers, fisherfolk, middlepersons, artisanal and industrial processors, by-product processors, exporters, local distributors, and consumers.

Figure 6 presents these central VC actors in its inner circle as the survey units. The middle circle depicts supporting actors along the VCs as well as direct collaborators and partners in the current study. The outer circle encompasses actors contributing to the institutional, regulatory, and policy framework. The strategies to sample the actors along the VCs differed between the potato research team and fish research team (see below).

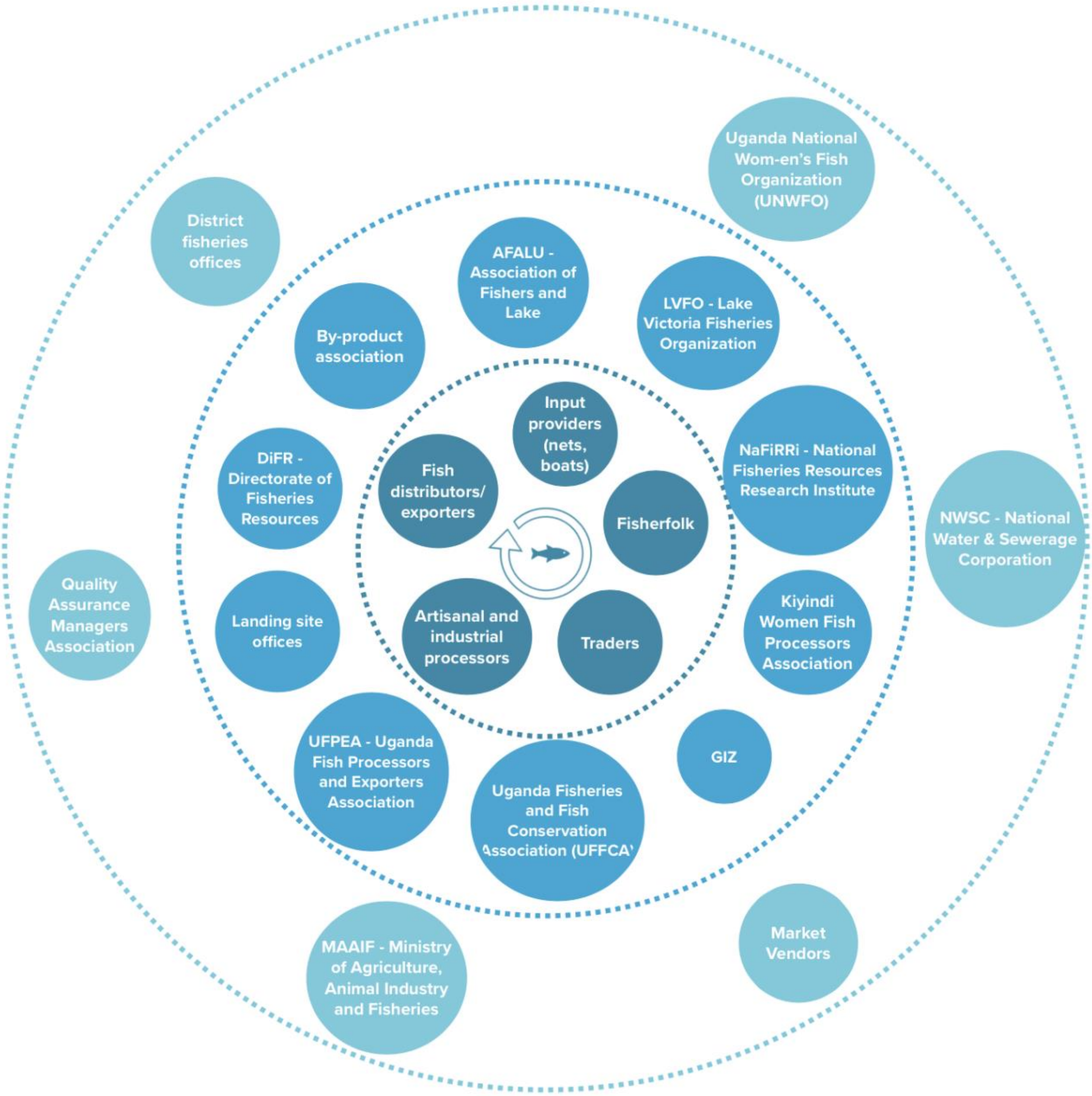

Figure 6a: Survey units, direct and indirect collaborators in the Nile perch value chain

Source: Own illustration

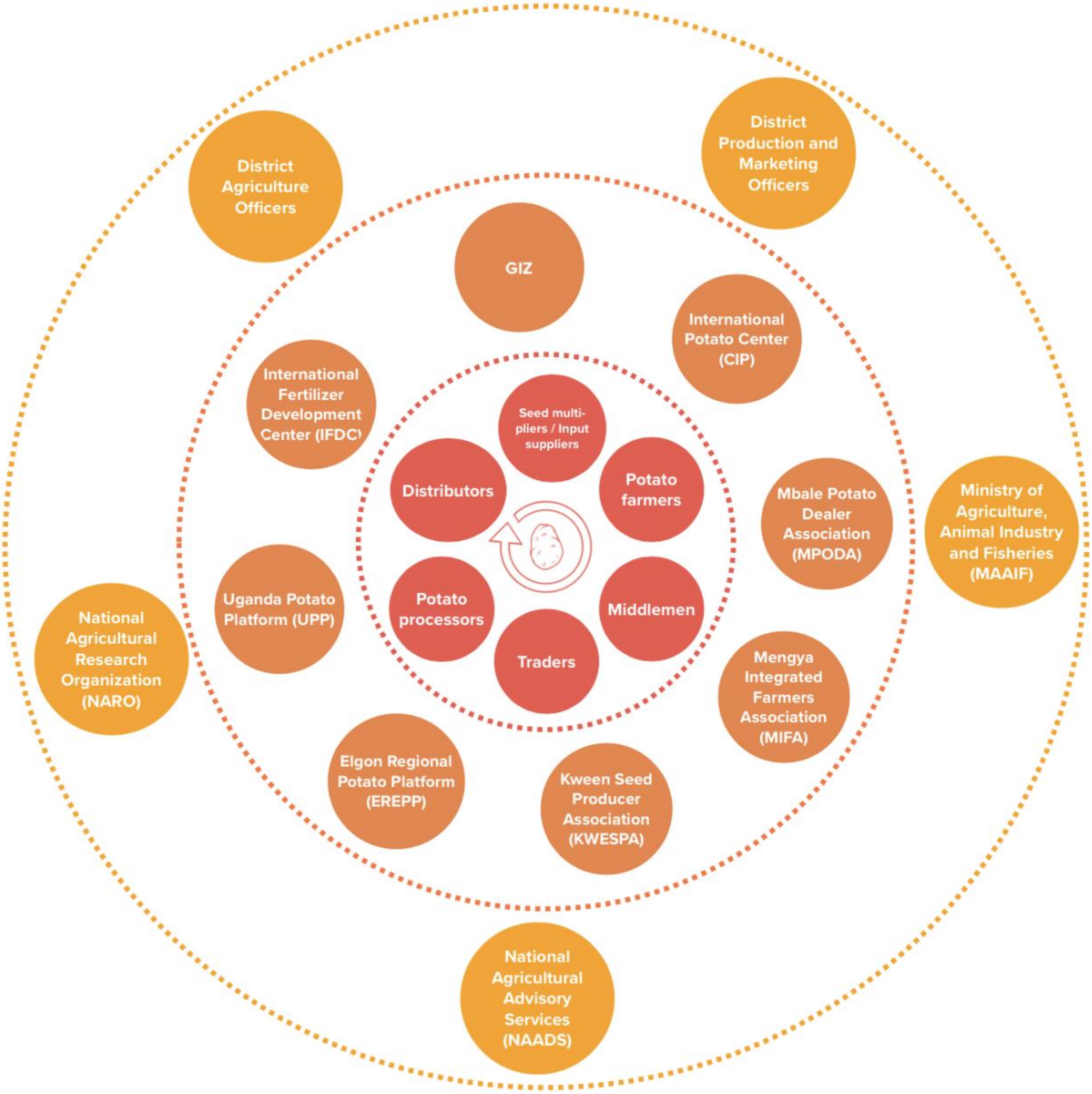

Figure 6b: Survey units, direct and indirect collaborators in the potato value chain

Source: Own illustration

4.3.1 Sampling of actors along the Irish potato value chain

Farmers

We selected potato farmers based on a stratified random sample. To do this, we used a potato farmer survey done in 2020 by IFDC (partial results published in IFDC, 2020; IFDC, 2021) which included ~500 potato smallholders in the Mt. Elgon area. The IFDC target farmers lived in the districts of Mbale, Kween, and Kapchorwa (see Figure 8). Preliminary analysis of the IFDC survey data showed that there are differences between the three districts in key production metrics such as field sizes, potato harvest yields, as well as farmgate prices (see Annex 6). We designed a village selection that equally covers the three districts.

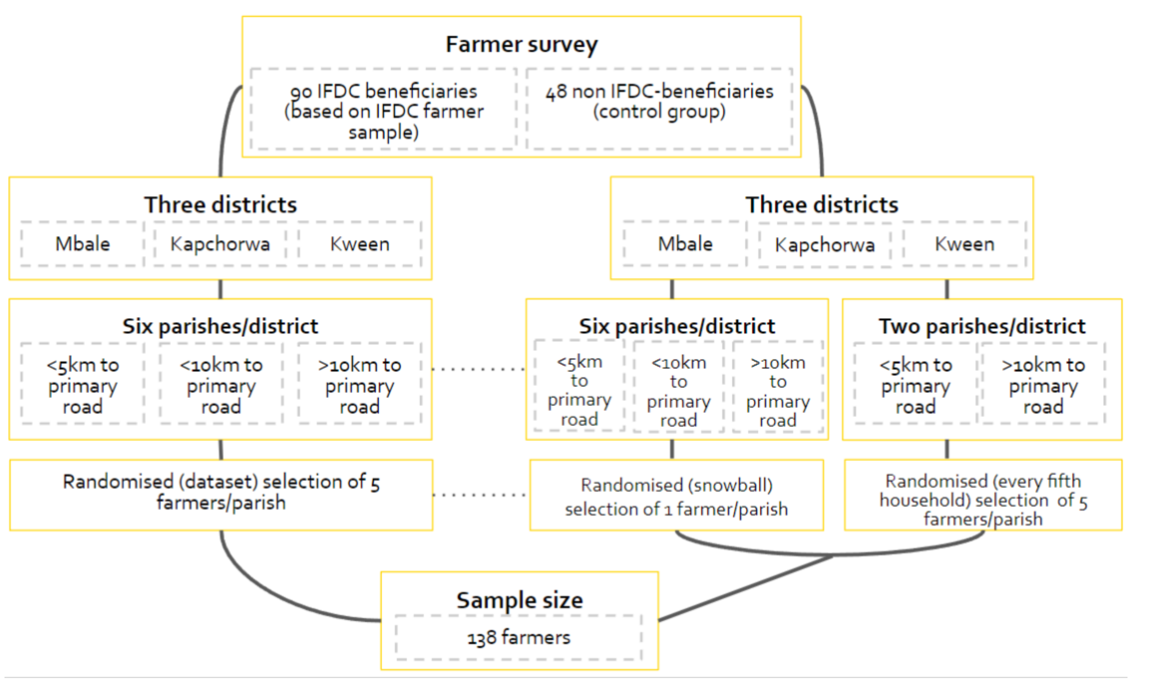

Figure 7: Farmer interviewee selection from the potato VC

Source: Own illustration

In each of the three districts, participants from six parishes[10] were invited to take part in the survey. The parishes were selected based on their proximity to the nearest primary (tarred) road. In each district, two parishes close to the primary

10 Parishes are administrative units. They were used instead of villages, as IFDC and GIZ use parish as a unit to gather farmers. Also, extension workers are responsible for covering different parishes.

(tarred) road (<5km) were selected, two parishes that were a medium distance (<10 km), and two that were rather far (>10 km) were randomly selected, leading to a total of 18 parishes (see Annex 7). Subsequently, in each parish 5 potato farmers were randomly chosen from the IFDC dataset leading to a total of 90 IFDC farmers surveyed. All farmers were given random numbers and we chose the 5 farmers with the highest random number. If one farmer was not available/could not be found, we replaced him/her with the next highest random number. In each parish, five potato farmers were randomly chosen from the IFDC dataset, leading to a total of 90 IFDC farmers surveyed. All farmers were assigned random numbers and we chose the five farmers with the highest random numbers. If a farmer was unavailable/could not be found, we replaced them with the next highest random number.

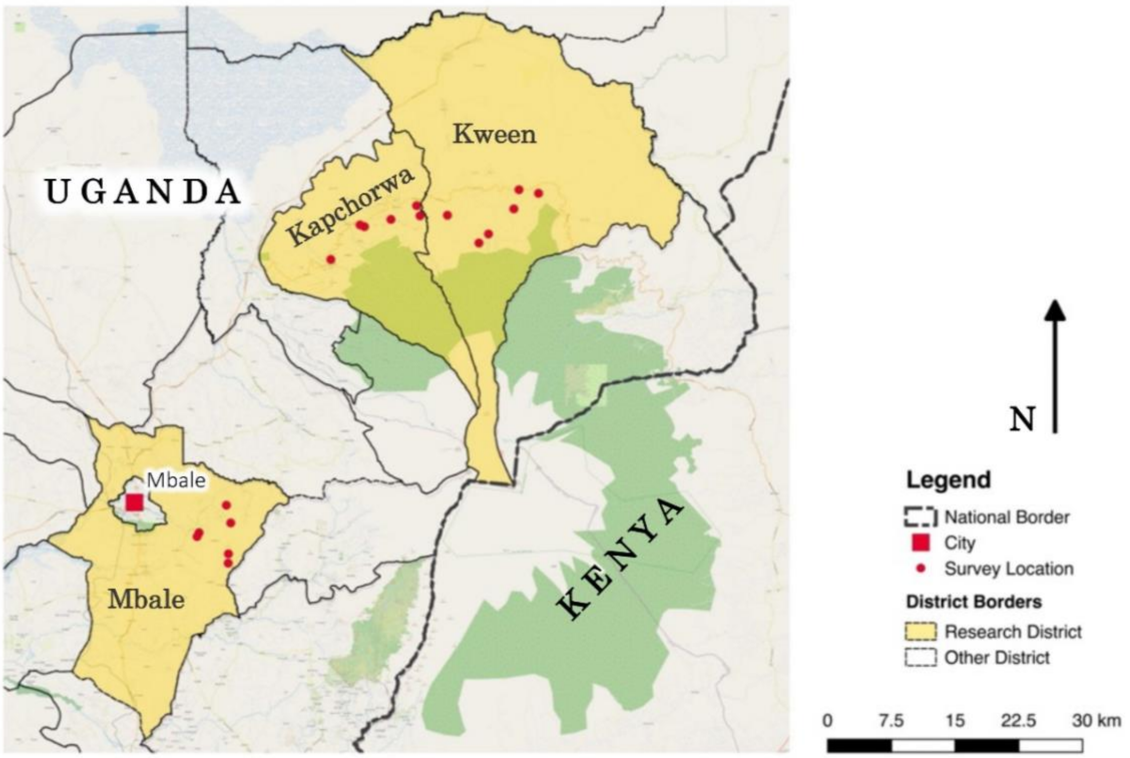

Figure 8: Study region for potato value chain and farmer survey

Source: Own illustration (QGIS)

Yet, as we were also interested in farmers who are not IFDC beneficiaries, we also established a control group of 18 non-IFDC farmers (one farmer per parish). Because inhabitant lists of non-IFDC farmers were unavailable, we asked each third IFDC farmer in our selection list to nominate a neighbouring farmer who grew Irish potatoes and was not an IFDC program beneficiary.

Additionally, we determined a second control group. In each of the three districts, two parishes were randomly chosen among the previously selected ones. Within those parishes, one non-IFDC village was purposely selected leading to a total of six non-IFDC villages. In each district, we choose one non-IFDC village that was close (<5km) to the primary (tarred) road and a second one was further away (>10km) (see above). Due to the lack of available data, the identification of these villages was supported by regional extension workers in the respective districts. Hence, five farmers in each village were randomly selected by systematically choosing every fifth house in the village, leading to a total sample of 30 households in this control group. Preconditions for the selection was that the households grew Irish potatoes and that they were not IFDC program beneficiaries.

The reason for adding control groups to our sample was that we did not know which criteria were used to select farmers and/or villages for the IFDC program and what role farmer groups (cooperatives and associations) played. In fact, self-selection and other selection biases are common in such interventions as farmers might have insufficient capital, resources, and/or interest to participate (Ito et al., 2012). Consequently, key variables of interest that we hypothesize to differ between IFDC and non-IFDC farmers (such as total potato production, potato and off-farm income, access to extension services, market price information, financial services and storage facilities, use of quality seeds, monthly savings, and farmer groups) receive special attention and differences between them are investigated.

Thus, in total, we interviewed 138 farmers. Among those, 65 % were IFDC beneficiaries and 35 % were not.

Input providers/Aggregators/Traders/Processors/Distributors

As an entry point to contact input providers, aggregators, traders, processors and distributors, we contacted the Uganda Potato Platform (UPP) which brings together key stakeholders active in the Ugandan potato sector[11]. UPP's goal is to improve the Ugandan potato VC and to link actors working with potatoes. Likewise, a regional representative body, the Elgon Regional Potato Platform (EREPP) aims to bring together regional stakeholders.

Early during the research process, the research team participated in a UPP conference in Kampala and was introduced to its national members. With support from the UPP, we followed a snowball sampling approach to establish contact with these VC actors. Similarly, a meeting with EREPP was organized early in the

11 See https://ugandanationalpotatoplatform.wordpress.com

research process. The UPP and EREPP key informants aided in a snowball approach to identify respondents, members, and non-members of the platforms (Angelsen et al., 2011).

4.3.2 Sampling of actors along the Nile perch value chain

Landing sites and fisherfolk

To identify SHS along the Nile perch value chain, six landing sites were selected from four districts (see Figure 9). The selection criteria were:

1. economic variety of districts in terms of target market orientation (export or local market) and degree of commercialization,
2. the status of the landing site (gazetted[12] or non-gazetted) and
3. the location (mainland and island).

In Mukono (fishing district), the gazetted Kiyindi landing site was selected. Kasenyi located in Wakiso (trade-oriented district) and Nakatiba in Kalangala were also included as gazetted landing sites. Among the non-gazetted landing sites, Masese and Kisima 1 from Jinja district and Nyoga in Kalangala district were chosen. Three landing sites were selected from the mainland (Kiyindi, Kasenyi, and Masese) and three from islands (Nakatiba, Kisima 1, and Nyoga).

Island landing sites were of particular interest because they have less infrastructure and fish have to be collected then transported via ferry or transport boats to factories or other landing sites. The shores of smaller islands in Lake Victoria are very good breeding grounds for Nile perch due to low human interference (KA4).

As part of our field research, we created a checklist for the landing sites criteria: management levels (e.g., existing record keeping on fish catches by fishery inspector), hygienic standards (use of coats, rubber boats, sinks, fenced area, etc.), infrastructure (existence of weighing station, ice plant, trucks, and electricity), and social facilities (proximity to hospitals, schools). This allowed us to compare the landing sites beyond the categories "gazette" and "non-gazetted".

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12 Gazetted landing sites are specialized landing sites, which fulfil higher hygienic standards, provide more advanced landing and supervision facilities (e.g., roofed area, sinks, truck ramps, fishery inspector, etc.) and are mostly used for the export-oriented fish handling. Therefore, they are particularly important for the trade and transport flows of Nile perch to factories.

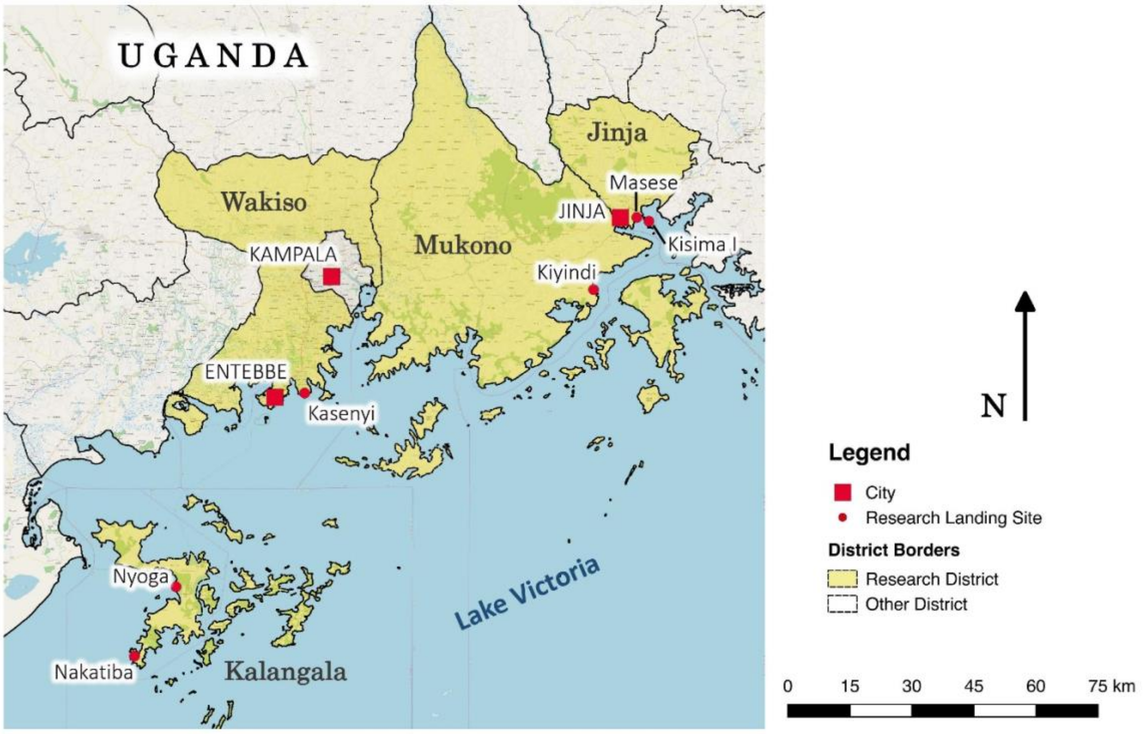

Figure 9: Study region for the Nile perch value chain

Source: Own illustration (QGIS)

To sample actors at the landing sites like fisherfolk, traders, or artisanal processors, an overview of the interactions between value chain actors was elaborated and key roles (such as maw trader, fisher, factory agent) were identified prior to establishing interviews and focus group discussions. Criteria such as gender were considered in our selection of key actors to account for gender disaggregated fishing-related tasks along the value chain. As we could not cover every field of responsibility at every landing site, we identified beforehand which actors would be of special interest in relation to the characteristics of the landing site. For the selection of these actors, the advice of a fisheries inspector or fisheries officer from the respective landing site was sought. For the FGD, this person mobilized a diverse group in relation to age, role, and status in the VC and their work. Focus groups were, thus, conducted either with male fishers or women who are involved in artisanal processing.

Other Actors

For other actors (industrial processors, distributors, authorities, researchers, and fishing organizations), we followed a snowball approach, using key informants to identify local respondents, particular distribution and processors (Angelsen et al., 2011). The first stakeholder workshop was a key event, because participants provided additional contacts, were informed about the aim of the research, and contributed to the method development. Interviews conducted during the exploratory phase (e.g., with the GIZ in Jinja) also helped identify other key stakeholders.

Stakeholders invited to the workshop were selected to cover national to local levels, a variety of perspectives (economic, social, political, and environmental), and a variety of activities and roles along the value chain. Among the 17 selected participants were representatives of institutions and organizations such as the National Fisheries Resource Research Institute (NaFIRRI), the Uganda National Women's Fish Organization (UNWFO), and the Association of Fishers and Lake Users of Uganda (AFALU) as well as direct VC actors like fisherfolk, a fish maw trader, and a salesperson from a local market (for an overview of the participants and their roles (see Annex 8).

4.4 Methods for data collection

For both VCs, we used a mixed-method approach including literature review, FGDs, PhotoVoice, semi-structured interviews, and quantitative surveys. Semi-structured interviews were conducted with people with unique knowledge in our area of research as well as value chain actors with specific knowledge about their work, e.g., fishers and potato traders.

Stakeholder workshops and farmer/fisher workshops were conducted during the SHSA 2.0 for both VCs to score categories, rank indicators, validate results, and seek feedback from participants. Noteworthily, assessment of indicators (after participatory scoring and category selection) was conducted using slightly different empirical methods for each VC (see Figure 4). This is further described below.

4.4.1 Exploratory phase (focus group discussions, key informant interviews, and PhotoVoice)

To understand the livelihoods of potato farmers in the Mount Elgon region, we conducted a preliminary assessment in the form of a PRA. More than 40 farmers participated in five FGDs, two of which were exclusively with women. We used simple ranking methods to address the questions: What are your biggest livelihood challenges? What are the most important development obstacles in potato production and in the community? What is needed to overcome these challenges (see Annex 9)?

In total, seven key informants and value chain actors shared important insights into the regional potato VC during semi-structured, open-ended interviews. These included the chairs of EREPP and Mbale Potato Dealer Association; the Production and Marketing Officers of Mbale, Kween, and Kapchorwa districts; and value chain actors. Interviews were also conducted with the Seed Production Officer of the National Agricultural Research Organisation (NARO) and the Crop Development Officer of the National Agricultural Advisory Services (NAADS) (see Annex 10).

Focusing on fishers' livelihoods, a similar approach was taken at landing sites. We conducted eight qualitative in-depth interviews with key informants and specifically elicited responses about sustainability challenges that fisherfolks face, positive aspects of their work, past developments of the Nile perch VC, and their vision for its future. Many questions were oriented to their daily work to better understand fisherfolks' livelihoods, their roles, and connections in the value chain. Qualitative interviews in the exploratory phase were not only limited to VC actors such as a maw trader, boat owner, and fisherfolk, but also included two Landing Site Officers and two managers from the GIZ in Jinja (see Annex 11). One FGD was conducted with 15 fishers to address the questions: How has fishing changed in the last ten years? What are the three main challenges in your work? What is your daily/weekly income? (see Annex 12).

For both potato farmers and fisherfolk, we used the PhotoVoice method (Wang & Burris, 1997) which allows researchers to "create a relationship with a group or community with a view to working together to generate new knowledge"(Jarldorn, 2018, p.12) . In a first step, participants take photos to answer specific questions. In a second step, they analyze and reflect on their data in a discussion (Jarldorn, 2018). We wanted rural farmers/fisherfolk to capture their daily realities in the context of their farming/fishing activities and share their understanding of sustainability and what they consider valuable in relation to their work. The questions that guided the PhotoVoice activities were:

- What is important for you, as a potato farmer/fisher/fish trader/processor?
- What is important for your (fisherfolk/farming) community?
- What are your hopes for the future of your work?
- What are your hopes for the future of the potato sector/fishing sector?

Figure 10: PhotoVoice introduction (left) and PhotoVoice participant's photo of lakeshore (right)

Source: Eva Kirmes and a PhotoVoice participant (of the Nile perch VC)

In the Mt. Elgon region, we employed the PhotoVoice method with seven potato farmers. At Lake Victoria, we used PhotoVoice with three fishers, one salesperson from the local market in Jinja, and a member of an artisanal women fish processors association in Kiyindi (see Annex 13). Participants attended a briefing session where we explained ethical and technical aspects of photographing and the expected timeline, answered questions, and distributed digital cameras. In a second meeting, the participants shared the photos they took and explained their reasons of choosing them as responses to the given questions. The photo presentation and discussion were conducted in groups with other farmers or fishers and individually with the salesperson and the artisanal fishing representative.

The explorative phase followed a transdisciplinary approach and involved mainly non-academic actors. It was key to contextualise and adapt our research to the observed reality, particularly in the development of sustainability hot spot indicators.

4.4.2 Stakeholder workshops for relevance scoring and indicator selection

To score the relevance of categories in the potato VC, four stakeholder workshops were held. One workshop was conducted with 13 UPP members, including some EREPP members, and took place in Kampala. The other three workshops were conducted with potato farmers in the districts of Mbale, Kween, and Kapchorwa, with a total of 19 participants. Farmers selected were IFDC program beneficiaries as well as representatives/members of farmers groups. The identification of the participants was supported by district extension workers.

During the stakeholder workshops, the method (see 4.2 SHSA 2.0) and 21 pre-selected categories (see Annex 3) were presented to the participants. The categories were distributed as follows: eight in the environmental dimension, eight in the social dimension, and five in the economic dimension. Each stakeholder was invited to individually evaluate the relevance of the categories within each VC stage by giving a score: 0 =n.a./do not know, 1 = low relevance, 2 = medium relevance, 3 = high relevance. Stakeholders were able to add and agree on new categories that were thought to be overlooked in the list suggested by the NAMAGE research team.

Subsequently, we aggregated all relevance scores per category and calculated the mean. Only categories with at least a mean value of 2.0 were considered for further analysis as categories scored below that cannot become a sustainability hot spot (Rohn et al., 2014). However, as all the categories in the social and economic dimensions scored higher than 2.0 during the stakeholder workshop, we adjusted the procedure. We prioritized the number of the highest relevance scores equal to the product of "no. of categories per dimension x 2". For example, the categories scored in the social dimension were eight. Hence, we multiplied 8 x 2 and selected only the 16 highest relevance scores for assessment in the following step. Table 2 in the results provides a summary of all relevance scores.

Subsequently, we identified and proposed a list of 120 indicators for the selected categories (see Annex 4). We asked VC actors and stakeholders to rank these indicators in descending order according to their importance in the potato VC. The format of this activity was an online survey, which was sent to UPP members, EREPP members, other VC actors as well as non-platform members from the Mbale, Kween, and Kapchorwa districts. A total of 24 respondents completed the online survey. As a result of this activity, 38 indicators (two indicators/category) were chosen across the production, aggregation, processing, distribution, and consumption stages.

The selected indicators were subsequently assessed and data was collected through quantitative and qualitative methods as well as literature review (see step 4 in Figure 4), as presented in the following subsections.

Figure 11: Workshop with Nile perch value chain stakeholders (left) and Irish potato farmers (right)

Source: Hendrik Hänke and Jasmin Ahmed

Concerning the scoring and ranking of categories and indicators for the Nile perch VC, a slightly different approach was followed. A refinement of the categories and indicators identified during our preparation period in Berlin was made based on new data acquired during the exploratory phase. As such, each indicator in each category was discussed by the researchers and new indicators were added and others were deleted. We created a new table of relevant indicators and categories which served as the basis for the stakeholder workshop (see Annex 5).

The first Nile perch VC stakeholder workshop was conducted following the exploratory phase and included actors from the Nile perch value chain to fulfil our aim of implementing a participatory research approach. After an introduction to the method, the stakeholders were taken through the eight environmental dimension categories, the seven social dimension categories, and the five economic dimension categories (see Annex 3). Once a common understanding of every category was attained, the stakeholders were asked to individually score the relevance of each category for each of the five value chain stages. The results were digitized and an average relevance for every category in each value chain stage was determined. Only categories with an average score of at least 2.0 were marked as relevant because they could become sustainability hot spots (Rohn et al., 2014).

Indicator selection was performed during the second part of the workshop with the same stakeholders. Participants were split into three groups and assigned one of the three dimensions of sustainability (environmental, social and economic) according to their expertise while also accounting for different perspectives within each group. Every group discussed the indicators that we proposed, deleted some, created others, and made priorities for the agreed upon indicators for each category. As a result of this activity, 67 indicators were selected across the production, aggregation, processing, distribution, and consumption stage (see Annex 5).

4.4.3 Indicator assessment

Semi-structured interviews

In total, we conducted a number of semi-structured qualitative interviews (15 with potato VC actors—except farmers and 31 for Nile perch VC actors (see Annex 10 and Annex 11). These interviews were slightly adapted to VC stages and the actors' knowledge.

From the potato VC, middlepersons, traders, input providers, processors, and researchers were interviewed. From the Nile perch VC, three maw traders, three fisheries inspectors, two factory fish traders, two fishers, one boat builder, one boat owner, two fish mongers, and representatives from associations, government agencies, and research institutions were interviewed.

All interviews were recorded, transcribed, if necessary, translated into English, and coded using the software MAXQDA (Version 20.4.2).

The purpose of these semi-structured interviews was to empirically assess the indicators selected for the aggregation, processing, distribution, and consumption stages (see section 5.3.3 for the potato VC and 6.3.2 for the Nile perch VC).

Focus group discussions with fisherfolk

We had positive experiences with using FGDs for data collection during the exploratory phase; as such, we opted to use this technique for indicator assessment in the Nile perch VC too. We aimed for one FGD per selected landing sites and managed to conduct five FGD over the period of the indicator assessment. Five to eight people participated in each FGD and each participant joined a short additional individual survey. Four FGDs were conducted with fishers as main actors of the production phase and compare gazetted and non-gazetted landing sites. Additionally, one FGD was conducted exclusively with women engaged in artisanal processing at the Kiyindi landing site through the Kiyindi Women Fish Processors

Association. Questions included environmental, social, and economic questions with a focus on agency, fairness, participation, economic benefits, and resilience.

Figure 12: Interview with a potato value chain stakeholder (left) and a Nile perch value chain stakeholder (right)

Source: Flavia Marà and Joanita Kataike

Quantitative potato farmers/fisherfolk surveys

A quantitative survey was conducted among 138 potato farmers (65 % IFDC beneficiaries, 35 % non-IFDC beneficiaries). The survey addresses household composition, potato production, sales and challenges, farming practices, agroecological practices, livelihoods, farming economics, income, access to extension services, and other (see Annex 14). The surveys were done on tablets equipped with the software KoboCollect from KoboToolbox[13]. The goal of the survey was to empirically assess potato production-related indicators (see step 4 in Figure 4).

Of the fisherfolk in the Nile perch VC who participated in FGDs (n = 36), a complementary quantitative survey was done on tablets with the KoboCollect application. Questions addressed access to resources (boats, fishing gear, fuel), economic resilience (through insurances, contracts, financial services), income, as well as fish consumption habits (see Annex 15).

13 See https://www.kobotoolbox.org

4.4.4 Validation / Feedback workshops

As a final activity, we organized separate validation/feedback workshops for Irish potato and Nile perch VC stakeholders at the end of the research phase in Uganda. The workshops took place in Mbale (for potato) and Kampala (for Nile perch). In the potato workshop, 20 actors participated, including EREPP, local district agricultural officers, the head of UPP, the International Potato Centre (CIP), and the GIZ. In the Nile perch VC workshop, 17 stakeholders participated. Participants were the same as for the first stakeholder workshop allowing the participants to link validation with previous category and indicator selection and relevance scoring.

The goal of the workshops was to present and discuss findings on the major SHS identified along the two VCs in Uganda and discuss potential recommendations (see Annex 16 and Annex 17).

Figure 13: Potato VC actors participating in the validation workshop

Source: Flavia Marà

The participants' recommendations were complemented with recommendations from the research team and developed using a two-step process. In the first step, an adapted version of the PEST analysis was conducted, assessing the political/administrative and technical feasibility as well as the economic, ecological, and social impact of the suggested recommendations. The highest ranked recommendations were adjusted and merged to five recommendations for the Irish potato value chain and six for the Nile perch value chain and analyzed using the SWOT approach (strengths, weaknesses, opportunities, and threats) before policy recommendations were drafted (see Annex 18).

4.5 Research ethics

We respect the privacy and confidentiality of participating stakeholders and research fellows. The research team always asked for consent to participate and provided information on the research project to the participants. A consent form (see Annex 19) was presented to each respondent.

Also, we did our best not to interfere in private spaces. The security and personal wellbeing of everyone was our first priority, especially in regard to the Covid-19 pandemic. Face masks, hand sanitizer, and Covid-19 rapid tests were freely available and distributed in interviews, focus groups, workshops, and other meetings.

Since we were visitors in rural regions and cooperated with farmers and fisherfolk, we regarded them as experts and tried to prevent Eurocentric notions of results and intrusion into their space. We strived to discover and share their knowledge without promoting inequalities within the local communities.

Do-No-Harm Approach

To reflect on our own positionality, we followed the "Do No Harm Approach" (Anderson, 1999). The Do No Harm Approach is a tool that aims to increase conflict sensitivity mainly in the context of international cooperation programs (Projects., 2016). It includes an understanding of the context, especially the relationships of the involved actors and situates the proposed project within this context, considering that negative aspects should be reduced as much as possible (Collaborative Learning Projects, 2016).

The analysis was done by the Ugandan and SLE researchers jointly based on the findings of the exploratory phase. In a first step of the context analysis, we looked at different interest groups and conflicting topics among the different actors of the VC. In a second step, aspects that may divide the different groups or cause tensions were emphasized in contrast to the third step that gave attention to connecting identified aspects and local capacities. The fourth step analyzed the nature of the project (Who is working with whom? Who takes decisions? What is provided and how is it distributed?) and the fifth step searched for the impact of the project on the dividers and connectors that were identified in steps two and three (Swiss Agency for Development and Cooperation, 2006). If this approach were to be applied in the context of project implementation, a sixth step (consider options if potential harm is identified) and seventh step (test the options) would have had to be taken. For us, in the research setting, we used this tool to sensitize ourselves to the context and identify strategies for action, for example, in reaction to a positive Covid-19 test result or incidence of potentially controversial topics like corruption or illegal activities.

Consequently, we conducted feedback rounds of our own actions during the research process, especially within the explorative phase. We applied the steps to the context of the Nile perch VC and identified potential risks of unintended side effects of the research (see Textbox 1 in section 6.1).

5 Results: Irish potato value chain

5.1 Exploratory phase

This section presents data collected during the exploratory phase through FGDs, key-informant and in-depth interviews, and PhotoVoice, as part of our PRA approach.

Farms in Kapchorwa, Kween, and Mbale show remarkable diversity, including a great number of different crops such as Irish potato, plantain, maize, yams, millet, sweet potato, pumpkin, cassava, and eggplants among others. Irish potatoes, plantain, beans, and maize were the reported main crops for home consumption, especially in the Mbale and Kween districts. Crops like plantain also provide fodder for livestock. The main cash crops for the communities include Arabica coffee, Irish potato, plantain, onions, beans, cabbage, and tomatoes. Some farmers use farmyard manure from their livestock in addition to inorganic inputs like fertilizers and pesticides. Farmers mentioned their lack of knowledge about the selection of suitable agricultural inputs and their appropriate application. The most common inorganic fertilizers used are urea, NPK, DAP, and CAN which are sold at about 140,000 – 190,000 UGX/50 kg in Mbale (39.2 – 53.2 USD).

The average land size per household is ~0.7 acre (0.3 ha) (unpublished IFDC survey data, 2021) and usually family owned. Yet, in most cases the man is normatively considered the head of the household, main decisionmaker, and owner of the land. It is only upon death that land is transferred to other family members, normally to the oldest son. Some households depend on leased land for potato farming with an acre of land leased at ~200,000 UGX ($56.5 US*)* per year. Most farmers rely on seasonal hired labor in addition to family labor. While land ownership is mainly male dominated, both men and women work in the field, with women being particularly involved in sowing and weeding[14]. Potato is a dual-purpose crop for both home consumption (10 – 30 % of the yield) and cash cropping (70 – 90 %). Potatoes, (usually boiled) are an integral part of these farmers' daily diets. The proceeds from crop sales, including potatoes, are reportedly used to buy land and livestock, pay school fees, and improve housing conditions.

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14 During the FGDs with women, several female farmers mentioned lack of cooperation within the household, especially with regards to the use of household income derived from the sale of potatoes. They reported that this sometimes leads to disagreements and domestic violence. Additionally, women farmers complained of men selling all their potatoes without leaving any for home consumption, which compromises household food security.

Figure 14: Potato affected by bacterial wilt and storage facilities identified as key issues

Source: Hendrik Hänke and a PhotoVoice participant

Besides farming, other farm income-generating activities (livestock rearing) as well as off-farm income sources are common, e.g., selling general merchandise in shops, "boda boda" business (motorbike taxis), tailoring (particularly among women), brickmaking, and employment in the civil service.

Lack of permanent housing structures as well as water and electricity access were mentioned as key livelihood constraints.

Virtually all farmers are organized in farmers or women's groups whose main activities include knowledge exchange, cooperation in purchasing and sales, periodic savings, and credit access for group members (up to 10 % /month interest rates). However, access to credits remains limited in our study region, since the maximum amount given to an individual is limited to twice the amount of his or her share capital within the group.

Major potato farming challenges mentioned by farmers were diseases like bacterial wilt and late blight, lack of storage facilities, lack of irrigation systems, and low market prices for potatoes. Suggested solutions included the constructing adequate storage facilities, accessing affordable quality seed, and improving road conditions. Given the challenges faced, interviewed farmers expressed their wish for future generations to be absorbed into the formal sector and to farm as a mere side business.

5.2 Analysis of the Irish potato value chain

The data presented in this chapter stems from triangulation of quantitative and qualitative data including results from FGDs, semi-structured interviews, and farmer surveys as well as secondary sources.

By analyzing the Irish potato VC in Mt. Elgon region, we identified the connections between actors and processes and the challenges and constraints at each distinct levels of the VC. Figure 15 below illustrates the actors involved in each VC stage, their linkages with other VC actors, and the product flows, i.e., ware potatoes, chips, and crisps in the study region.

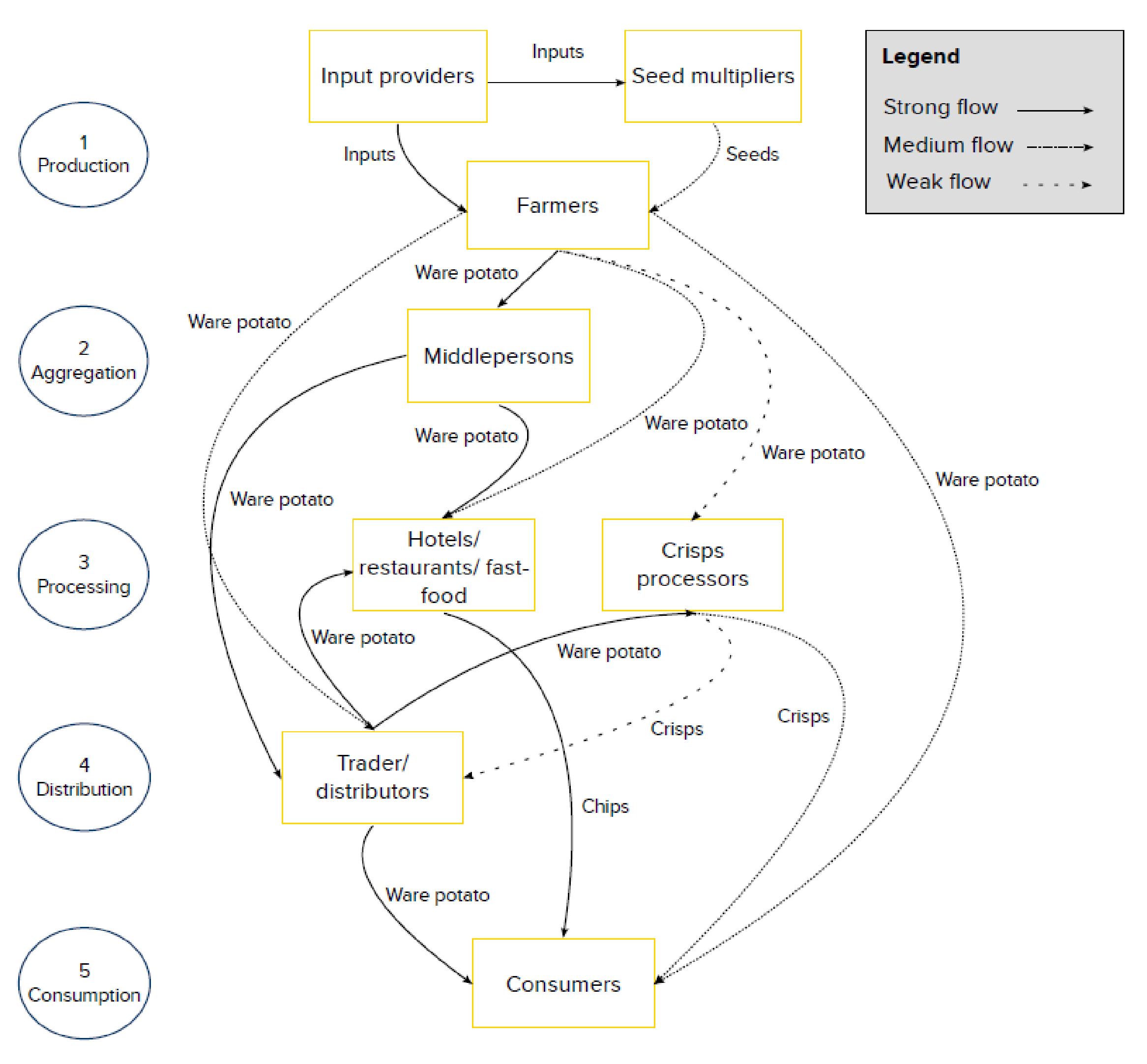

Figure 15: The Irish potato value chain in the Mt. Elgon region

Source: Own illustration

a) **Production**

Potato farmers, seed multipliers and input providers constitute the actor groups within the production stage.

Most of the smallholders in the districts of Kapchorwa, Kween, and Mbale produce Irish potatoes twice a year in rainfed conditions, with the two main growing seasons being March – July and August – December. According to farmers who participated in the FGDs, yields are higher in the first rainy season than in the second, due to seasonal rainfall patterns. Other factors that influence productivity are seed quality and agricultural inputs such as pesticides and fertilizers. Some interview farmers reported better yields during the first season when they may have access to high-quality seeds provided free of charge by IFDC or purchased from traders who source seeds from Kabale, in southwestern Uganda. However, these are rather costly due to the long distances between the two regions (~700 km). Only a few of the surveyed farmers have access to seeds produced by local multipliers. Most farmers reported using seeds saved from their previous harvest, resulting in losses and low yields.

We found that farmers sell 70 – 90 % of their harvest and consume the remainder. Farmers mainly sell their produce to middlepersons or traders at the farmgate on a cash basis. Farmers also occasionally sell their potatoes to other farmers in the village. However, individuals or farmer groups seldom aggregate their harvest and wholesale it in the market.

In the study area, four farmer-led seed producers associations were identified. These are Mengya Integrated Farmers Association (MIFA), Kween Seed Potato Producers Association (KWESPPA), Kapchorwa Seed Potato Producers Association (KASPPA), and Wanale Seed and Ware Potato Producers Association (WASWAPPA). The members of these associations receive trainings and mentoring to produce quality-declared seeds within the framework of the GIZ-PNSP project. In addition to farmers, some seed potato multipliers like MIFA are also connected to Agromax, a private company which provides plantlets and technical support to screenhouse[15] owners. Agromax sources its seeds from the National Agricultural Research Organisation (NARO), which obtains germplasm from the International Potato Centre (CIP). NARO produces basic seeds to ensure that farmers have access to good quality/certified seeds. A clear difference between Agromax and

15 A screenhouse is a structure in which mini-tubers are produced from in-vitro plantlets. These plantlets require four months in the screenhouse to mature and produce mini-tubers and an additional three months for sprouting (IFDC, 2019b). One plantlet produces ten mini-tubers.

NARO is that plantlets produced by NARO are subsidised so screenhouse owners prefer to buy plantlets from NARO (Gildemacher & Rappoldt, 2019b). Agromax sells one plantlet for 1,300 UGX ($0.37 US), while NARO charges 1,000 UGX ($0.28 US per plantlet (IFDC, 2019b). NARO's seeds are delivered to farmers by National Agriculture Advisory Services (NAADS) to local district governments as well as contracted seed multipliers.

Most of the challenges encountered in the production stage affect farmers. Despite GIZ/IFDC interventions to improve access to good quality seeds, farmers complained about the **lack of good quality/certified seed** which greatly affect their overall yields. Most interviewed farmers (54 %) use their own saved seed, which are of low quality as they are susceptible to pests and diseases.

The main problems reported by farmers is the inability to access alternative seed sources, e.g., from seeds multipliers, district agricultural extension services, or seedstock from the southwest due to financial and physical constraints. Most farmers who purchase seedstock reportedly obtain seeds from seed traders who are reputed to be untrustworthy and to provide poor seeds at high prices despite claiming they are good quality seeds from good sources, for example from the NARO multiplication centre in Kabale.

Farmers reported **high incidence of bacterial wilt and late blight** affecting the potato crop, with blight being the most common disease, according to over 70 % of the farmers interviewed (IFDC, 2021). Farmers reported an estimated 10 % loss of potatoes in the field due to pests and diseases.

Also, **declining soil fertility** due to constant cultivation and inappropriate and/or long-term fertilizer application was reported as a major problem affecting overall agricultural production in the districts and, more specifically, potato production.

Increasingly **uneven distribution of rainfall**, in combination with the lack of irrigation systems, was reported to make planting decisions difficult since all potato farmers practice rainfed agriculture (UBOS, 2020). Notably, farmers in Kapchorwa complained of a long drought that greatly affected their potato production in early 2021.

Most farmers do not have access to storage facilities to keep their harvested potatoes. According to Tatwangire and Nabukeera (2017), the l**ack of adequate storage facilities** results in 9 – 10 % of post-harvest losses for farmers. Instead, farmers harvest and sell their potatoes directly to middlepersons or traders to avoid storage. Sometimes, middlepersons provide laborers to harvest the potatoes. As a consequence of inadequate storage capacity, farmers sell their potatoes at low prices when the seasonal supply is high, which reduces profitability substantially (Gildemacher et al., 2009).

Since the start of the COVID-19 pandemic, farmers across the three districts reported **low potato prices,** ranging from 20,000 to 30,000 UGX per 100 kg bag ($5.55 – 8.33 US). The pandemic and the repeated lockdowns had severe impacts on farmers' livelihoods and market prices; according to the FGD, farmers often sold potatoes prior to the pandemic at 40,000 – 80,000 UGX /100 kg ($11.1 – 22.2 US). The comparatively low profit is mainly due to **high production costs** (see SHS economic benefits below), particularly agricultural inputs (e.g., seeds, pesticides, fertilizers, protective gear). Also, several farmers claimed that **fake and low-quality inputs** are often sold on markets, resulting in poor agricultural performance. Furthermore, farmers lamented their **lack of protective gear** which exposes them to agrochemicals which may have long-term adverse effects on their health[16].

Pesticides used in potato farming in Uganda are fungicides (72 %), insecticides (62 %), and herbicides (3 %) (Okonya & Kroschel, 2015). Ugandan potato farmers applying chemical pesticides (n = 204), reported symptoms including runny nose (60 %), itching skin (43 %), coughing (43 %), dizziness (42 %), sensation of burning skin (25 %), and teary eyes, indicating that agrochemicals are not safely used by most potato farmers (Okonya & Kroschel, 2015).

Most of the farmers also admitted **lacking market information** and receiving market price information from middlepersons. Thus, due to limited access to transparent and up-to-date market information, farmers experience price dumping by middlepersons (Tatwangire & Nabukeera, 2017). Farmers also highlighted the **poor state of roads** as a major barrier to access large markets in the main town centres where higher prices are offered. The problem is more severe in the rainy season. Indeed, the farmgate prices received by farmers in 2019 and 2020 decreased with distance from roads and towns; that is, farmers in Mbale received higher prices than in Kapchorwa, with Kween receiving the lowest prices, on average (IFDC, 2021; see Annex 6).

Regarding seed multiplication, interviews with key informants highlighted numerous challenges. According to one representative from NARO, far too **little quality-controlled seed** is produced in the country. They indicated NARO is only able to provide 5 % of the seeds needed in Uganda. Additionally, the interviewee

16 According to our findings, the use of personal protective equipment by farmers is low. Farmers reported using gumboots (73 %), gloves (7 %), face masks (16 %), and long-sleeve shirts (42 %).

deplored the low soil quality of seed multipliers and lack of certification, both negatively affecting seed quality. Beyond certification, there is too little budget to supply more quality seeds to farmers in the Elgon region, according to a representative from NAADS, a publicly financed organization mandated to distribute agricultural inputs. While the interviewees agreed that scaling up seed supply is highly needed, one interviewee was critical about involving the private sector in seed production, as it would put profit over quality.

b) Aggregation

Based on our findings, the aggregator role is mainly performed by middlepersons in the potato VC in the Mt Elgon region. They are the key contact between farmers and traders and play an influential role in the market (Ferris et al., 2001). Generally, middlepersons come from the same village or surrounding areas where potato farmers dwell. Here, middlepersons collect ware potatoes in bulk from farmers and transport them to central markets in the district to sell to traders. One interviewee mentioned that he also delivers ware potatoes directly to processors. Nevertheless, occasionally restaurant and hotel owners purchase ware potatoes in bulk directly from farmers

We noticed that there are few traders in the study areas who also fulfil an aggregator function. These traders have direct contacts with local farmers, through which they know when potatoes are ready to be harvested (Ferris et al., 2001).

Poor road conditions and infrastructure deficits in rural areas of Uganda represent a major challenge in aggregation. Aggregating actors also face a lack of or limited access to adequate storage facilities, resulting in **post-harvest losses** during aggregation (Gildemacher et al., 2009).

c) Processing

In the Eastern region, this VC stage is dominated by small-scale processors, whereas, larger and formally licensed potato processors are mainly located in Kampala. Hence, the processors included in this VC assessment are primarily local restaurant and hotel owners who prepare and sell chips and seldom crisps–the latter being produced in smaller quantities. In fact, research has shown that over 70 % of hotels/restaurants/fast food joints in the study region process potatoes into chips, while only 32 % make crisps (Tatwangire & Nabukeera, 2017).

Generally, processors buy ware potatoes from middlepersons and traders. As mentioned above, few interviewees from the processing stage also reported purchasing ware potatoes from farmers. One of the largest Ugandan potato processors we interviewed in Kampala reported being supplied primarily by traders and producers from the Southwestern region; however, new business opportunities and linkages are being developed with potato producers in the Eastern region due to increasing demand for potatoes.

As we learnt from a hotel manager in the Kapchorwa district, a major challenge at the processing stage is the **lack of a consistent and reliable supply of high-quality potatoes**, that is, potatoes suitable for processing (disease-free, undamaged, uniformly sized, uniformly humid potatoes) (Tesfaye et al., 2010). Varieties with different features are often mixed, creating a problem for standardized procedures in processing plants (Gildemacher & Rappoldt, 2019b). According to an interviewed hotel owner in Kapchorwa, **food loss** is a critical challenge in the processing stage: potatoes rot during transport, especially as a result of humid conditions caused by soil/mud being packed inside the potato bags. The same interviewee emphasized the above-mentioned factors reflect the lack of cooperation between producers and processing enterprises, as well as the low product quality caused by low quality seeds. These circumstances, combined with **high price volatility,** create fluctuating profit margins and motivate processors to meet their potato requires largely through imports.

Another interviewee pointed out the **lack of industrial processing** facilities in the Eastern region. This is a major drawback for regional value addition. Likewise, **infrastructure deficits** in transportation as well as unreliable electricity supply affect industrial potato processing negatively (IFDC, 2019b; World Bank Group, n.d.-d).

d) Distribution

According to the framework provided by FAO (2014) (see chapter 4.1), this stage entails two different groups: business actors who sell to the buying public (i.e., traders) and business actors who sells to other businesses (i.e., distributors). Several interviewees reported doing both (trade and distribution), selling ware potatoes to direct consumers in the market as well as to processors and other traders in more distant markets, e.g., in Kampala. Nevertheless, one difference that lay between traders and distributors relates to sourcing the potatoes; distributors do not have business relationships with farmers, but traders may buy directly from farmers. As shown in Fig. 9, distribution of crisps from processing companies to retailers and finally to consumers is not identified in the investigated VC.

Like farmers and processors, the traders interviewed reported widespread **lack of adequate storage facilities**. **Insufficient and unreliable supply** and **price fluctuations** have an adverse impact on their businesses. Additionally, **infrastructural deficits, insufficient access to financing**, and **payment delays** were named as key constraints. Just like farmers, traders reported feeling they were **cheated by middlepersons**.

e) Consumption

The Irish potato is a highly nutritious staple crop. It contains high quality protein, carbohydrates, vitamins C, B1, B3, B6 and folate, and minerals such as potassium, magnesium, zinc, and iron while being low in fat (GIZ, n.d.; Tatwangire & Nabukeera, 2017). These vitamins and minerals are the nutrients that the poor rural population in Uganda particularly lacks (Ugandan Bureau of Statistics, 2016).

Our findings show that potatoes are among the three most important crops grown for home consumption in the study area, alongside maize and beans. Across all the three districts, households reported that potatoes constituted part of their daily diets with boiled potatoes commonly consumed for breakfast, lunch, or dinner. Our findings also show that farming households consume potatoes three to four times a week, on average, and consume 10 – 30 % of their own potato crop, with more consumption in the rainy season due to the abundance of potatoes. Noticeably, Mbale farmers consume fewer of their own potatoes than farmers from other districts. Likely, this is attributed to their close proximity to main roads and the central market in Mbale, which offers far better prices to them than might be available to farmers in Kapchorwa or Kween. They also have access to more traders/middlepersons due to their proximity to the Mbale central market.

According to Kisakye et al. (2020), consumers that purchase raw potatoes mostly consider characteristics such as red skin, large size, and good taste. Due to its red skin, *Victoria* is the consumers' most-preferred improved variety in Eastern Uganda (Kisakye et al., 2020). Mbowa and Mwesigye (2016) also report that *Rwangume*, *Kinigi*, and *Kachpot 1* are preferred by processors due to their big tubers. Other characteristics consumers look for in the marketplace include lack of sprouting, no greening, no spots, and smooth skin (Katundu et al., 2010). Additionally, consumers prefer varieties that do not form a watery texture and break while being cooked (Kisakye et al., 2020).

Households in the Elgon region prefer to consume cooked potatoes in the following order as: boiled potatoes (39 %), fried whole potatoes (33 %), chips (17.8 %), and crisps (1.2 %) (Tatwangire & Nabukeera, 2017). Our findings in Kapchorwa, Kween, and Mbale also show that households consume potato flour mixed with maize flour to form *posho*[17]. At times we fry, at times we boil since the oils are not good, at times we mix with maize flour and make a sort of posho and we mingle. (female participant during a PhotoVoice discussion group in Kapchorwa). Potatoes can also be consumed as *katogo* (mixed sauce) which is a mixture of potatoes with any sauce, e.g., beans, peanuts, or meat among others (Kisakye et al., 2020).

Tatwangire and Nabukeera (2017) reported the following factors in order of importance in consumer preferences for potatoes: taste (22 %), ability to mix potato product with other foods, e.g., maize flour (8.4 %), ability to consume it boiled without oil (7.2 %), good for one's health (6 %), client preference (3.6 %), and affordability (1.2 %).

In addition to home consumers, Tatwangire and Nabukeera (2017) categorizes two more groups of potato consumers in our study area, i.e., consumers in fast food restaurants and consumers in institutions and hotels. With the emergence of COVID-19, however, potato consumption by institutions such as schools and hotels reduced drastically due to travel restrictions and closures of institutions like schools. This was confirmed by local traders and consumers during several key-informant interviews amid our study. For instance, the manager of a restaurant in Kapchorwa used to purchase over ten 100kg bags per week before COVID-19, but now purchases an average of five 100kg per week.

The potato VC at the consumption stage is marred with challenges including **food loss and waste, poor quality cooking oils, solid waste generation** through use of polythene bags for "take away" food, and **risk of non-communicable diseases** caused by high consumption of processed potatoes. For instance, **food loss** at the household level in Eastern Uganda is estimated at about 5 – 9 % (Tatwangire & Nabukeera, 2017). This is attributed to poor quality potatoes and inconsistencies in the varieties grown. For instance, potatoes with deep eyes, blemishes, and thick skin can lead to large losses during peeling as more is cut away to leave a cleanly peeled potato desirable to the consumer (Tatwangire & Nabukeera, 2017). Other food losses at the household level is caused by rotting during storage due to factors mainly originating at the production level.

Most street vendors use oils to make chips and crisps and the oil is used several times until it changes colour and/or thickness. Also, the same oil can be used for frying several different foods, contaminating the oil which eventually affects the

17 *Posho* or *ugali* consists of a thick, cooked porridge often made from maize flour and consumed across sub-Saharan Africa as a staple.

quality of the fries and the health of the consumer (Kajunju et al., 2021). Frequent consumption of street foods such as chips and crisps prepared with **overly reused and unfiltered oils** can cause health-related issues such as **food poisoning, digestive disorders, and cancer** (Snack vendors reusing cooking oil-Unhealthy, 2019). The informal nature of the street food vendors makes complicates quality control and exposes consumers to various health risks. Apart from that, frying chips produces substantial greenhouse gas emissions (Carvalho et al., 2018).

The growth of the fast-food industry has led to increased consumption of processed potato products such as chips, crisps, and egg rolls. However, a high consumption of potatoes, most especially processed potatoes, is highly linked to the **rise of obesity** and, consequently, a **risk factor for development of non-communicable diseases** such as type2 diabetes independent of the body mass index and other risk factors (Muraki et al., 2016). (Muraki et al., 2016)

5.3 Sustainability hot spots assessment

Sustainability hot spots are calculated by multiplying the relevance of a category with the impact score (see Chapter 4.1 and Figure 5). To ensure practicability, the impact is only assessed for the categories (at the specific VC stages) with the highest relevance score. The relevance score and the selection of the indicators (see section 6.3.1) to determine the impact score were done by VC stakeholders. The research team then translated the data on the indicator into a single impact score (see section 6.3.2).

5.3.1 Relevance scoring

In total, 33 VC actors were introduced to and scored the relevance of categories. New suggestions for categories included: marketing and export, governmental support, advocacy groups, partnerships, research, financial savings, storage facilities, and cooperative exchange visits. The research team agreed with the participants that these topics were sufficiently covered by the 21 proposed categories but could serve as indicators in a next step.

Calculating the average relevance scores resulted in virtually all categories in the social and economic categories receiving average scores above 2.0 and, therefore, potential hot spots. Looking at all categories at each VC stage that received an average relevance rating of at 2.0 (medium) was beyond the scope of this research and unfeasible. Committed to a multidimensional understanding of sustainability, we decided to only assess the impact of the 13 categories across the value chain stages in the environmental dimension that were rated above 2, as well as the 16

Table 2: Relevance scores of categories in the Irish potato VC in Uganda

Dimension	Category	Production	Aggregation	Processing	Distribution	Consumption
Environmental	Biodiversity	**2.84**	1.39	1.73	1.19	**2.00**
	Soil health	**3.00**	0.69	0.63	0.73	0.87
	Input use	**2.88**	1.62	1.57	1.33	1.17
	Synergy	**2.91**	1.20	1.11	1.17	1.33
	Carbon footprint	**2.31**	1.66	1.96	1.59	1.70
	Water footprint	**2.52**	1.97	1.63	1.21	1.45
	Recycling	**2.52**	0.84	1.32	0.86	1.36
	Food loss and food waste	**2.70**	**2.35**	**2.45**	**2.46**	**2.66**
Social	Inclusion	**2.79**	2.52	2.67	2.70	2.58
	Access and use of resources	2.72	2.48	2.57	2.30	2.04
	Social values and diets	2.52	2.25	2.41	2.44	2.66
	Fairness	2.70	2.73	**2.82**	2.73	**2.79**
	Co-creation of knowledge	**3.00**	**2.79**	**2.88**	**2.81**	2.76
	Agency	**2.97**	**2.81**	**2.84**	2.74	**2.80**
	Participation	**2.94**	**2.88**	**2.91**	2.70	2.70
	Legal framework and institutional support	**2.94**	**2.87**	2.77	**2.87**	2.20
Economic	Economic diversification	**2.87**	2.68	2.81	2.67	2.10
	Economic resilience	2.76	2.75	2.64	**2.76**	2.44
	Connectivity	**2.85**	2.61	**2.88**	**2.84**	2.39
	Commercial viability	**2.88**	**2.88**	**2.84**	**2.88**	2.48
	Economic benefits for all stakeholders	**2.82**	2.80	**2.82**	2.81	2.22

Source: Own calculation, data from the workshops with potato farmers in Mt. Elgon region and other value chain stakeholders in Kampala (impact assessed only for items in bold) categories across the value chain stages with the highest relevance rating in the social dimension, and the 10 categories across the value chain stages with the highest relevance rating in the economic dimension. If we went for the highest overall relevance ratings, the environmental dimension would have dropped out completely. Looking at 17 in the social and 11 in the economic dimension was based on the number of categories per dimension, namely 8 in the social and 5 in the economic, times two plus one additional as the last rankings were *ex equo*. Table 2 shows all average relevance scores and highlights the categories and VC stages that were selected for impact assessment in bold[18].

5.3.2 Indicator selection

The relevance scoring limited the number of categories assessed from 21 to 19. To assess the impact at the most relevant VC stages, we derived a total of 119 potential indicators from the exploratory phase, literature review, and relevance scoring workshop discussions.

As we could not collect data on all these indicators, we asked 21 members of the EREPP and the UPP (representing all VC stages and actors) to rank the proposed indicators and add more if they deem them incomplete. Subsequently, we based our impact assessment on the two top-ranked indicators. Table 3 presents these 38 indicators and their respective category (see Annex 4 for a full list of indicators and the ranking results).

5.3.3 Evidence-based indicator assessment

The evidence-based assessment of the selected indicators was conducted through own survey data, expert interviews, and secondary data. Following the empirical assessment of the two indicators, the research team condensed the findings into a single impact score which could either be low (1), medium (2), high (3), or not applicable. Multiplying this impact score with the relevance score above, we identified a total of 12 sustainability hot spots (SHSs).

Below, we outline the impact scores and the rationale for the categories and VC stages that were identified as SHSs. See Annex 20 for an extensive list of all other

18 Following the assessment of the impact scores of the identified categories in the VC stages (see next section), we detected an error that had occurred in the calculation of the relevance scores (see Table 2). Both relevance scores of the economic category "Economic benefits for all" in the aggregation and distribution stages initially had values < 2.76. This is the reason why we did not consider this category in the mentioned VC stages, but the category "Economic resilience" for the following assessment (see sections 5.3.2 and 5.3.3).

impact scores for the categories and VC stages that could have become SHSs in terms of relevance but received an impact score too low.

Table 3: 38 top-ranked indicators selected by UPP and EREPP through an online survey

Indicator selection

Dimension	Category	Indicator 1	Indicator 2
Environmental	Biodiversity	Crop rotation	Use of local varieties
	Soil health	Composting/manuring	Mulching
	Synergy	Agroforestry	Afforestation
	Input use	Quality seed production	Use of high-quality seeds & alternative sources
	Carbon footprint	GHG emission	Access to clean energy
	Water footprint	Access to water storage	Water recycling
	Recycling	Composting/ manuring	Waste management
	Food loss and waste	Post-harvest management	Use/Availability of storage facility
Social	Inclusion	Jobs for women, youth, unskilled laborers	Joint household decision-making
	Fairness	Fairness of profit distribution	Fair employment
	Co-creation of knowledge	Horizontal exchange	Access to quality extension services
	Agency	Presence of and membership in trade unions/ associations	Access to market price information
	Participation	Participation in decisions on what to produce and how	Participation in farmers organizations, cooperatives, women's groups
	Legal framework and institutional support	Existence of legal framework and regulations	Access to quality extension services
Economic	Economic diversification	Number of crops	Off-farm income /activities
	Economic resilience	Access to insurance	Contracts
	Connectivity	Proximity of producers and consumers (or processors)	Trust between producers and consumers
	Commercial viability	Capacities to compete sustainably	Competitiveness against imported products
	Economic benefits for all stakeholders	(Annual) profits	Ability to invest in business opportunities

Source: Own table; data from online survey with value chain actors and stakeholders

5.4 Sustainability hot spots

Table 4 shows that the majority of the 12 SHSs are in the production stage. Only one SHS was identified in the aggregation stage, whereas two SHSs were identified in the processing and distribution stages. No SHSs were found in the consumption stage of the VC. The category "food loss and food waste" was a SHS across the VC stages, with the exception of consumption.

SHS 1: Soil health in the production stage

Selected indicators: Composting/Manuring; Mulching
Relevance score: 3.0 | Impact score: 2 | Sustainability Hot Spot Score: 6.0

Composting and manuring are known for improving soil fertility, soil structure, water holding capacity, and microbiological activity and restoring degraded soils (Wezel et al., 2020). Manuring is one adaptation strategy Ugandan farmers deploy against climate variability as it enhances soil fertility (Mubiru et al., 2018). In Mbale district, only 20 % of farmers make compost from their crop residues, while 30 % leave them on the field as mulch, 15 % feed them to their livestock, 30 % stock them and 5 % burn them. -For farmers with livestock, waste materials in the forms of dung, urine, and bedding are additional materials that can be composted or used directly as fertilizer on the field. Farmers who compost animal dung are fewer than those who apply it directly in the field or dispose of it as waste (Nankya et al., 2019).

Our survey data shows that around 75 % of farmers apply manure on their field, mostly produced by their own animals. Given that 98 % of farmers own livestock (see below), around 25 % of farmers do not apply manure, even though they may have some available. Only 59 % of farmers make compost and 70 % of them use it on their potato fields. IFDC farmers use compost slightly more frequently (65 %) than non-IFDC farmers (51 %).

Soil erosion is another challenge on farms located in highland areas of Uganda including those on Mt. Elgon (Bamutaze et al., 2021). Mulching is among the activities known to minimize soil erosion, but some farmers have only applied it in perennial crop fields (Bamutaze et al., 2021). Some potato farmers who practiced mulching adopted it as an adaptation strategy to climate variability (Mugagga et al., 2020). Previous studies indicate that mulching is not a common practice among potato farmers as only 16.8 % of the farmers of the studied sample had mulched their fields (Mugagga et al., 2020; Twagiramaria & Tolo, 2016).

Table 4: Sustainability hot spots along the Irish potato value chain in the Mt. Elgon region

Dimension	Category	Production	Aggregation	Processing	Distribution	Consumption
Environmental	Biodiversity	5.6	N/A	N/A	N/A	2.0
	Soil health	**6.0 (1)**	N/A	N/A	N/A	N/A
	Synergy	5.8	N/A	N/A	N/A	N/A
	Input use	**8.6 (2)**	N/A	N/A	N/A	N/A
	Carbon footprint	4.6	N/A	N/A	N/A	N/A
	Water footprint	2.5	N/A	N/A	N/A	N/A
	Recycling	5.0	N/A	N/A	N/A	N/A
	Food loss and food waste	**8.1 (3)**	**7.1 (4)**	**7.4 (5)**	**7.4 (6)**	5.4
Social	Inclusion	5.6	N/A	N/A	N/A	N/A
	Fairness	N/A	N/A	**8.5 (7)**	N/A	N/A
	Co-creation of knowledge	**6.0 (8)**	5.6	5.8	5.6	N/A
	Agency	**8.9 (9)**	5.6	5.6	N/A	N/A
	Participation	5.8	2.9	5.8	N/A	N/A
	Legal framework and institutional support	5.8	5.8	N/A	5.8	N/A
Economic	Economic diversification	5.8	N/A	N/A	N/A	N/A
	Economic resilience	N/A	N/A	N/A	**8.3 (10)**	N/A
	Connectivity	**8.6 (11)**	N/A	5.8	2.8	N/A
	Commercial viability	5.8	2.9	5.6	2.9	N/A
	Economic benefits for all stakeholders	**8.5 (12)**	N/A	5.6	N/A	N/A

Source: Own calculation based on data from indicator assessment with value chain actors and stakeholders

The farmers did not carry out mulching due to the limited space between the potato plants (Mugagga et al., 2020). Ngosong et al. (2019) state that mulching improves soil health through reduction of soil evaporation rates, increases moisture retention, enhanced nutrient availability through improved soil biological activity, and suppression of weeds among others. Adekalu et al. (2007) further note that mulching helps in the control of soil erosion through increased infiltration and thus reduction of surface runoff. Therefore, mulching should contribute to soil health in potato production.

Our own survey found that a higher share of IFDC farmers (44 %) practice mulching on potato fields than control group farmers (31 %). Taken together, 82 % of them use crop residues, 61 % grass, and 4 % other materials.

Given the low uptake of mulching, the medium spread of composting, and the widespread practice of manuring, we suggest an overall medium (2) impact score. Multiplied with the unanimous relevance score of 3.0, soil health in the production phase is a SHS.

SHS 2: Input use in the production stage

Selected indicators: Quality seed production; Use of high-quality seeds & alternative seed sources
Relevance score: 2.9 | Impact score: 3 | Sustainability Hot Spot score: 8.7

The indicators chosen for input use were quality seed production, use of quality seeds, and access to alternative seed sources. As a result of the participatory selection of indicators, this does not directly refer to reduction of dependency in purchased inputs as suggested by agroecological principles (FAO, 2018b; HLPE, 2019). Many farmers highlighted their need to access inputs in the exploratory research phase of this project.

In Uganda, 90 % of potato farmers use their own saved seed, which is of low quality, while few farmers use seeds obtained from conventional ware potato markets (Ferris et al., 2001; Mwesigye & Mbowa, 2016). The main reasons for farmers to use their own saved seed include the high transaction costs for seeds, the lack of a clear seed distribution system, and limited information on the source of seeds (Aheisibwe et al., 2016). One of the challenges with using farmers' own saved seed is bacterial wilt infection, which reduces yields (Aheisibwe et al., 2016).

In the Mt. Elgon area, where potato production is transiting from subsistence to commercial production, only 3 % of the farmers use seeds from the Kachwekano Zonal Agricultural Research and Development Institute (KAZARDI) (Namugga et al., 2017). In Uganda there are „nine Zonal Agricultural Research and Development Institutes conducting adaptive research in the nine agro-ecological zones of Uganda“ (National Agricultural Research Centre, n.d.). Some farmers have resorted to using their own saved seeds for two to four concurrent seasons before buying new seed from multipliers due to the high purchasing costs involved (Tatwangire & Nabukeera, 2017).

For the few farmers who can afford quality seeds, access is limited by existing seed multipliers' low total seed production and low certification rate (47 %) (Mbowa & Mwesigye, 2016). There are few private seed suppliers who can contribute to the desired increase in seed production (Vanderzaag et al., 2021). Sadly, there are reports that even when farmers are able to purchase improved seed, the seed they receive is of poor quality (Mbowa & Mwesigye, 2016).

Our survey showed that most of the farmers (54 %) use their own seeds that are usually neither quality controlled nor certified, with a slight difference between IFDC (52 %) and non-IFDC (60 %) farmers. The second most common source of seeds (40 %) is the local market which faces similar issues and almost no difference in access rates between IFDC farmers and the control group. Around 36 % of the surveyed farmers source their seeds in the southwest (Kabale) with non-IFDC farmers more likely to use this source than IFDC farmers (45 % versus 35 %). Almost 30 % of farmers said they get their seeds from other sources, mainly neighboring homes, Kampala, and middlepersons. Around 15 % of IFDC farmers also use quality-controlled seeds by IFDC, and 4 % of non-IFDC farmers report to do so too. IFDC farmers also use seeds from seed multipliers more frequently than non-IFDC farmers (13 % and 4 %). Non-IFDC farmers are more likely (7 %) to use seeds from the local government or extension workers than IFDC farmers (2 %). This is exacerbated by 55 % of farmers indicating that they do not know alternative seed sources other than the ones they use and 50 % saying they know alternative sources but do not have access to them, mainly for financial (60 %) and physical (50 %) reasons. Both did not vary substantially between IFDC and non-IFDC farmers.

Seed multipliers' position on the use of and access to quality seeds appeared to be more favorable than farmers'. The majority of surveyed seed multipliers obtained seeds for multiplication from government agricultural research stations. All interviewees reported good practices in the production of seeds, e.g., planting in disease-free soils and continuous monitoring. High price fluctuations due to weather conditions as well as supply and demand variation were reported, with sales prices ranging from 80,000 UGX – 230,000 UGX ($22.2 - 63.9 US) per 100 kg. Alternative sources known to the interviewees were traders, though their products were claimed to be of lower quality.

Given quality seed's central downstream role in the entire value chain and the widespread shortfalls in production of and access to quality seeds, we deem the impact score of seed inputs in the production phase to be high (3).

SHS 3: Food loss[19] in the production stage

Selected indicators: Post-harvest management; Use/availability of storage facilities Relevance score: 2.7 | Impact score: 3 | Sustainability Hot Spot score: 8.3

Post-harvest loss is a common constraint along the potato value chain in Eastern Uganda. Most losses are brought about by cuts, bruises, rot, greening, and sprouting, which mainly result from lack of adequate postharvest handling of ware potatoes (Tatwangire & Nabukeera, 2017). Limited storage and processing facilities, as well as poor road networks that render connecting producers and final consumers difficult contribute to food losses (Tatwangire & Nabukeera, 2017). The harvesting equipment, such as hand hoe and oxen, can damage the potatoes and contribute to postharvest losses (Wasukira et al., 2017).

Our survey data shows that 78 % of farmers sort the potatoes after harvesting, 52 % spread them, 17 % clean them, and 16 % spray them with pesticides, with "Macozeb" (dithiocarbamate fungicide) and "Roket" (cypermethrin and profenofos insecticide). Around 9 % of farmers, regardless of their membership or non-memberships at IFDC, do not prepare/process their potatoes post-harvest. Most farmers store their potatoes in their own house (66 %), a fifth (21 %) use traditional granaries, some (15 %) sell their potatoes immediately and do not store them, and only 2 % use a modern ambient store[20]. Only 11 % of farmers claimed to theoretically have access to these modern ambient stores and the remaining 89 % of farmers had either a lack of physical access (64 %), financial access (27 %), did not know about them at all (14 %), or had to sell immediately. IFDC farmers store potatoes less often in their houses (63 % as opposed to 71 % of non-IFDC farmers), more often use traditional granaries (23 % versus 19 % of the control group), and less often sell immediately. However, both groups have almost no access to modern granaries with the only large difference being that non-IFDC farmers cited lack of financial access to granaries (40 %) more often than IFDC farmers (20 %).

Seed multipliers, who we also considered to be a part of the production phase, faced a different situation. All interviewed seed multipliers reported being in the

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19 The (FAO, 2020) distinguishes food loss as "the decrease in the quantity or quality of food resulting from decisions and actions by food suppliers in the chain, excluding retailers, food service providers and consumers" from food waste as the same dynamic "by retailers, food service providers and consumers". We hence decided to use food loss for the production, aggregation, and processing phase, and call it food waste in the distribution and consumption phase.

20 It should be stated here that this finding is unsurprising. According to EREPP interviewees, only five modern ambient stores have been built in the region, three of which collapsed due to inadequate construction material. Moreover, as the District Agricultural Officer of Kapchorwa pointed out, his entire district has never had a single ambient store. This explains why by 0 % of farmers indicated they theoretically have access to a store.

process of building modern seed storages with support from IFDC. They also reported successfully using maize and ware potato stores and residential houses for alternative storage. Yet, there might be a selection bias as all interviewed seed multipliers were affiliated with IFDC.

The general lack of adequate storage facilities in the production phase exposes farmers to price susceptibility, particularly price fixing by middlepersons who are aware farmers cannot store potatoes. Drawing on all available evidence and our own data, we consider the impact score of food loss in the production phase as high (3).

SHS 4: Food loss in the aggregation stage

Selected indicators: Post-harvest management; Use/availability of storage facilities
Relevance score: 2.4 | Impact score: 3 | Sustainability Hot Spot score: 7.2

The majority of middlepersons reported a loss of about 10 % during storage with one interviewee reporting having given up on storage due to the high losses incurred and now focussing on immediate sales. This is line with numbers reported from southwestern Uganda (Aliguma et al., 2007). Reasons cited were high temperatures in storage facilities, insects, rats, pests, and thieves. Storage length varied between several days in a wooden granary up to several months in dark and ventilated stores with shelves. The only post-harvest handling mentioned by one of the interviewees was spreading the potatoes. Given the high loss of potatoes in the aggregation phase, we suggest a high (3) impact score.

SHS 5: Food loss in the processing stage

Selected indicators: Post-harvest management; Use/availability of storage facilities
Relevance score: 2.5 | Impact score: 3 | Sustainability Hot Spot score: 7.5

All the processors participating in the interviews reported having access to storage and experiencing losses of 2 % to 10 %. The reasons for loss mentioned were being cheated by sellers (e.g. selling rotted potatoes, putting muds in bags) and rotting due to lack of post-harvest cleaning. The length of storage reported varied between several days to one week. Storage facilities mentioned were in-house storage, home granaries, and other storage facilities. Given the high loss, short storing times, and use of inadequate storage facilities, we suggest a high (3) impact score.

SHS 6: Food waste in the distribution stage

Selected indicators: Post-harvest management; Use/availability of storage facilities
Relevance score: 2.5 | Impact score: 3 | Sustainability Hot Spot score: 7.5

The majority of traders and distributors interviewed reported losses of 1 – 12 % during distribution with one interviewee reporting selling immediately for financial reasons and another interviewee reporting losses of up to 40 % and 10 % during transport and storage, respectively. Reasons reported were premature harvest, diseases, storage length, poor harvesting practices, lack of sorting, theft, and damaged packaging materials. Only one of the interviewees reported having their own storage facility and was the interviewee reporting the smallest percentage of loss. Prices for storage reported by two interviewees amounted up to 1,000 UGX/bag/night and monthly costs of 80,000 – 100,000 UGX ($22.20 to 27.80 US). The only post-harvest handling mentioned by two out of the 4 interviewees was the spreading of potatoes. Given the high losses and costs for storage, we suggest a high (3) impact score for food loss in the distribution phase.

SHS 7: Fairness in the processing stage

Selected indicators: Fairness of profit distribution; fair employment
Relevance score: 2.8 | Impact score: 3 | Sustainability Hot Spot score: 8.4

The majority of potato processors we interviewed considered producers to be the most disadvantaged VC actor in terms of fair profit distribution along the VC while one processor, however, claimed the opposite to be true. Tatwangire and Nabukeera (2017) compared gross profit margins across the potato value chain actors in Mbale. The authors note that profitability along the chain is highest for the processors, followed by the farmers, retailers, and wholesalers. They attribute retailers' and wholesalers' lower profits to the high marketing costs incurred. Tatwangire and Nabukeera (2017) also report a price disparity between female and male producers with female producers often offered lower prices for their produce. The authors attribute this to women's low bargaining power and lack of time to extensively search for alternative buyers due to their involvement in unpaid housework.

Our empirical data shows that, on average, farming households in Mbale, Kapchorwa, and Kween earn an annual gross income of $464.40 ± $63.19 through potatoes. However, very high production costs of $350.54 ± $34.03 per year per farming household were recorded, leading to an average annual net cash income of only \$86.57 ±\$72.42[21]. The highest production costs are seed purchase and fertilizers. Our findings show that potato production is more profitable for farmers in Mbale followed by farmers in Kween, with Kapchorwa potato farmers having the lowest profits. This is further supported by a survey done by IFDC in 2019 and 2020 (IFDC, 2021, see Annex 6). Our recorded annual gross income is slightly higher than the \$327.57 – \$384.00 reported in Mbale and Kabale by Kyomugisha et al. (2018). Other chain actors in our study suggest a profit distribution of: processor > traders > dealers > market sellers > middlepersons > producers. Yet, it must be noted that farmers grow potatoes for both home consumption as well as sales. So even a negative net income balance applies for some farmers who cultivate potatoes exclusively for subsistence purposes.

In their study about determinants of profit and market efficiency of the potato value chain, Kyomugisha, Mugisha, and Sebatta (2018) note that VCs are most profitable for farmers when farmers sell directly to rural traders, followed by when farmers sell directly to urban traders. The authors further note that the least profitable chain was the longest and involved farmers selling to urban traders through brokers after which the traders sold to processors who sell to the final consumers. Kyomugisha, Sebatta, and Mugisha (2018) also found that value chains involving middlepersons/brokers provided less profits for farmers. They, however, appreciate the fact that the brokers fill an existing market gap and their absence would lower the market efficiency. The authors also reveal that farmers can increase their profit by 25 % by simply processing the potatoes, i.e., washing, drying, sorting, and grading. Therefore, the easiest way for farmers to increase their profit might be on-farm post-harvest handling.

However, gross margins across the different actors may not be a good reflection of profitability due to the difficulty of assessing the margins for the other actors, especially the middlepersons and traders who often were unwilling to share information.

Employment fairness is described as social security which in return is defined by the International Labour Organisation as

> *the protection which society provides for its members, through a series of public measures, against the economic and social distress that otherwise would be caused by the stoppage or substantial reduction of earnings resulting from*

21 As mentioned in section 5.1 Exploratory phase, potato farmers sell 70 – 90 % of their harvest while 10 – 30 % are consumed at home. This share is not part of the above net cash income calculation. The value of potatoes consumed annually at home is roughly between \$15 – 45 US per household.

sickness, maternity, employment injury, unemployment, invalidity, old age and death; the provision of medical care; and the provision of subsidies for families with children. (Schmitt & De, 2013 2011)

In our study, we adapted this definition of fairness to the Ugandan context and, therefore, refer to fairness as payment of a fair wage (above the national and international poverty line that allows a living income or decent living) in addition to a contribution to the country's National Social Security Fund (NSSF) and employee health insurance. Living income is defined as "the net annual income required for a household in a particular place to afford a decent standard of living for all members of that household" (Mason & Weiss, 2021).

According to Mbowa and Mwesigye (2016), in western Uganda the average number of employees at trading level businesses along the potato VC is two for retail, eight for wholesale, and up to 14 for dual-purpose businesses9. The authors further note that over 70 % of the people employed at the trading level are youth, possibly due labour intensity, making the potato VC a critical sector for youth employment. At the processing level, the authors report that, on average, a processing business employs three people, 59 % of whom are female in southwestern Uganda. They note that only 13 % of processing businesses in southwestern Uganda are registered and only 67 % of those own a trading license, making this sector largely informal. The informal nature means that the businesses are not monitored and thus are not governed by existing laws, freeing them from their responsibility to their employees' social security (e.g. contributing to the NSSF, providing health insurance, and ensuring workplace safety) (Mugoda et al., 2020). Lack of formal contracts in informal employment also leads to lower wages, as seen in our data with small-scale processors in Mbale, Kapchorwa, and Kween paying very low wages ranging between $28 to $71 US per month without additional benefits. This is below the absolute poverty line of $1.90 per person per day and far below the annual living income for Eastern Uganda which is estimated at $4,029 US for an average household of approximately seven persons (Mason & Weiss, 2021); in Mt Elgon's case, household sizes are larger (~8.5 persons).

It is only the large, registered potato processors located in Kampala that offer better wages and contribute to their employees' NSSF as mandated by the laws regulating formal businesses. During an interview with the biggest potato processor in Kampala, a representative shared that wages in the firm are about $85 US per month for unskilled laborers while skilled laborers earn $571 – 857 USD per month depending on their position. While unskilled workers earn below the living wage, the income for skilled workers is way above the estimated net living wage for the horticultural industry in Kampala region which is estimated at an average of $177 US per month (Khan & Buyinza, 2020).

The majority of the processor interviewees did not offer benefits to their employees and paid salaries between 50,000 UGX to 250,000 UGX per month ($13.90 – 69.40 US), depending on their qualification (Ugandan national poverty line is $0.88 – 1.04 US per person per day, devinit.org 2021). Only one of the interviewed processors reported paying benefits like health insurance and pension for their employees.

All interviewees reported employing a majority-female staff mainly responsible for peeling, cleaning, cooking, and serving. A gender pay gap could not be identified due to limited data. Two of the interviewees reported offering jobs to unskilled laborers; one reported offering youth internships.

Given the unfair profit distribution across the VC, the lack of fair employment opportunities, and the lack of exact data, we suggest a high (3) impact score.

SHS 8: Co-creation of knowledge in the production stage

Selected indicators: Horizontal exchange[22]; access to quality extension services
Relevance score: 3.0 | Impact score: 2 | Sustainability Hot Spot score: 6.0

Farmers mostly exchange knowledge on (potato) farming in group meetings (73 %), at farm visits (67 %), or at social gatherings (26 %). Around 17 % of farmers called other farmers via phone and 12 % exchanged via radio. In terms of the types of knowledge exchanged, farming practices (98 %) were followed by disease management (67 %), marketing (46 %), financial management (43 %), and post-harvest management (31 %). Frequent horizontal exchange between farmers can, therefore, be described as a common practice.

In 2001, NAADS took over the provision of extension services from the traditional local government extension system (Nkonya et al., 2020). With huge initial success, NAADS was suspended by the Ugandan president in 2007 and resumed activity in 2014 after comprehensive reform (Rwamigisa et al., 2018). According to the National Services Delivery Report, only ~30 % of households involved in crop production indicated their need for extension services, compared to over 40 % and 90 % of those involved in animal husbandry and fish farming,

22 The categories included in the indicator "horizontal exchange" included occurrence and frequency of group meetings, social gatherings, farmer-to-farmer visits, phone calls, radio, and other (open response option).

respectively (UBOS, 2015). The report also showed that farmers engaged in animal husbandry were more likely to be visited than crop farmers. Our findings show that NAADS provides high-quality seed potato to selected farmers in Kabale, Mbarara, Mbale, Kapchorwa, and Kween. Its role in the potato VC is limited to the production stage and there are no plans to extend the services to other parts of the chain, mainly due to a lack of resources. NAADS works with the quality assurance department of MAAIF to ensure that the seed supplied is of good quality.

Priegnitz et al. (2019) documented Irish potato farm typologies in southwestern Uganda and reported that over 68 % of potato farmers had access to extension services with over 56 % of them receiving extension services from NAADS. Tatwangire and Nabukeera (2017) further report that the number of extension visits farmers receive has a positive and significant effect on their technical efficiency and decisions to participate in the market. This is in line with findings by Priegnitz et al. (2019) who report that frequent visits from extension workers led to higher adoption rates of agricultural innovations. The extension services offered focus on access to quality seed, market information, and use of improved varieties. The main challenges faced by extension workers are poor road infrastructure, organizational challenges, embezzlement of funds, and poor funding of the extension sector (McCole et al., 2014).Additionally, Shimali et al 2021) note that training of extension workers (i.e., general education, competencies in nutrition, and communication skills) need improvement in Uganda.

Our data shows that slightly more than two-thirds (69 %) of farmers have access to extension services. Group meetings were reported to be the most common and preferred channel for receiving extension services. There is a large difference between IFDC farmers (90 %) and control group farmers (42 %), however. Of those farmers who reported accessing extension services, only 74 % of IFDC farmers say they receive extension services from IFDC, 59 % point to local government, and 9 % to other actors, including NGOs. The non-IFDC farmers access extension services rely on the local government (77 %), other actors (18 %), and IFDC (12 %). Those farmers who accessed extension services said they were able to receive information about farming practices (96 %), post-harvest management (41 %), financial management (32 %), and marketing (30 %). Roughly 45 % of these farmers are satisfied with the extension they receive, 48 % are neither satisfied nor dissatisfied, and 7 % are dissatisfied. This means that almost a third of all farmers interviewed and almost 60 % of randomly selected control group farmers have no access to extension at all. Those who can access extension services still only have a 30 % chance of learning about financial management and marketing, and are mostly neither satisfied nor dissatisfied with the services they receive.

The majority of seed multiplier interviewees reported having no specific need for extension services as they felt they already have sufficient expertise. This said, the majority confirmed having access to extension services with one interviewee reporting a high and another reporting a low level of satisfaction due to the low frequency of interactions with extension providers. All interviewees reported being part of an organized group of seed multipliers which meet as irregularly as 1 – 2 times per year or as regularly as weekly.

Given the high frequency of knowledge exchange between farmers, the medium access to quality extension services, and the lack of marketing and financial information exchange, we suggest an overall medium (2) impact score.

SHS 9: Agency in the production stage

Selected indicators: Presence of and membership in trade unions / associations; Access to market price information
Relevance score: 3.0 | Impact score: 3 | Sustainability Hot Spot score: 9.0

According to Tatwangire and Nabukeera (2017), over 70 % of interviewed potato farmers in the Elgon region were part of a farmer group. The most well-known farmer groups in the region include WASWAPPA, MIFA, Bushuiyo Women's Group, Wanale Highland Farmers Association, and Kepchesombe farmers group. According to Mbowa and Mwesigye (2016) about 70 % of farmer groups in southwestern Uganda are registered with the local government; the majority are registered at the sub-county level. Registration information is not available for the Mt Elgon region. Most of their activities are focused on savings and credit and participation in training in better agronomic practices and not on e.g. collective marketing, which has been also confirmed in southwestern Uganda, (Mbowa & Mwesigye, 2016).

Tatwangire and Nabukeera (2017) report that potato farmers in the Elgon region receive market information from traders and fellow farmers. This is similar to potato farmers in southwestern Uganda whose main source of market information is middlepersons (Aliguma et al., 2007). However, due to underlying trust issues between farmers and traders, the authenticity of such information is suspect. In fact, Aliguma et al. (2007) report that middlepersons control the flow of market information and make it difficult for other actors to gain access to better markets. Tatwangire and Nabukeera (2017) also note the gender disparity in market access with male farmers gaining more access to market information than their female counterparts as a result of men's more active involvement in potato marketing and sales.

Of all interviewed farmers, 87 % are members of an organized group (farmer, saving or women´s groups). Here it is important to distinguish between IFDC and non-IFDC farmers. All (100 %) of IFDC farmers are members of a group, and only 63 % of non-IFDC farmers. The remaining 38 % of non-IFDC farmers (that is, 13 % of the farmers surveyed in this study) are not a part of any group and stated they do not participate in a group because of lack information about groups (28 %), are too busy (28 %), lack physical access (22 %), lack financial (11 %) access, are hindered by family obligations (17 %), or are simply not interested (22 %). Almost all farmers (93 %) know of existing groups in their parish.

Farmers who belong to a group typically are part of a farmers group (79 %), savings group (78 %), and/or a women's group (33 %). While 77 % of farmers knew potato prices on the local market, 24 % knew the prices on the regional level, and only 11% on the national level in the capital. Surprisingly, 23 % of farmers, therefore, did not even know the local prices and the ones who did mostly got their information from middlepersons (50 %) or other farmers (42 %). The few who knew prices on the regional level also learned them from middlepersons (58 %), other farmers (29 %), or from people they had called in the region (17 %). The few respondents who knew the prices on the national level also learned them from middlepersons (50 %) or called people in the capital (20 %). Interestingly, this does not vary a lot between IFDC and non-IFDC farmers, with the only notable difference being that control group farmers are slightly more likely (29 %) to know the prices on the regional level than IFDC farmers (20 %). Given that so many farmers depend on middlepersons for price information, only 54 % verified this information—and mostly did so by asking other middlepersons or farmers. This lack of knowledge of market prices had a high impact on profitability and, therefore, livelihoods.

The situation looked different for seed multipliers. The interviewees reported a fairly high level of price knowledge, specifically on the local level and in the western region of Uganda. Sources of information differed considerably, from farmer organizations to personal visits and informal exchange. All interviewees reported being part of an organized group that meets infrequently (1 – 2 times per year) or frequently (weekly) and address a wide range of themes (sourcing planting materials, apical cuttings, yields, market access, quality seed production). The majority of seed multipliers reported knowing organized groups apart from their own.

Given that many farmers are part of organized groups, but these groups (1.) largely do not address key areas of concern such as of marketing, financing, and pricing; (2.) do not seem to impart market/price knowledge, we suggest a high (3) impact score.

SHS 10: Economic resilience in the distribution stage

Selected indicators: Access to insurance; Contracts
Relevance score: 2.8 | Impact score: 3 | Sustainability Hot Spot score: 8.6

The Ugandan insurance sector has not developed insurance products and services suitable for smallholder farmers and other agricultural VC actors. Instead, insurance schemes have been designed for large-scale farmers growing high-risk crops like horticultural crops and large-scale commercial dairy farmers (International Bank for Reconstruction and Development / The World Bank, 2019). The absence of insurance schemes for smallholder farmers and other VC actors makes them extremely vulnerable to the vagaries of weather and losses due to transport bottlenecks. Upon realizing the vulnerability of small-scale farmers, the government introduced the Uganda Agricultural Insurance Scheme (UAIS) under a public–private partnership with over 11 leading insurance companies in the country. One of the aims of the scheme is to increase access to credit by smallholder farmers and others (World Bank, 2019). The number of farmers that currently use agricultural insurance is roughly 150,000,representing less than 2 % of the population active in the agricultural sector (UNDDR, 2021). However, an audit of the performance of the UAIS revealed that the majority of the beneficiaries of the scheme are medium- to large-scale producers with an average farm size of more than 5 ha, further alienating the smallholder farmers that it was designed for. Virtually all farmers we interacted with in Mbale, Kapchorwa, and Kween lacked agricultural insurance, exposing them to risks.

Although the insurance schemes available at the production stage of the VC are gaining some attention, little to no attention is given to insurance of agricultural produce in transit (the distribution phase) in Uganda. One of the recommendations of the World Bank Group is to expand the UAIS scheme to other parts of the VC so as to make the sector more resilient and productive (World Bank, 2019). This would ensure that the demand side drives the supply side which would make the implementation of the scheme feasible. There is no government-supported scheme for other agricultural VC actors to date. Only a handful of private insurance companies provide "goods in transit" insurance, among which is Britam insurance company and UAP insurance. This insurance scheme would protect distributors against

theft while in transit, damage caused by accidents during transit, loss during transit, damage caused during transit, fire, lightning, breakage of bridges, collision *with or by the carrying vehicle, over-turning of the vehicle, derailment or accidents of like nature to the carriage.* (Britam Holding PLC, n.d.)

Distributors' reliance on private insurance companies makes insurance rather expensive and ultimately restricts access to such insurance products.

Given that also all interviewees reported having neither access to insurance nor steady contracts outside of verbal agreements with their customers, we suggest a high (3) impact score.

SHS 11: Connectivity in the production stage

Selected indicators: Proximity of producers and consumers (or processors); Trust between producers and consumers
Relevance score: 2.9 | Impact score: 3 | Sustainability Hot Spot score: 8.6

A staggering 81 % of surveyed farmers sold their potatoes to middlepersons, 19 % to neighbouring homes, 10 % to other agents (mostly traders and local markets), and 5 % to neighboring villagers. Only 7 % sold directly to consumers and 2 % directly to restaurants or processors. The weak links between farmers and consumers, and farmers and processors could be explained by the fact that farmers largely could not list any other actors between themselves and the final consumer, which is why 40 % answered that "they did not know" any actor. Farmers who reported knowing other actors in the VC, mentioned middlepersons (39 %), traders (33 %), and dealers (10 %). Only 8 % of farmers reported knowing restaurant owners and 2 % reported knowing processors. Farmers believed the biggest buyers for their products were in the regional capital of Mbale (49 %), followed by 21 % other places (mostly Kapchorwa, local market, or do not know), 18 % neighbouring homes, and 9 % Kampala. Only 10 % of farmers knew at least some of their consumers. Farmers were also asked whether they frequently sell to the same consumers, which only 36 % affirmed. This means that overall, only ~3 % of farmers know consumers who they frequently purchase their goods.

Seed multipliers reported to sell to research organisations and farmers, whom they reported to sell to middlemen/traders who in turn sold to consumers and processors.

Given that surveyed farmers are largely unaware of other actors down the VC, only knew middlepersons and not their consumers, and there was no indication of trust between producers and consumers, we suggest a high (3) impact score.

SHS 12: Economic benefits for all stakeholders in the production stage

Selected indicators: (Annual) profits, Ability to invest in business opportunities Relevance score: 2.8 | Impact score: 3 | Sustainability Hot Spot score: 8.4

While the average gross income of farmers amounts to $450 US ± $61 US (mean ± standard error) per year, on average, average production costs of $341 US ± $33 US per average farming household resulted in an average annual net income of $86.6 US ± $72.4 US only. However, the variances were relatively large as suggested by the standard error of the mean for net income. Furthermore, high gross and net profit disparities between male and female farmers were observed.

On average, farmers save 105,400 UGX ± 24,000 UGX per month, the equivalent of $29 US ± $7 US, all income sources combined. Given that this is just an average and one bag of seeds exceeds this amount by far, the ability to invest in the farm appears to be limited. Moreover, men tend to have more control over the household budget and 56 % of the control group farmers were male as opposed to 24 % of IFDC farmers. However, all these factors can only contribute to rather than cause the difference recorded. Out of the 81 % of farmers who have access to financial services, 95 % depend on savings groups, only 30 % can access banks, less than 2 % have access to microcredit, and 11 % revert to money lenders. With lower savings group membership rates, control group farmers have lower access to financial services (69 %), on average, compared to IFDC farmers (89 %). Given the need for collateral, even in savings groups, and the immensely high interest rates, the access to financial services does not directly translate into the ability to invest in their own business for farmers, however.

As for the seed multipliers interviewed, while the majority reported having access to bank loans, they deemed them unattractive financial service due to their high interest rates. One interviewee reported that access to financial services could only be obtained via the saving group, an option described as neither stable nor reliable from another of the interviewees. Interviewees reported selling twice per year, in line with the production season, with demand being higher for production in the first rainy season. The interviewees reported being able to save from about 3.6 million UGX/year to 10 million UGX/year ($1,008 – 2,800 US).

6 Results: Nile perch value chain

6.1 Exploratory phase

This section presents data collected during the one-week exploratory phase in and around Jinja (see Figure 4) based on the following methods: key-informant and expert interviews, an FGD, and PhotoVoice, as part of our PRA approach.

Fishing in Lake Victoria, especially for Nile perch, is characterized by a complex interdependence of actors who base their livelihoods mostly or exclusively on fishing (KS1; KS2; MA3)[23]. the success of fishing depends strongly on the ownership and type of boat (motorized or non-motorized), which means different investment in terms of time, labor, and money (KY4; MA3; KS1). Economic benefits along this VC are affected by price fluctuations, particularly at the production and artisanal processing levels (KY1; KY3). Especially profitable is the fish maw of the Nile perch, which is traded at 25,000 UGX [24]per kilogram ($ 6.90 US), while a kilogram of the whole Nile perch is currently sold by the fishers for 14,000 to 18,000 UGX (US$ 3.90 – 5.10 US) (MA2; KY2).

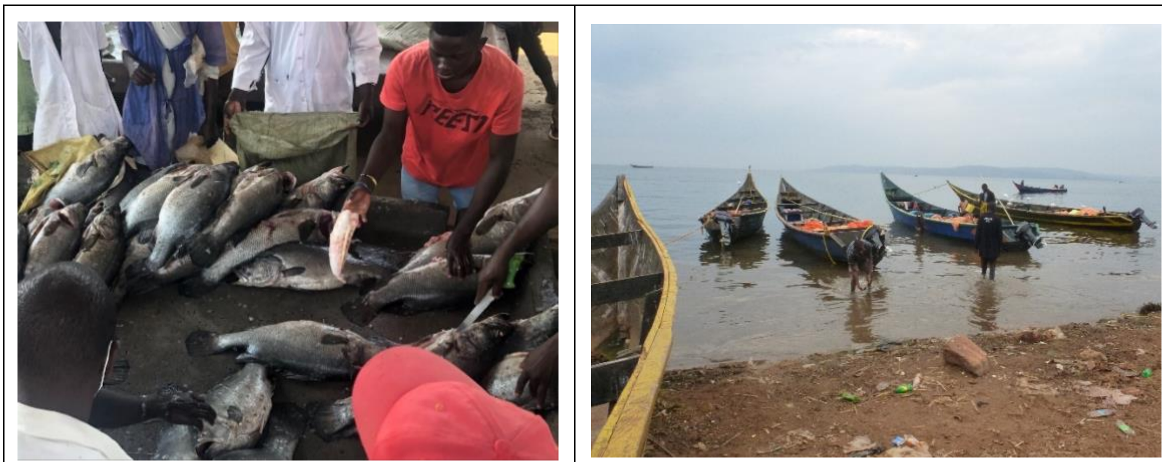

Figure 16: Fish maw extraction and boats as success key factors in fishing

Source: Jasmin Ahmed and a PhotoVoice participant

23 In the Nile perch chapters codes are used as references to the respective interviews, focus groups, field visits, etc., conducted during our research. A list can be found in Annex 11: List of interviews for the Nile perch VC.

24 Due to price fluctuations these prices might vary slightly from information in other literature.

Moreover, as the demand for fish maw is high, maw traders can choose to whom to sell their product (MA2).

Nile perch fishing is currently undergoing a recession that has affected VC actors since January 2021 and which they attribute mainly to fish die off resulting from a lack of oxygen in Lake Victoria (MA2; KY1; KS2; JN1). Fishers are used to seasonal variation in fish availability, but currently, many fishers are unable to catch anything for days on end and some factories do not operate at all (JN2; MA2; MA3). This also affects other VC links, for example, supply stores, fish lifters and handlers at landing sites, or transport businesses in the surrounding area (MA3). Although Nile perch is the most economically lucrative fish in Lake Victoria, *mukene* and Nile tilapia are seen as important alternatives when there Nile perch catches are low (JN1; KY4). Therefore, "different bodies [like the EU] are promoting aquaculture as an alternative source of livelihood" (JN2).

Do-no-harm within the research on the Nile perch VC

The exploratory phase helped us to better understand the local context in relation to conflicts and our role within it, as researchers. Although we did not conduct an entire Do-No-Harm approach, at least, we applied the Do-No-Harm steps. See, here, some examples:

Step 1: Groups and conflicts
- Fishers and Uganda's army patrolling on Lake Victoria: illegal, unreported, and unregulated fishing activities
- Fishers and boat owners: fishers reluctant to report catch to the boat owner (mistrust) and boat owners' dependencies on fishers (little share of gains)

Step 2: Dividers and tensions
- Age: maw business is done by younger people, yet older people have more experience
- Nationalities/Belonging: export sector dominated by Indian-born Ugandans, fish maw business dominated by Chinese-born business permit holders
- Gender: division of labor and opportunities

Step 3: Connectors and capacities
- Lake: income source; common goal is to preserve its resources
- Formal associations: AFALU or UFFCA do advocacy work

Step 4: Project characteristics
- Participatory, for example, in relevance scoring
- Compensation paid to participants

Step 5: Potential influence
- We might shape how participants think about research and the regions of our origin
- Potential of raising issues that might be uncomfortable for those involved (corruption, illegalities)
- Power imbalance might obstruct equal participation and bias research results

The generally low catches of Nile perch are strongly correlated to illegal fishing activities such as the use of small-meshed fishing nets that catch juveniles (JN2; MA1). Among other factors, harmful fishing practices are supported by the substantially lower price of small-meshed nets in comparison to legal-sized nets (MA3). Interviewees expressed the need for more commitment from government authorities to enforce laws, especially concerning the import and use of illegal gillnets (MA2; KY1; KY3). At the same time, criticism of the current FPU patrols was expressed repeatedly: the military is not seen as an expedient choice to regulate the lake in the long term, especially as they are associated with corruption and severe harassment (MA3; KS1; KS2).

The prevalence of FPU patrols coincides with low-level organization at landing sites. We noticed the fisherfolk's desire to rebuild a community management structure at the landing sites, like the former BMUs (KS1; MA3). According to interviewees, without these structures, it is difficult to encourage people follow rules regarding, for example, hygiene (MA1). This hope for a changed, organized environment was especially voiced by women who face challenges accessing activities within the Nile perch VC (KY1; KY4). Saving associations are considered particularly important for financial and social mutual support (KY4). To bring gender-related concerns within the fishing sector to a higher level, national associations like the Ugandan National Women's Fish Organization (UNWFO) were founded and recently gained momentum (KY1).

Figure 17: Nile perch weighing and director of the Kiyindi Women Fish Processing Centre

Source: PhotoVoice participant and Eva Kirmes

Overall, most respondents showed awareness not only of economic challenges, but also of environmental and social challenges within the Nile perch VC. Pessimistic views and the wish for non-fishing employment opportunities for one's children (MA3; KS1) alternated with more hopeful perspectives driven by the aim to overcome specific obstacles, such as more Ugandan participation in the export sector (which promises higher income) (JN1; MA2; KY3; JN2). Apart from the indicated challenges, constraints mentioned include the increasing price of fuel (MA2; KY2), lack of financial institutions (KY2), transportation difficulties (ice and infrastructure) (KY1; KY3; MA3), and the proliferation of water hyacinth (MA1). Suggestions for improvement centered on political instruments like funds or laws and the execution of existing laws (MA1; MA3).

6.2 Analysis of the Nile perch value chain

The Nile perch VC is a network of complex connections from the local to international scales (Kimani et al., 2018).

The present section outlines, insofar as possible, a map of the VC actors as assessed during field research through a quantitative survey, qualitative interviews, stakeholder workshops, and literature research. As mentioned earlier, the Nile perch VC can be divided into four processing branches and their related output products (see Figure 18):

1. Industrial processing for export markets
2. Artisanal processing for local and regional markets
3. By-product processing and marketing
4. Fish maw (swim bladder) processing and marketing

a) Production

The Lake Victoria shorelines and islands host 363 approved landing sites (locations where fish are landed, handled, and traded), of which approximately 30 are gazetted. It is estimated that more than 36,000 fishers are engaged in fishing around Lake Victoria (Kimani et al., 2018). Nile perch and Nile tilapia, which are caught using the same fishing methods, are caught using gillnets or longlines with hooks that are cast overnight. Capture fishing activities on Lake Victoria are predominantly carried out on small wooden boats, operating largely with outboard motors, although boats with oars or sails are still existent (Kimani et al., 2018; Peter & van Zwieten, 2018).

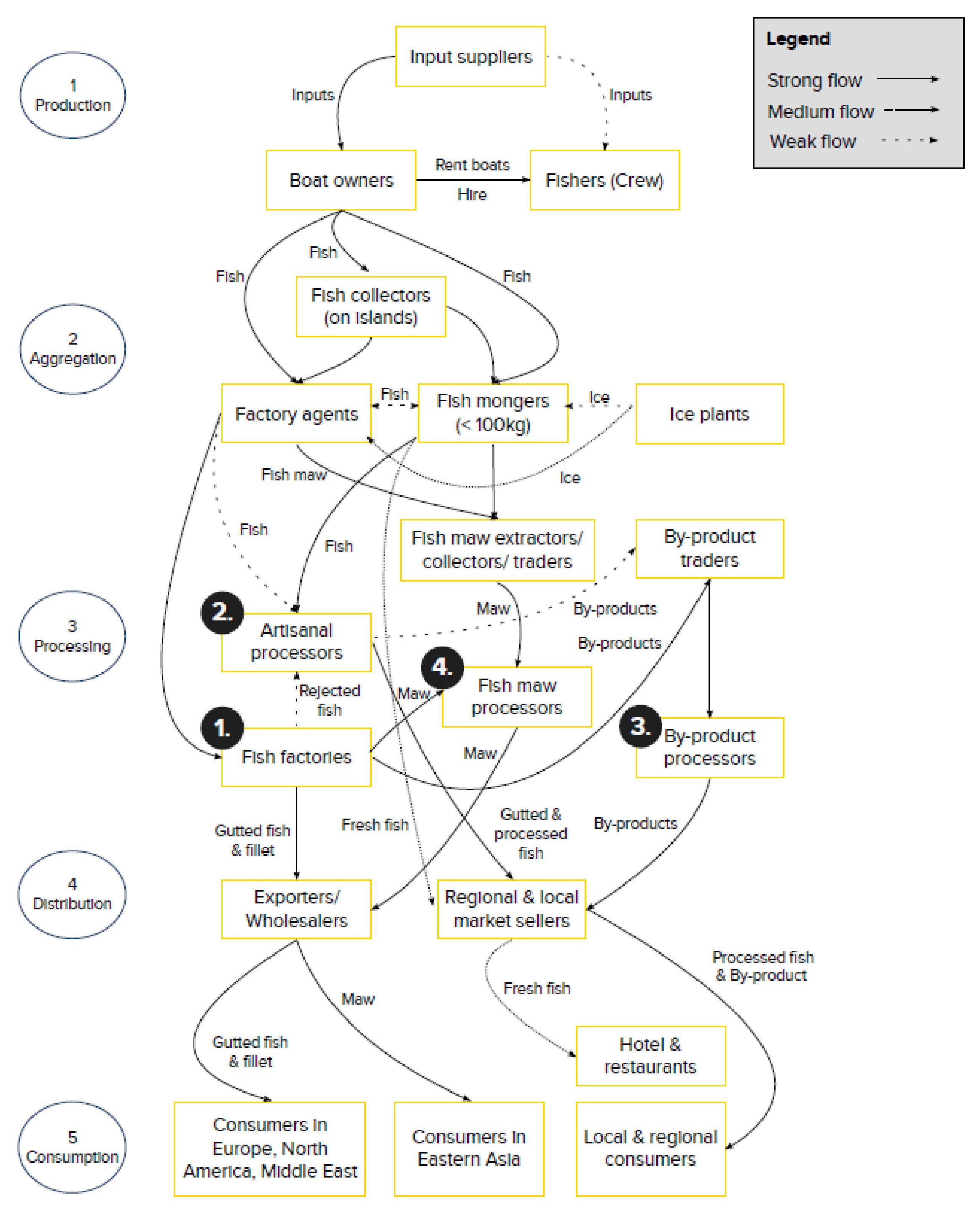

Figure 18: Nile perch value chain map

Source: Own illustration

Since the enactment of the Fishing Regulations in 2010, fishers need to fish with nets of a minimum mesh size of 6 inches, use boats of a minimum length of 28 feet, and own a fishing permit/license (Mpomwenda, 2018). Because of the high equipment and operational costs, many fishers work as crew members and do not own boats themselves, necessitating profit sharing among crew and owners. Our survey results (n = 30) show that a normal pattern of profit sharing between boat owner and crew members exist. The typical scenario is that 40 % of the profit from a fishing trip goes to the boat owner to meet their operational and fixed costs (fuel, gear, maintenance, license, permits, etc.). The remaining 60 % of the profit is split between the owner and the crew. On a typical boat with two crew members, this means each crew member would take home about 15 % of the daily profit.

Figure 19: Artisanal boats at landing site

Source: Hendrik Hänke

However, in many cases a fishing trip can be unsuccessful, resulting usually in minor compensation for the fishers and a loss for the boat owner. A few boat owners go fishing themselves, but in most cases, they own multiple boats at a landing site and operate in a coordinative function.

The high operational costs exert much economic pressure on the production stage, which is struggling with **declining catches due to overexploitation** of the stocks, illegal fishing practices, and eutrophication of the lake (Bassa et al., 2021; Kolding et al., 2008). As a result, fishers **use illegal fishing methods** such as small-meshed monofilament gillnets to catch some undersized (immature) Nile perch or Nile tilapia for home consumption or meeting local market demand (Peter & van Zwieten, 2018).

To reduce the occurrence of illegal fishing methods, a presidential directive initiated the activities of the Fisheries Protection Units (FPU) on Lake Victoria in January 2017. The FPUs burned undersized boats and illegal gear on a large-scale around Lake Victoria, confiscated catch, and arrested many fishers operating without permission (KS2; MA7).

b) Aggregation

Fishers and/or boat owners sell their fish to middlepersons at the landing site, often having stable, durable, and loyal business relationships with them (Kimani et al., 2018). In many cases, fishers are provided with advance payments or loans by middlepersons, **making fishers dependent** upon and bound in silent obligation to middlepersons (own observation; Kimani et al., 2018). All middlepersons buy an annual permit at 500,000 UGX ($140 US) that allows them to trade fish (KY6; Fish (Fishing) Rules, 2010).

The major share of landed Nile perch, around 96 % (Kimani et al. 2018), is traded to factory agents, who deliver the Nile perch to the fish factories. Fish are transported ungutted to factories in order to maintain hygienic conditions for products entering the export market; gutting fish at the landing site is considered unhygienic (MAAIF, 2017). Nile perch for export is landed almost exclusively at gazetted landing sites where fish are handled under strict inspection protocols regarding size, quality, and hygienic conditions. The size of fish accepted at factories is, at minimum, 50 cm and is controlled with a slotted size measure. Technically, 85 cm is the upper **fish length limit**, however, it is **not controlled and enforced** in Uganda (NPFMP2, 2015). Nile perch catches from many islands are collected at non-gazetted but designated landing sites then transported to gazetted sites on the mainland, in accompaniment of a fish moving permit—a document clearly stating the origin of the fish—issued by a designated person at the landing site.

Factory agents operate predominantly at gazetted landing sites and maintain substantial capital to buy fish in bulk to meet factories' demand, often providing transport and icing of the fish as well (Ikwaput-Nyeko et al., 2009; Kimani et al., 2018). During the study period (August to October 2021), the price for Nile perch was between 13,000 to 15,000 UGX per kg ($ 3.65 – 4.20 US) depending on **price fluctuations** and fish size. Factory agents reported profit margins of 500 UGX ($0.14 US) per kg between buying-in from the fishers and selling to the factory.

While 96 % of landed Nile perch is sold to factory agents, the remaining 4 % is sold to local fish mongers who usually handle not more than 100 kg per day, operate with smaller cash funds, and sell to the local market (Kimani et al., 2018). Nile perch that enters local markets are often gutted fish that have had their swim bladders sold into the maw market or have been rejected by factory agents due to their size or quality. Some fish mongers hold rank or have informal agreements with fishers at a landing site then resell the acquired fish to factory agents.

In recent years, the business of fish maw trading experienced a boom due to new regulations in the sector and increased demand from the eastern Asian consumer markets (MAAIF, 2017). Fish maw is by-product with high economic value and has become a pillar of the Nile perch VC. For instance, in 2016 Uganda exported 352 tons of fish maw at $31.6 million US. The export of 14,600 tons of Nile perch filets in the same year was valued at $79.5 million US (Bagumire et al., 2018).

Prior to 2017, fish maw was the exclusive business of the factories, which gave rise to illegal extraction and smuggling between the Lake Victoria countries (Bagumire et al., 2018). Since then, government has opened the market to local dealers, who can be licensed for extraction and trading.

Fish maw is particularly profitable in large Nile perches (above 4 kg), because maws of 80 grams and above are particularly desired by the processors, though smaller maws of 5 grams or more are also traded (Bagumire et al., 2018). Local prices per kg are between 300,000 UGX to 600,000 UGX ($71 – 142 US) depending on quality. The maw business has created opportunities for middlepersons: extracting, collecting, and trading of maws is either done by different handlers or all by one person. While large Nile perch were once sold whole almost exclusively to factories, the artisanal maw trading sector now guts the fish, extracts their large, high-value maws, and sends the gutted fish to the local market. Notwithstanding the above, all maw traders sell their maws to Chinese-owned processing plants in Uganda since the consumer markets are exclusively located in China/eastern Asia. Those factories then ship the maw frozen or dried to processors in eastern Asia for onward movement to Chinese and Hong Kong markets (Bagumire et al., 2018; Kaelin, 2018).

Other by-products, e.g., skin, fat, offcuts, bones, and heads, are low-value products, with selling prices ranging from 450 UGX to 8,000 UGX ($0.10 – 2.30 US) per kg, depending on product. They are bought from fish factories by specialized by-product traders and processors in bulk (per ton) and are then processed under **low hygienic standards** in open-air facilities (KM1). Fish skins and bones are salted and sundried, while fish heads are usually smoked (JN2; KM1).

c) Processing

The vast majority of Nile perch is processed in industrial processing plants, which buy fish in bulk (usually by the 7-ton truckload) from factory agents. At the moment, eight of those factories are operating, however, also undergoing a **recession due to the recent decline of Nile perch stocks** (KM5; Kimani et al., 2018). In 2016, factories processed 64 tons of fish, but had the capacity to process 540 tons

(Kimani et al., 2018). Especially during the 1990s and early 2000s—after tapping into new export markets in Europe and the Middle East—the Lake Victoria fisheries experienced a strong upswing, accompanied by initiation of numerous **processing plants that subsequently shut down** again due to overexploitation of Nile perch stocks (Matsuishi et al., 2006; Njiru et al., 2007).

Fish factories employ a large number of staff (on average, above 100 employees) who wash, gut, filet, trim, and pack the fish. The main products are chilled and frozen filets, which are either flown out or shipped, and frozen, gutted, and beheaded whole fish. Nile perch products are predominantly exported to Europe, the Middle East, and North America (Kimani et al., 2018).

Artisanal processing of the Nile perch includes salting, drying, and/or smoking and is often conducted at home and under **substandard hygienic conditions** (KY1). Existing guidelines for food safety and quality assurance of smoked fish in Uganda exist, but are barely implemented due to a **lack of propagation and enforcement** (MAAIF, 2019; JN6; KY8). Some parts of the fresh fish are also sold to high-end hotels and restaurants or at lower prices to roadside stands offering deep-fried food and local restaurants (Kimani et al., 2018).

Fish maws are mainly processed by factories owned by Chinese enterprises that export the final product to eastern Asia. In 2018, about 21 companies of this type were active in the sector (Bagumire et al., 2018). Artisanal maw processing is in decline as the quality of the final product is low (insufficient drying, undesired colour, damaged maw surface) and consequently often rejected or sold cheaply to exporters. Declining Nile perch stocks also affect the artisanal maw sector (Bagumire et al., 2018).

d) Distribution

Factories export most Nile perch products to the European Union (most of the buyers are wholesalers from the Netherlands, Spain, and Italy (KM3)) and Middle East; fish maw is sold to Chinese factories within Uganda for onward shipping to eastern Asia.

Factories must be registered and have an Establishment Approval Number (EAN), which allows them to export into the EU. They also need certification from the DiFR that states the production is in line with the HACCP (Hazard Analysis Critical Control Points) guidelines for standard operating procedures for fish inspection and quality insurance (MAAIF, 2017; KM3).

To ensure that quality and safe products are accessed by the processing plants, sets of upstream controls that include documentation, slot size, and inspections, among others are put in place at the gazetted landing sites. Hygienic handling and selection of acceptable Nile perch (size > 50 cm) is strictly controlled before fish enter factories. Approved fish shipments are issued with a Local Fish Inspection Certificate from the landing site that guarantees the origin and hygienic handling of the fish (KM3).

e) Consumption

Nile perch provides an affordable white filet meat that does not contain tiny bones, which makes it very popular and easy to introduce in the EU export market as an alternative to, for example, cod (KM5; Asnake, 2018). The fish contains several valuable nutrients, such as omega-3 unsaturated fatty acids, which reduce, for instance, the development of heart diseases (Murage et al., 2021).

In Uganda and East Africa, Nile perch is the second-most preferred fish after Nile tilapia (Ayuya et al., 2021). Most **Ugandans avoid fresh Nile perch** because of its fishy taste (JN4) and consume it smoked or salted, which reduces perishability and makes the fish more affordable (Kimani et al., 2018).

On the local level, fish traders also buy Nile perch by-products like fileted carcasses, skin, fat, and off-cuts, which they process to produce smoked, salted, and sun-dried products. The smoked fish is sold in western Uganda; predominantly Kasese district. Other salted and sun-dried by-products are exported to the Democratic Republic of Congo (DRC) (KM1). Most of the by-products are used in soups or as supplements since they provide flavor and contain valuable nutrients like collagen proteins, zinc, iron, calcium, and lipids (Asnake, 2018; Muyonga et al., 2004).

The maw is an important food in eastern Asia and contains culinary, medical, and spiritual properties (Wen et al., 2015). As one of the "four precious treasures" (Kaelin, 2018, p.3) — a group of dried aquatic products—it is a very valuable food and treated as a delicacy. Nile perch maw is rated as a mid-quality maw compared to other fish species and 500 grams can be sold between $200 – 675 US in the retail market depending on size and quality (Kaelin, 2018). The Cantonese kitchen has approximately 500 million consumers and an emerging, solvent customer group. Besides this growth in the consumer market, the **demand for Nile perch maw in east Africa has dramatically increased** during the last years due to overexploitation of other maw-providing fish species, e.g., sturgeon and croaker (Ben-Hasan et al., 2021; Kaelin, 2018).

6.3 Sustainability Hot Spot Assessment

6.3.1 Relevance scoring and indicator selection

Table 5: Relevance scores of categories in the Nile perch VC

Dimension	Category	Production	Aggregation	Processing	Distribution	Consumption
Environmental	Biodiversity	3.0	2.12	2.06	2.06	
	Water quality	2.88		2.47		2.35
	Synergy	2.76				
	Equipment	2.94	2.06	2.0	2.12	
	Carbon footprint	2.53				
	Water footprint	2.56		2.65		2.06
	Recycling & Food Loss	2.47		2.65	2.24	2.29
	Animal welfare	2.59		2.24		
Social	Access and use of resources	2.94	2.59	2.94	2.71	2.06
	Social values and diets	2.24				2.35
	Fairness	2.47	2.53	2.47	2.41	
	Co-creation of knowledge	2.71	2.47	2.71	2.71	
	Agency	2.59	2.47	2.59	2.47	
	Participation & Inclusion	2.29	2.12	2.53	2.41	
	Legal framework and institutional support	2.76	2.59	2.76	2.35	
Economic	Economic diversification	2.65	2.29	2.71	2.41	2.00
	Economic resilience	2.65	2.41	2.53	2.47	
	Connectivity	2.59	2.41	2.65	2.82	2.12
	Commercial viability	2.71	2.41	2.53	2.47	
	Economic benefits for all stakeholders	3.00	2.71	2.65	2.53	

Source: Own data, calculated from workshop with value chain actors and stakeholders in Jinja

Table 6: Top 67 indicators selected by stakeholders in the first stakeholder workshop

Indicator selection

Dimension	Category	Indicator 1	Indicator 2	Indicator 3	Indicator 4
Environmental	Biodiversity	Intact fish breeding grounds	Fish species diversity	Undersized/ Immature fish	Abundance of fish
	Water quality	Eutrophication	Heavy metals	Microplastics	
	Synergy	Water level	Benthic	Buffer zones	
	Equipment	Boats with/ without motors	Gillnets		
	Carbon footprint	GHG emission			
	Water footprint	Chemical inflows	Water use		
	Recycling & food loss	Use of non-fish waste material	Use of fish processing by-products		
	Animal welfare	Catching methods	Undersized/ Immature and oversized fish	By-catch	
Social	Access and use of resources	Access to boats	Access to gear	Access to fuel	Hygienic handling
	Social values and diets	Food and nutrition security	Tradition and identity	Cultural taboos and norms	
	Fairness	Fair employment	Condition of women and children	Profit distribution	Corruption
	Co-creation of know-ledge	Traditional knowledge	Horizontal exchange	Vertical exchange	Extension services
	Agency	Participation in trade union / association / saving group	Dependencies on other actors		

Dimension	Category	Indicator 1	Indicator 2	Indicator 3	Indicator 4
Social	Participation & inclusion	Inclusion of vulnerable groups	Participation in decision making		
	Legal framework and institutional support	Existence of legal framework and regulations	Enforcement of laws	Utilization of Permits	
Economic	Economic diversification	Processing	Different methods and fish species	Participation in the fish maw business	
	Economic resilience	Financial services	Non-fishing income/activities	Contracts	Governmental support 5[25]: Access to insurance
	Connectivity	Access to market information	Use of digital tools	Marketing channels	Market access 5: Trust
	Commercial viability	Capacities to compete sustainably	Market concentration/monopolization	Competitiveness with export market	
	Economic benefits for all stakeholders	Profitability	Price volatility	(Annual) income	Tax payments 5: Number of employees
Source: Own illustration, data obtained from value chain actors and stakeholders in Jinja					

6.3.2 Evidence-based indicator assessment

The evidence-based assessment of the selected indicators was conducted through expert interviews, FGDs, survey data, and secondary data review. Following the empirical assessment of the selected indicators, the research team condensed the findings into a single impact score which could either be low (1), medium (2), high (3), or non-applicable (0). We indicated a line (—) when there was no data available to evaluate the impact of the respective VC stage within the category which occurred a few times for the environmental dimension. Multiplying

25 For three categories, the stakeholders opted for five indicators, which are presented in the same column as indicator 4.

this impact score with the relevance score above, we identified a total of 14 sustainability hot spots.

Below, we give an overview of landing site characteristics as they are the framework of our data collection. Then, we present all 14 SHSs and the reasons they are significant as SHSs. For information on the non-hotspots that received lower relevance and impact scores, see Annex 21.

6.3.3 Characteristics of landing sites visited during the research phase

As a base for the indicator assessment, a checklist of landing site characteristics was completed for every landing site (see checklist and results in Annex 22). There four categories of landing site characteristics assessed are

1. management,
2. hygienic/protection standards,
3. infrastructure, and
4. connection/environment.

Three gazetted landing sites were targeted: Kasenyi, Kiyindi, and Nakitiba. At all these landing sites we observed adequate management conditions as all three had fish lifters/handlers, boats of adequate sizes, and official inspectors who kept regular and updated records, especially on fish catches. The three gazetted landing sites had adequate handling and storage facilities that facilitated the prompt removal of fish waste from handling surfaces. Handlers wore white coats and rubber boots. The area of work was fenced off, well roofed, had sinks supplied with clean, running water, and had toilets. Electricity, loading ramp/trucks, and a weighing station were available at all the three landing sites. Other active projects and social services like schools and hospitals were operational in the three landing sites. However, inadequacies in infrastructure were noted in the three gazetted landing sites. All three landing sites lacked a paved road. Nakatiba did not have an ice plant.

Conversely, the three non-gazetted landing sites were characterized by lack of infrastructure and a lower degree of organization. At Kisima 1, while fish catch statistics were being updated, there was no official fisheries inspector or officer to formally record routine data. This landing site had fish lifters and handlers, but the sizes of boats was illegal. Kisima 1 had only one toilet. It also lacked adequate handling/storage facilities; handlers did not have white coats and rubber boots; there was no fenced-off handling area; and no sinks with running water. Infrastructure components were not available at this landing site. While Kisima 1 lacked project support, some social services such as schools and hospitals were available.

At Masese, we observed the presence of boats of adequate sizes and an official landing site inspector who kept regular records on fish catches. However, lifters and handlers were inadequate. Although Masese had a toilet and workers wore white coats and rubber boats, it was observed that handling and storage of fish was inadequate and operations occurred in an unfenced area without a roof. Furthermore, Masese’s only infrastructure was a weighing station; it lacked an ice plant, a loading ramp, and connection to a paved road. Nonetheless, there was evidence of project support, but no visible basic social services such as schools and hospitals.

Nyoga landing site lacked fish lifters and handlers, but had boats of adequate sizes and an official landing site officer responsible for keeping routine fish catch data. Hygiene conditions at this landing site were unsatisfactory with only a toilet, no adequate handling and storage facility, workers not supplied with white coats and rubber boats, and no fenced operational area or sinks with running water. While Nyoga has electricity supply, it is not connected to a paved road and does not have an ice plant, loading ramps, or weighing station. There was evidence of project support and basic social services such as schools and hospitals.

6.4 Sustainability hot spots

Table 7 shows that the majority of the 14 SHSs are in the production stage. Only three SHS were identified in the processing stage. In the following section, we outline the SHSs and their impact scoring.

SHS 1: Biodiversity in the production stage

Selected indicators: Intact breeding grounds; Species diversity; Catch of undersized Nile perch; Abundance of Nile perch
Relevance score: 3.0 | Impact score: 3 | Sustainability Hot Spot score: 9.0

The SHS 1 (Biodiversity) for the Nile perch VC received the highest possible score of 9.0, highlighting the severity of biodiversity concerns in the production stage. The Nile perch breeding grounds are endangered by several threats that do not necessarily relate to fishing directly, particularly inflows from factories, human settlements, and agricultural activities (e.g., palm oil farming on Ssese islands) (JN3; KL1; KM4). However, fisheries also contribute to habitat destruction, for instance through use of illegal fishing methods. Often illegal nets, especially monofilaments, are cast close to shorelines and prevent Nile perch from breeding or they catch undersized juveniles (JN3; KA2; KL1; KY5; MA4; NY2).

Table 7: Sustainability hot spots along the Nile perch value chain at Lake Victoria

Dimension	Category	Production	Aggregation	Processing	Distribution	Consumption
Environmental	Biodiversity	**9.0 (1)**	4.2	**6.2 (2)**	4.1	n.a.
	Water quality	**8.6 (3)**	n.a.	0.0	n.a.	4.7
	Synergy	**8.3 (4)**	n.a.	n.a.	n.a.	n.a.
	Equipment	**8.8 (5)**	2.1	2.0	2.1	n.a.
	Carbon footprint	2.5	n.a.	n.a.	n.a.	n.a.
	Water footprint	—	n.a.	5.3	n.a.	—
	Recycling & food loss	2.5	n.a.	2.7	—	0
	Animal welfare	5.2	n.a.	0	n.a.	n.a.
Social	Access and use of resources	**8.8 (6)**	5.2	2.9	2.7	0.0
	Social values and diets	**6.7 (7)**	n.a.	n.a.	n.a.	2.4
	Fairness	**7.4 (8)**	5.1	4.9	n.a.	4.8
	Co-creation of knowledge	2.7	2.5	5.4	5.4	n.a.
	Agency	**7.8 (9)**	4.9	5.2	2.5	n.a.
	Participation & inclusion	4.6	2.1	5.1	2.4	n.a.
	Legal framework	**8.3 (10)**	5.2	2,8	2.4	n.a.
Economic	Economic diversification	5.3	4.6	5.4	2.4	0
	Economic resilience	**7.9 (11)**	4.8	**7.6 (12)**	2.5	n.a.
	Connectivity	5.2	2.4	2.7	2.8	2.1
	Commercial viability	5.4	2.4	**7.6 (13)**	2.5	n.a.
	Economic benefits	**9.0 (14)**	5.4	5.3	5.1	n.a.

n.a. = No assessment of impact during field research and SHS scoring due to low relevance scoring (< 2.0) by stakeholders

— No data available

Source: Own calculation, data from indicator assessment with value chain actors and stakeholders

This is particularly problematic since smaller fish have not yet reached the reproductive age (Kimani et al., 2018; MA4). In Nyoga, we observed undersized and non-motorized boats cast monofilaments only 2-3 m away from the shoreline (NY3).

Additionally, undersized Nile perch is often caught as by-catch during *mukene* fishing, which is conducted with small-meshed nets cast in pelagic waters. By applying such nets, very young Nile perch is caught and cannot be differentiated from the preferred *mukene* prey (KA4; KM3).

In total, almost all interview respondents were very concerned about the status of the breeding grounds (Likert scale: Average = 4.64 (n = 11), while 1 = strongly disagree that conservation of breeding grounds is important, 5 = strongly agree) and many called for better protection measures (KA2; KY6; JN5). On the other hand, knowledge about exact locations of breeding areas, breeding behaviour, and the connection between functional breeding and healthy fish stocks was observed to be very limited in FGD with the fishers (KS3; MA4; NA1; NY1).

The biodiversity and resilience of the Lake Victoria ecosystem was affected, in essence, by the artificial introduction of Nile perch in the 1960s and the boom of its population in the middle of 1980s (Witte et al., 2007). Lake Victoria used to have a large variety of fish species, particularly of haplochromine cichlids. Before the increase of the Nile perch population, there were more than 500 species of these endemic cichlids and many of them are extinct, being a prey for Nile perch.

However, after the massive fishing activities focusing on Nile perch in 1990s, the equilibrium between the species is now being restored (JN3; Witte et al., 2007).

Overfishing of Nile perch stocks became an issue shortly after Nile perch were targeted by commercial and export-oriented fisheries in the 1990s (Mkumbo et al., 2007). Lack of management and low enforcement of fishing regulations have resulted in permanent, high pressure on Nile perch population in Lake Victoria (Kimani et al., 2018; NPFMP2, 2015). The latest introduction of strict rule enforcement (regarding legal fish size, permits, boat size) by the military's FPUs has led to recovery of Nile perch populations (JN3; JN5; KA2). The research institute NaFIRRI found that the lake-wide stocks of Nile perch above 10 cm rebounded to 457,000 tons in Sept 2017 after being at their minimum of 393,000 tons in August 2016 (LVFO, 2019; JN3).

Despite this apparent growth of the stocks, Nile perch catches are at their historical minimum and experienced a recent breakdown in January 2021, which was acknowledged by all VC actors (e.g. KA1; KA4; KS3; KY7; KY9; MA4; NA1; NY2). Almost all respondents answered that they were very concerned about the decline of fish abundance (Likert scale: Average = 1.79 (n = 14), while 1 = Sharp decline of fish abundance, 5 = Sharp increase). Reasons for this decline are the ongoing eutrophication of the lake (see SHS 3) and the use of illegal fishing gear and the subsequent catching of undersized fish (see SHS 5). These effects are intensified by the drastically increase in number of fishers and boats over the last 10 years. This puts even more pressure on all fish populations; the catch methods applied and increased capacities further exacerbated this problem (JN6; KM2; KM5; NY3). For example, the District Fishery Officer of Ssese islands summarizes:

> *Too many people, too much capacity. Nowadays in Kalangala, we have 4,000 boats. At some point we had 1,000—with even less capacity, less nets, no engine.* (KL1)

SHS 2: Biodiversity in the processing stage

Selected indicators: Intact breeding grounds; Species diversity; Catch of undersized Nile perch; Abundance of Nile perch
Relevance score: 2.06 | Impact score: 3 | Sustainability Hot Spot score: 6.18

The processing stage is a SHS in biodiversity, mainly due to two reasons: (1.) the industrial export-oriented processing sector is focused on Nile perch as its almost-exclusive export commodity and, consequently, puts much pressure on producers. (2.) The artisanal processing sector absorbs undersized, immature Nile perch that have been illegally caught and rejected by factories.

In contrast to the production stage, the processing sector is only interacting to a limited degree with the natural environment of Lake Victoria. The pressure on the biodiversity and depletion of Nile perch stocks is, therefore, caused indirectly through the business relations and economic pressure exerted by the export business and discharged upstream the VC upon the fishers (see SHS 12). As a result of overfishing, the Uganda Fish Processors & Exports Association (UFPEA) imposed strict restrictions for minimum Nile perch size on the factory processing sector, even before it was implemented by the Fish (Fishing) Rules in 2010 because they saw themselves confronted with the collapse of Nile perch fish stocks in the late 2000s (KM5). Although today they strictly reject and trace undersized fish supply, their demand for the resource is relentless (KM3). In addition, the fishers and middlepersons are economically dependent on factories through a system of loans and investments (see SHS 9).

Artisanal processing also contributes to non-compliance of fishing rules since its actors provide wide marketing channels for undersized Nile perch. Captured fish that would be rejected by factories are diverted from gazetted landing site and bypass through smaller landing sites (MA7). Undersized Nile perch are commonly seen at roadside stands as well as in fish markets, predominantly smoked or salted (JN3; KY6).

It can be argued that the remaining VC stages also contribute to high resource pressure on Nile perch stocks. The consumption stage has an especially significant influence, in both target markets: in the export countries, consumers are inflating demand for filet and, in the local market, Ugandans are driving up demand for undersized fish (KY5; NY2). The latter group has no reasonable alternatives because of the lack of affordable fish and other proteins in legal markets (KS3).

SHS 3: Water quality in the production stage

Selected indicators: Eutrophication; Heavy metals; Microplastics
Relevance score: 2.88 | Impact score: 3 | Sustainability Hot Spot score: 8.65

Water quality is a SHS in the production stage since it has a crucial influence on fish health, quality of breeding grounds, and an associated abundance in Nile perch stocks. Besides that, particularly fishers are interacting with the lake environment and are severely affected by pollution.

The eutrophication of Lake Victoria has been on-going since the 1960s and reached its peak in the 1990s[26]. Although long-term monitoring data is not available, the last nutrient assessment in 2018/19 showed a considerably improved (yet equally alarming) state over the 1990s when the invasive water hyacinth was covering the the lake's larger bays (Deirmendjian et al., 2021; JN3). After controlling the hyacinth invasion biologically, nutrients were absorbed by algae that then experienced a bloom (JN3). High prevalence of algae and its decomposition deplete the oxygen content in specific layers of the lake. In periods of no winds, deeper water layers become hypoxic (JN3). When the water then suddenly mixes (e.g., due to seasonal storms) the low oxygen availability can paralyze large fish like Nile perch that require high oxygen contents due to its large and fast-moving metabolism. Following the research institute NaFIRRI, the consequence is

26 The eutrophication of Lake Victoria became an issue in the 1960s due to a sharp human population increase which densely populated the lakeshorelines. Most of the human settlements at Lake Victoria and its inlets had no basic sewer or water treatment system. Consequently, human waste flowed into the lake and caused eutrophication.

devastating fish kills, as seen in January and February of 2021 (Deirmendjian et al., 2021; JN3; KY5; Olokotum et al., 2020).

Heavy metal inflows in Lake Victoria have not been recorded in very high or concerning quantity so far (JN3); however, mercury inflows from gold mining occur (Arinaitwe et al., 2020). This endangers Nile perch since, as a top predator, it bioaccumulates the mercury loads of all its prey species (Arinaitwe et al., 2020; JN3; KM5). In addition, large Nile perch individuals are often traded informally in the artisanal market to local consumers after maw extraction; this marketing channel does not uphold the rigorous quality controls applied to exported fish. This is particularly dangerous in large, older fish, which bioaccumulates even more heavy metals during its lifetime (Arinaitwe et al., 2021; JN3). Some fishers during FDGs also complained about factories that release chemicals along the shorelines and cause fish kills in the surrounding waters (KS3; MA4).

Microplastic pollution from the breakdown of plastics from monofilaments nets, gillnets, and lakeshore human settlements is becoming a concern in the Lake Victoria ecosystem (Badamasi et al., 2019; FG3). While all VC stages could be affected by microplastics, since it bioaccumulates in fish and affects the health of the fish stocks and their habitat, microplastics are currently understudied and have only recently become a focus of research (JN3).

Other VC stages are affected by the degradation of the water quality as well, since the vigour of the VC depends on the health of the fish stocks and their habitat. However, they are not influenced or influence it to an extent that it scored a hotspot.

Figure 20:Polluted lakeshore area (left) and truck with charcoal (right)

Source: PhotoVoice participants

SHS 4: Synergy in the production stage

Selected indicators: Water level; Benthic; Buffer zones
Relevance score: 2.76 | Impact score: 3 | Sustainability hot spot Score: 8.29

Synergies within the agroecological framework describe the way VCs interact with their environment (Wezel et al., 2020). Fishers are highly dependent on and have a close connection to the lake, since they extract its natural resources, live at its shores, and relate their traditions and beliefs to it (Cepić & Nunan, 2017). Therefore, the production stage is a SHS in the synergy category, but not the other VC stages.

During the last few years, Lake Victoria has experienced a dramatic rise in water levels—an estimated 1.5 m (EN1). So far, the causes and effects of this development on the ecosystem are little understood. However, the consequences for fishing communities are severe: the lake flooded many settlements and landing sites and some residents have been displaced. Nile perch and other fish species migrated from their established habitats to other areas and their spawning grounds have been disturbed (JN3; KA3; KL1; KY5).

Figure 21: Flooded settlement at Nakatiba landing site

Source: Eva Kirmes

The research institute NaFiRRI concluded that the causes of this phenomenon are most likely the loss of buffer zones around the lake and its catchment areas (JN3). Due to population growth, deforestation of riparian vegetation for farmland

and settlements, and the swamp drainage, rainwaters from the catchment areas cannot be stored and run off directly into the lake (JN3).

The chairperson of the fishers association AFALU remembers that:

> *30 years ago, first of all, we had a lot of forests. You know, on the Lake Victoria, it could rain almost every day because of forests; nowadays: deforestation. In the past, many years ago…, you could just walk into the water, just a few meters underwater, young fish were playing around you. (KM2)*

The rising water levels and degradation of water quality described above (see SHS 3) also affect the benthic zones of Lake Victoria. Benthic zones are important breeding grounds for Nile perch. Flooding, eutrophication, and pollution of the benthic zones affects the diversity and abundance of invertebrates, which are prey species of various fish species in the lake (Sekiranda et al., 2004; Van Bocxlaer et al., 2021).

SHS 5: Equipment in the production stage

Selected indicators: Boats with/without motor; Gillnets
Relevance score: 2.94 | Impact score: 3 | Sustainability Hot Spot score: 8.82

Gillnets are the most frequently used type in Lake Victoria. Use of illegal gillnets (e.g., small mesh-size (< 6 inches) and/or monofilament nets) are major problems in Nile perch management (JN3; Cepić & Nunan, 2017). Illegal nets are widely regarded as one, if not the major, threat to Nile perch, as also reflected by the high Likert scale scoring it received in our survey. The vast majority of interviewees judged that their use has a highly negative effect on the Nile perch stocks (Likert scale: Average = 1.4 (n = 15), while 1 = very negative effect, 5 = very positive effect).

Monofilament and undersized nets have adverse effects on Nile perch stock reproduction as they catch immature fish, leave non-biodegradable microplastics in the lake, and, therefore, have longstanding effects on the ecosystem (Cepić & Nunan, 2017; JN3; KS3; KY5). Although they are strictly forbidden and the rules are enforced by the FPUs, many fishers still cast illegal nets as livelihood and nutrition strategies, especially during times of fish scarcity (KS2; NY2). Interviewees also said that lack of awareness of the ecological consequences and lack of social pressure invigorates the problem: rule non-compliance is widely accepted in fishing communities and not condemned (Cepić & Nunan, 2017). This non-compliance is thought to be rooted in government's strategy to enforce fishing rules (Fish (Fishing) Rules, 2010; NPFMP2, 2015) among fishers, while ignoring the supply source of the illegal gear. Illegal gillnets are widely available in local shops, smuggled into the country, and produced in Uganda (KA3; NA1; NY1). Fishers feel unfairly treated being imprisoned and punished by the military repeatedly (KS2), while well-connected people close to the government are not prosecuted as one interviewee shared, "People who import them [the illegal gears] have another status" (KM5).

The second indicator was boat with or without motors (as a determinant of boat size). Small, light boats cannot operate with a typical outboard motor since those suck such boats into the water. The legal boat sizes (> 28 ft.) are those that can operate with a motor and, therefore, go farther out in the lake, beyond Nile perch breeding grounds at the shoreline (KL1; NPFMP2, 2015). At the landing sites, almost all boats are of legal size and have motors; however, illegal small boats, propelled manually with an oar, can often be observed fishing close to the shorelines (KL1; MA7; NY3).

Though other VC stages within this category have not been scored as SHSs, they contribute to economic pressure to overexploit lake resources, e.g., high export demand creates shortages of Nile perch for the local market.

SHS 6: Access and use of resources in the production stage

Selected indicators: Access to boats; Access to gears; Access to fuel; Hygienic handling
Relevance score: 2.94 | Impact score: 3 | Sustainability Hot Spot score: 8.82

We suggest a high impact score for this indicator because fishers reported having lost their access to their own boats as a result of new (2017) requirements for minimum boat size (MA4). Most fishers have access to fishing gear (between 80 – 100 % of fishers at all landing sites), but don't own it themselves (e.g. in Nakatiba, only 14 % of the consulted fishers own their own fishing gear, 29 % in Nyoga). However, most of the those who do not own fishing gear are supplied with it by the boat owner. There was a visually noticeable correlation between infrastructure availability at gazetted landing sites and monopolisation of the industry with fewer fishers owning their own boat and gear at these sites (see Annex 22).

Distance to the nearest fuel station is far at many sites, especially for island landing sites (e.g., about one hour travel time from Nyoga landing site was reported by fishers). Even more problematic is the high fuel cost (KS2; KA3; NY1). As fuel is in short supply, respondents expressed frustration when seeing the military consuming huge amounts of fuel with their outboard engines on the lake (KM2; KM4).

For the indicator "Hygienic handling", we noted a great difference between gazetted and non-gazetted landing sites. While all six landing sites have toilets, the non-gazetted landing sites Masese, Kisima 1, and Nyoga lack sinks and use lake water instead of tap water (KS3; NY1). Also, at the non-gazetted landing sites, we observed inadequate handling and storing, sometimes observing fish left on the floor and slow waste removal. Storage conditions vary by the status of the landing site (gazetted/non-gazetted): Masese, Kisima 1, and Nyoga lack rooves, ice plants, and fenced-off storage/processing areas (see Annex 22; KS3; NY1). Nevertheless, Masese, as a non-gazetted landing site, shows certain characteristics of gazetted landing sites: it has a roof and weighing station and some workers wear coats and rubber boots, which is not the case for Kisima 1 and Nyoga.

In the processing and distribution stage, we scored this category with 1 due to strict hygienic standards forced by the export markets (EN1; KM3). Furthermore, the location in cities, especially for the industrial processing, enables easy access to resources (EN1; KM3). In the aggregation stage, we scored it with 2 because transport from island landings sites is challenged by a need for cooling facilities suited to the infrastructure at the landing sites (NA2; NY2).

Figure 22: Boots and icing of Nile perch as indicators of hygienic handling practices at the landing sites

Source: Lukas Eichelter and Eva Kirmes

SHS 7: Social values and diets in the production stage

Selected indicators: Food and nutrition security; Tradition and identity; Cultural taboos and norms
Relevance score: 2.24 | Impact score: 3 | Sustainability Hot Spot score: 6.71

This was given an impact score of 3 based especially on the indicator "Cultural taboos and norms", to a lesser degree on "Tradition and identity", while "Food and nutrition security" was not considered problematic in this context.

The main cultural taboo concerning fishing is the prohibition of women on or close to fishing boats and their participation in fishing activities as described by one interviewee:

> *… like I told you, fishing is labour, very labour intensive and is mainly done at night and the nature of a woman, a woman is a weak person and also most of these women their husbands cannot allow them to be outside home with other men for fear that they may fall victim of being taken for sex. And then in some traditions, some ethnic groups believe that if a woman touches fishing inputs or nets, that net may fail to catch fish. We have some landings where women are not allowed to go there. They must stay very far away. So, they have to use someone else to transact what they want to do. And then… some tribes women are not allowed to eat certain species of fish like protocteras…* (JN3)

Other interviewees suggested women are not always taken seriously in business, especially in the lucrative Nile perch VC (KY8) and may be pressured to exchange sex for better access to fish (Medard, 2012). As a result, women are mainly involved in the processing and distribution stages of the VC and the few who do not align with these norms and go fishing are exposed to "gossip", which stereotypes them in their communities (NA2; Nunan & Cepić, 2020). In the processing and distribution stages, women are highly valued because employers attribute trustfulness and conscientiousness to them (KM3; Nunan & Cepić, 2020). The BMUs (for further explanation see SHS 9) were seen as a potential platform for women's representation in the VC because women representatives successfully reached other women through their networks (Nunan & Cepić, 2020).

An aspect under *"Tradition and identity"* that supports high scoring for this indicator in the production stage is the tragedy of the commons often experienced when actors do not exert a sense of ownership over natural resources. Interview partners mentioned many actors have an exploitative mentality and come to the lakeshores for short-term profit, but do not consider long-term environmental aspects (KS3; KM2; KM4).

One of our interview partners added:

> *My grandfather and my father wouldn't allow me to catch a small fish. My grandfather they would beat me, and I was beaten indeed: Why are you catching that one?... What are you going to eat tomorrow? The other day? Leave it! Leave it! So, they had that ownership at that time... which is lacking now. Now, how can we create that ownership for the owner of the boat, the owner of the net to say that the small fish [we] don't catch it?* (KM4)

The indicator "Food and nutrition security" is not an issue because, due to its smell, Nile perch is not locally preferred (JN4) and does not contribute significantly to food and nutrition security in Uganda, despite most respondents indicating they eat fish (mainly Nile tilapia) at least twice a week and some everyday. Nevertheless, changes in Nile perch consumption patterns may arise due to the new law on fish maw which will see Nile perch arriving in local markets as a by-product of the rapidly growing maw trade.

SHS 8: Fairness in the production stage

Selected indicators: Fair employment; Condition of women and children; Profit distribution; Corruption
Relevance score: 2.47 | Impact score: 3 | Sustainability Hot Spot score: 7.41

This category was scored with the highest impact score, especially because of the indicators "Profit distribution" (which at the production stage is linked to "Fair employment") and "Corruption". Employment at the landing sites is shaped by relations between fishers (who are crew members) and boat owners. In this relationship, the profit distribution disfavors crew: after the costs of petrol, gear, licensing, and boat maintenance costs are deducted from the net product, the boat owner normally keeps 50 % of the remaining money and the two or three crew members combined receive the other half (JN3; NA1; NY1). Many regard this as very little, considering the risk the crew take on their 12-hour overnight shifts on the lake. According to interviewees, the highest profiting VC actors are traders and factory owners (KA2; NY2; MA4; NA1) and many don't consider their business profitable anymore (KA3; KS 4; KA4).

Corruption is widely reported and influences business negatively: 10 out of 12 respondents indicated that corruption influences their business to a high or a very high degree (Likert scale: Average = 4.08 (n = 12), with 1 = very low influence, 5 =

very high influence). Although corruption was mentioned in relation to many VC stages and actors, we observed a tendency toward the production stage (KY6; MA6; KS1; KA2; NY2). Lake patrols were repeatedly associated with corruption (NA1; KA4), with sale of confiscated fish (MA5) and selectively applying punishments on the lake (KS3; NY1) being reported. Corruption also seems to be involved with the import of illegal nets into the country (JN5; NA1).

Children work in the fishing sector: 42 % of respondents knew of children working in the industry (KY5; JN4; KS4). School closures during the Covid-19 pandemic has seen children's participation in the industry increase as they accompany their parents, for example, to cast nets on the boats or to push the boats into the water (KY5; MA4; NY2; JN5). This is not always seen negatively because "the level of unemployment in youths is very high so someone instead just… sitting at home they would rather come and work here and then they go back with some little money to have a life" (KM1). As reported in the category "Social values and diets" the conditions of women's participation in the industry is shaped by uncertainties, less access to employment, and less power within the sector (NY2).

Within the other VC stages, corruption was less-frequently observed; in fact, many aspects of employment and sales in those stages are regulated through formal contracts.

SHS 9: Agency in the production stage

Selected indicators: Organization; Dependencies
Relevance score: 2.59 | Impact score: 3 | Sustainability Hot Spot score: 7.76

Organization is an issue from the local to the national level. At the landing sites, some actors have saving groups that count as credit and savings associations (NA1; NY1; NY2; KY5). Within a rotating system, a small amount of money is collected weekly from every member and disbursed to another member after a certain time (NY2; JN6). These groups are uncommon at the landing sites and don't connect other actor groups (KA3), but are most popular with women as a tool to support each other (JN6; Nunan & Cepić, 2020). On a broader institutional level, there are organizations for fishers like AFALU which unites fisherfolks and the Ugandan fisheries and fish conservation association (UFFCA) which does advocacy work, but they are few and have little influence (KM4; KY5)

It was thanks to the influence of UFFCA that, in the early 2000s, BMUs) were established to organize fishing at landing sites through efforts such as fishers/traders' registration, keeping beaches clean, and participating in patrols with government officers (Barratt et al., 2015; KM4; Nunan & Cepić, 2020). As they included many different actors and had a quota for women, they had the potential to represent the voices of the people at the landing sites (Nunan & Cepić, 2020; KM4). But respondents claimed that political responsibility was never given to them (KM4) and "politician[s] came in trying to influence who should be up elected" (KM2). In 2015, BMUs were abolished by the president justified as an official response to corruption (Nunan et al., 2018).

The other indicator "Dependencies" is mainly shaped by fishers' great dependencies on boat owners. As small boats are not allowed to fish on Lake Victoria anymore, many fishers do not own a boat and cannot afford the gear, "so, from being... independent fishermen on a small boat they switch now to being dependent on a boat owner" (JN3; similar in NA1; NY1). The fishers we interviewed in FGDs agreed on being strongly dependent on boat owners (MA4; NY1).

But, to a lesser degree, boat owners are dependent. They rely on fish traders (MA4; NY1; NY2) as well as fishers (KA1). When no fish is landed boat owners and traders do not gain capital on their investments in boats, equipment, or loans made to secure the delivery of fish exclusively to them (KY6). Several traders and boat owners reported that fishers sometimes sell fish while they are still aboard, instead of bringing it to the trader or boatowner at the landing site (KY6). On a Likert scale, participants from all VC stages indicated high dependencies on other VC actors (Likert scale: Average = 4.25 (n = 12), while 1 = very low dependencies, 5 = very high dependencies).

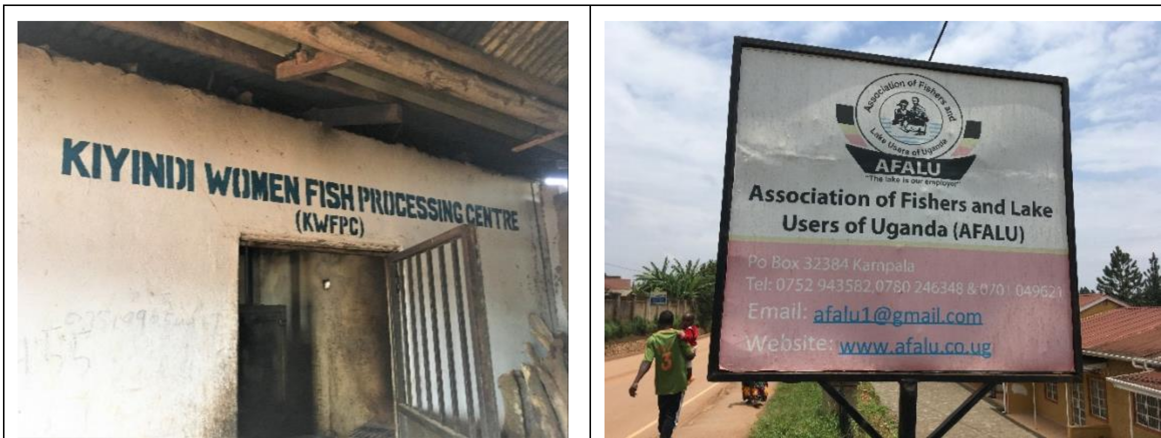

Figure 23: Building of a women's fish processing association and head quarter of AFALU in Kampala

Source: Eva Kirmes

As high dependencies imbalance market power and low organization levels both affect fishers wellbeing, we scored the category "Agency" in the production stage with the impact score 3.

SHS 10: Legal framework in the production stage

Selected indicators: Existence of legal framework; Application of laws; Permits
Relevance score: 2.76| Impact score: 3 | Sustainability Hot Spot score: 8.29

In general, the legal framework for fishing in Uganda is quite progressive and well-coordinated through LVFO/DFiR and export standards force strict regulations within the industrial processing sector. At the production stage, permits for all main VC actors and boats are required (Fish (Fishing) Rules, 2010) and complied with by fishers, boat owners, and fish and maw traders: 94 % of the respondents stated that the boats they use for fishing are licensed and 81 % of the fishers possess a fishing license (n = 31) The reasons for scoring this category with the highest impact score for the production stage lie in the other two indicators: "Existence of legal framework" and "Application of laws".

After a great recession of Nile perch populations in 2006, the private sector, through UFPEA, demanded a clear management framework and, in cooperation with LVFO, the Ugandan government enacted a law on the minimum size of caught Nile perch (KM5). The statutory instrument enacted in 2010, the Fish (Fishing) Rules, regulates Nile perch fishing in Uganda and includes policies such as the restriction of use of mesh gillnets on Lake Victoria of less than five inches, the prohibition of certain nets like monofilament nets and trawl nets, and the prohibition of fish sales before landing or without license or permit (Natugonza et al., 2020). Since 2017, fish maw extraction and trade has been guided by the Fish Assurance Rules which focus mainly on handling and processing conditions. They cover determination of processors' and exporters' license costs and provide movement control for the export and import of maw (Natugonza et al., 2020).

Despite these recent changes, many respondents complained about lack of regulations and ill-advised priorities: They feel that the Ugandan government should stop promoting fish supply to factories, support local markets, and better control factory waste water inflows (KA3; KA4). Interviewees requested a framework that favors community management structures and financial support tools similar to those offered to other agricultural sectors (KM2). AFALU and LVFO both recommended more robust and clear penalties for illegal fishing practices, because they do not "hurt" enough and can be easily paid off as fines (JN5; KM2).

The biggest challenge identified by respondents at this level is the execution of laws, particularly in relation to FPU patrols (JN3; JN5; KM2; NA2). In Uganda, comprehensive operations have been conducted to curb illegal fishing activities on Lake Victoria since 2017 (Kantel, 2019). The FPUs have the power to search boats for undersized fish and small maw and to ban and confiscate destructive fishing gear (Natugonza et al., 2020). Implementing this has seen a decrease in juvenile Nile Perch in local markets (Natugonza et al., 2020). Most respondents stated that the introduction of FPUs was necessary, but has only a small positive environmental impact and is not a long-term solution (KM4; KM5; NY2). They also note that practical implementation is not effective and costly (KM4) and that enforcement efforts should target more influential people whose activities have a noticeable effect on the lake, rather than targeting subsistence fishers (KA3; KA4). Of 20 interviewees, 16 indicated they feel restricted by laws in their fishing activities (KA3; MA6; NA1; NY1).

The processing sector was not identified as a hot spot due to the industrial sector's stringent adherence to minimum landed fish sizes at gazetted landing sites and hygiene standards to meet foreign trade obligations (EN1; KM3; KA2; KY5; NA3).

SHS 11: Economic resilience in the production stage

Selected indicators: Financial services; Non-fishing income/activities; Contracts; Government support; Insurance
Relevance score: 2.65 | Impact score: 3 | Sustainability Hot Spot score: 7.94

In terms of economic resilience, the production stage of the Nile perch VC is not able to access formal financial services. This increases dependency on informal cash or in-kind credit offered by boat owners or middlepersons (SHS 11). In our study, we found that 78 % of the respondents at the production stage rely on fishing as their main economic activity. In an interview with fishers at Nyoga landing site, the respondents asserted that "almost 90 % of the fishers depend exclusively on fishing while some few also work in the palm oil factory as casual workers". This makes economic resilience a challenge as more people come to rely on fishing and overexploit lake resources (KL1). In addition, two important pillars of economic resilience were absent at the production level of the VC: contracts and insurance.

The category "Economic resilience" was also assessed using the indicator "government support". Some respondents said they do not receive support from the government and feel the government exploits them (NY1; KS3). Yet, others conceded the government supports them through extension services, e.g., in the form of knowledge exchange:

> *Yes, the government has now really improved our fishing and has given us a lot of knowledge on handling trading, we have now shifted from the ancient business away, and we are now doing at least a modern business. Because now the government has encouraged us to handle the fish well, maintain hygiene, give us licenses/permits.* (KY9)

SHS 12: Economic resilience in the processing stage

Selected indicators: Financial services; Non-fishing income/activities; Contracts; Government support; Insurance
Relevance score: 2.53 | Impact score: 3 | Sustainability Hot Spot score: 7.59

At the processing stage, factory agents are formally contracted to stipulate the quality and quantity of Nile perch with retained price information because of high price volatility. In an expert interview, it was argued that "the one who offers the highest price takes the catch" (NA3). Owing to this fact, quality assurance mechanisms are imperative in fisheries and prices vary from one supply to another because of the latent perishability of the Nile perch.

More so, there is very low-income diversification in factory processing (KM3). The only type of fish processed for the international export market is the Nile perch; the dependency is consequently high. In addition, fish factories have high fixed costs and are in constant need of Nile perch supply, especially in times of resource scarcity. The availability of raw Nile perch has never been as low as now, according to a factory manager from Entebbe (EN1). Indeed, the processing capacity of Ugandan factories is with 540 tons per year far exceeds the actual processed volume (64 tons in 2016) (Kimani et al., 2018). Despite this, abandoning the business is too risky for processors because of their high investments and fixed costs (KM3).

The high cost of the current crisis in the Nile perch value chain underscores the need to strengthen its resilience. However, the empirical evidence revealed that the category "Economic resilience" at aggregation, distribution, and consumption did not score an SHS. For instance, there were many reasons why contract arrangements were not concluded between fishers and aggregators or distributors. One of the reasons is the uncertainty of the Nile perch catch. This was ascertained by KY3 who argued that "there is no formal contract between him and the fishers, but it is just a matter of trust, so it is informal even at the factory level; it is just a matter of trust; we do not have a contract with them" (KY3).

SHS 13: Commercial viability in the processing stage

Selected indicators: Capacity to compete sustainably; Market concentration/ monopolization; Competitiveness with export market
Relevance score: 2.53 | Impact score: 3 | Sustainability Hot Spot score: 7.59

The majority of the respondents were confident about the quality of fish filets that enter the European and Middle Eastern export markets. To confirm quality assurance of Nile perch exported to international markets, a key informant commented that "we look at the eye color, we also consider a lot of features before we award a tick for export" (KA2).

The indicator "Market concentration/ monopolization" generated interesting findings. Actors, who have concentrated market power are likely to dominate the market. KA4 ascertained that "there is someone who has concentrated a lot of power in the market and the others are dependent on him or her… For instance, they want us to take all the fish to the fish factories/industries" (KA4). In the Nile perch VC those powerful actors, most likely the factories and export companies, who have financial resources are seen as the most profitable (KA2, KA4, KS3, KY5, KY6, KY7, KY9, MA4, NA1, NA3).

At the same time, the industrial processing sector is almost exclusively run by native South Asian factory owners, who also hold the majority of seats in the processors and exporters association UFPEA (KA4, KM5). Many actors in the Nile perch VC believe that they form a sort of closed business elite and prevent Ugandans from entering this profitable market sector (KA4, KL1). The chairperson of a fish traders at one landing site summed up that "all [factories] are owned by the Indians and they monopolize the business and even government is on their side" (KA4). A former UFPEA chairperson explained that entering the industrial processing and export sector requires a good network since high initial capital investments and official approvals are needed. Besides that, South Asian businesspeople are very engaged and well-connected in many Ugandan industry branches and additionally have advanced fisheries and business-related education (KM5). In order to bridge this gap, employing more Ugandans in leading positions would be a step forward. This is also in the interest of factory owners, as they benefit from the local knowledge of Ugandan employees (KA4, KM5).

The last indicator under the "commercial viability" category is "capacities to compete sustainably". It was perceived that the government of Uganda needs to streamline the sustainability of fisheries to improve competition, starting by addressing illegal fishing gear imported into or produced in Uganda that deplete the lake.

Figure 24: Closed factory (left) and woman paying fisher at Kiyindi landing site (right)

Source: PhotoVoice participants

NY1 stated that

> *these nets [monofilament] are more affordable by fishermen and have more catch than the legal ones because they pick all sizes. The legal framework should put in place an effort to streamline sustainable fishing and ban the importation of illegal fishing nets. Government should also support fisheries by making fishing inputs more affordable for the ordinary fishermen and provide alternative livelihoods to fishermen to promote sustainable competition.* (NY1)

On the other hand, the category "commercial viability" was not relevant to the rest of the VC actors/levels, except processing, since the upstream Nile perch VC actors have alternative market channels to sell their catch. Therefore, competitiveness with the export market is irrelevant and has no impact on their market.

SHS 14: Economic benefits in the production stage

Selected indicators: Profitability; Price volatility; Income; Tax payment; Number of employees
Relevance score: 3 | Impact score: 3 | Sustainability Hot Spot score: 9

The assessment of these indicators resulted in one of the highest hot spot scores at the production level. The basic survey data provided evidence that 75 % of the production chain actors do not earn sufficient profit.

Furthermore, KS3 added that the

> *closing down of the factory has exploited fishermen, because the processors get the fish maw, get the bones, they get the filet, they get the skin, literally the get everything even including fats/oil, so the processors benefit more than any other Nile perch chain member.* (KS3)

These findings correspond to the study by Kimani et al. (2018*)* who discovered that economic benefits are a key constraint particularly at the production stage of the Nile perch. A profit analysis showed that fishers need to reach a considerably higher number of fish per month per person to break even. While they need to handle 18 kg/month/person, middlepersons break even at 1.5 (factory agent) and 4.7 (monger) kg/month/person. This shows that fishers are especially threatened in times of Nile perch scarcity. Also, the results of our quantitative survey suggest fishers and boat owners are particularly threatened, since they tend to be the lowest income group (especially crew members) in the VC and do not have a formal safety net, like insurances and contracts. Crew members in our sample (n = 22) earned an average of 65,000 UGX ($18.20 US) on a successful day, but only 5,300 UGX ($1.50 US) on unsuccessful days.

Boat owners carry high risk, since they shoulder fixed and operational costs. If a trip is unsuccessful, they carry the financial loss themselves, which pushes them to accept middlepersons' and factories' informal loans and investments (KY6; NA2; NY2).

The other VC stages also have low economic benefits in times of Nile perch scarcity; however, losses do not affect them as dramatically. Middlepersons have lower fixed costs than producers and are often financially secured through factory companies. The processors also face challenges during recessions, but in times of stable Nile perch supplies, their business is very profitable, allowing them to rebuild financial reserves (KM3; KM5).

7 Discussion

7.1 Trends in the Irish potato and Nile perch value chains and the way forward

7.1.1 Potato VC

Our results confirmed existing evidence found in the literature and unveiled new challenges and untapped potentials in the Irish potato VC in the Mt. Elgon region.

At the farm and production level, we found soil health, including soil fertility and erosion, to be of growing concern. Diseases such as late blight and bacterial wilt are very common and the two management options to effectively combat them are fungicides/pesticides or purchasing clean qualified potato seeds such as rooted apical cuttings (RAPs). The latter one is, so far, rarely adopted by farmers and unaffordable. An average potato farming household saves a monthly equivalent of 105,400 $\pm$ 24,000 UGX ($29 $\pm$ $7 US), all income sources combined, which makes farm investments generally tricky.

Little organic fertilizer is used and little awareness about organic pesticides, alternative pest control, and their impact on soil and agroecosystems currently exist among potato farmers. We suggest that good and effective agricultural practices to prevent and mitigate soil erosion, improve fertility, and boost soil health requires further exploration and scaling up (see section 7.3.1 for agroecological potential of potato farming in Uganda). GAPs established by the FAO (Lutaladio et al., 2009) in other African countries (GIZ and CIP) for potato farming could be explored (Harahagazwe et al., 2020).

In Table 8, we compiled a summary of GAPs that could be relevant for improving the sustainability of potato farming in Mt. Elgon region. To address the most pressing issues mentioned above, such as soil health and fertility, Lutaladio et al. (2009) recommend applying organic fertilizers, such as farmyard manure, where available and appropriate. This should be well-decomposed and used at a minimum rate of 10 tons per ha. The utilization of incompletely decomposed manure risks compromising dry matter content and crop maturity, as well as spreading diseases. In addition, if manure and inorganic fertilizers are used at once, it is important to reduce the amount of nitrogen applied by 30 %, as too much nitrogen may impair the formation of tubers (Harahagazwe et al., 2020; Lutaladio et al., 2009). According to Harahagazwe et al. (2020), an adequate use of chemical fertilizers, in parallel with organic ones, promotes good growth of potato plants. However, inorganic fertilizers should be applied first and mixed well with the soil, before planting the seed potato, as a direct contact between the two may risk burning the sprout (Harahagazwe et al., 2020).

Table 8: GAPs for potato farming

GAPs	Characteristics/Properties
Crop rotation	▪ Potatoes can be the first crop in a rotation. They can also be grown after cereals and before legumes ▪ Rotation helps to reduce the risk of pests and diseases, and manages weeds
Soil preparation with minimum disturbance	▪ Reduction of tillage practices improves soil drainage and aeration ▪ Helps to restore degraded soils and improves yields by reducing soil degradation, erosion and nitrate leaching
Spacing	▪ Variety and size of the tubers determine the spacing, density and depth of planting ▪ Planting of seed potato produces a dense canopy that curbs weeds
Manure and fertilizer application	▪ Applying manure before planting ensures a good nutrient balance and protects the soil from erosion and compaction ▪ Fertilizer application at the plant roots is most effective and the NPK ratio 1-1-1 helps to prevent tuber spoilage
Weeding and hilling up	▪ Always keep the seed potato clean from weeds to reduce the risk of pest and diseases and improve water and nutrients uptake by the crop ▪ Good hilling (with ridges of 45 cm) increases numbers of tubers and yields
Diseases and pest management	▪ Planting healthy and clean seed potatoes and growing potatoes in rotation with recommended crops (e.g., maize and barley) help reduce pests and diseases ▪ Reduce or remove weeds around the tubers as they can transmit viruses
Roguing or "negative selection"	▪ Roguing is carried out by inspecting, identifying and removing abnormal plants in the potato field ▪ An important practice to assure the production of good quality seeds
Dehaulming	▪ Dehaulming consists of removing potato shoots before the plant is fully mature to obtain larger yields of small to medium-sized seed tubers ▪ It fortifies the skin of the tubers to prevent from damages during harvest, transport and storage
Harvesting, sorting and grading	▪ Potatoes are ready to be harvested when the skin is hard enough (it should not slip when rubbed with the thumb) to avoid damages and diseases during storage ▪ Before potatoes are sorted and graded by size, they are left to dry off for 30 minutes, as the skins can be delicate at this stage

Source: Based on Harahagazwe at el. (2020); Lutaladio et al. (2009)

Literature, our own survey data, and the GIZ program suggest that access to potato storage is an ongoing issue; however, we also noted that farmers' knowledge of post-harvest handling is very low. A large share of non-IFDC farmers, in particular, is unaware of the existence of modern ambient stores, and the knowledge and spread of on-farm stores is extremely low with many farmers storing potatoes in their houses or selling their harvests immediately to bypass storage needs. This might be partially caused by the lack of integration of post-harvest handling and marketing in extension services and horizontal knowledge exchange. Surprisingly, we also found that these two aspects, together with financial management and access to financing, are rarely discussed with governmental extension workers and NGOs, despite farmers' need and willingness to engage in these subjects.

Therefore, exchange on and implementation of good practices for post-harvest management are in dire need. According to Lutaladio et al. (2009), potato should be managed carefully during harvest and before storage to reduce possible bruises and cuts. It is important to clean the tubers and free them from plant and soil residues. In case of wounds, the crop should be stored for 5-20 days in a place with a temperature of about 15 – 18 °C and high humidity (95 %) to minimize water loss and avoid contamination by rotting organisms. Generally, temperature and humidity are critical for good potato storage. Lutaladio et al. (2009) recommend keeping ware potatoes in a dark environment with good ventilation, a temperature of 6 – 8 °C and a humidity of 85 – 90 %. Potatoes destined for processing can be stored at temperatures of up to 10 °C.

There is little vertical knowledge creation and exchange in the VC, with many non-IFDC farmers lacking access to extension services. Existing multistakeholder platforms could provide an interesting inroad to both vertical and horizontal knowledge exchange and sector coordination.

Beyond these multistakeholder platforms, VC connectivity is low, especially given that it is a domestic and comparatively simple VC. Most farmers know middlepersons, but do not know anyone else down, or even up, the VC. The short VC and VC actors' willingness to strengthen both vertical and horizontal relationships and cooperation suggests great potential for future VC promotion including building trust and introducing VC actors, establishing contract farming, and focusing on building local and regional processing capacities.

Ugandan consumers and their choices might, thus, be key. Due to research methodology (consumption was not scored as relevant by stakeholders), consumption was unexplored in this research (see chapter 4.2).

At the same time, processors and/or the private sector, in general, might play a greater role in investing in and linking smallholders, e.g., delivering high quality seeds and inputs, as they have to import some of their potato stock from abroad as domestic production does not meet the Ugandan demand. Yet, the yield gap in potatoes is large. While Parker and Wauters (2021) suggest that, given current resources, yields increase of 200 % would be immediately achievable , other authors estimated potential increases of around 300 % in the Mt Elgon area (Kagoda et al., 2013).

An important question is the overall profitability of potato farming even if actual yields meet projected yield increases. As we saw, potato production costs are high, which render net returns very low. However, if the goal is home consumption, net returns might not be the main goal of potato farming. Yet, if potato farming remains a commercial activity, the overall profitability of potato farming should be looked at in terms of labor requirements and relative profitability compared to other commonly grown subsistence and cash crops in the region, e.g., plantain, beans, cassava, and maize. Further research in this regard is needed.

Concisely, we find a dual challenge, and possibly even a dilemma of potato VC promotion in Uganda. Most potatoes farmers supported by German development cooperation consider potatoes an important staple crop for their communities, consuming 10 – 30 % of their crop boiled and selling the remaining 70 – 90 %. When the potatoes are sold into urban markets, they are processed into chips and crisps by the growing fast-food sector in Ugandan towns, and hence transformed into highly unhealthy foods. Though potatoes from Eastern Uganda are less preferential to potatoes from the southwest for chip production in Kampala, they are still used by regional restaurants, hotels, and in street kitchens in Mbale and other regional places in Eastern Uganda (own survey data). German development cooperation might, thus, support the regional fast-food sector and consequent unhealthy food habits. On the other hand, for poor rural farmers themselves, boiled potatoes represent an important source of many macro- and micronutrients which are lacking in other stable crops in the area (plantain, cassava, etc.).

7.1.2 Nile perch VC

This VC is generally well investigated and is the subject of a great number of profound research reports (e.g., Bagumire et al., 2018a; Kaelin, 2018; Kimani et al., 2018). Many of those reports are published by the LVFO in cooperation with the GIZ project Responsible Fisheries Business Chain Project.

In addition, the Ugandan national research institute NaFIRRI is implementing intense research on numerous topics in very relevant areas, e.g., eutrophication and ecosystem changes in light of climate change, microplastic pollution, and greenhouse gas emissions in fisheries. These analyses, especially the latter topic, could supplement our VC analysis as we had no opportunity to assess the carbon footprint of the VC activities. However, NaFIRRI is in permanent need of additional financial and human resources (JN3).

Socioeconomic and social factors affecting lake societies and the fishing sector (e.g., gender relations, HIV prevalence at landing sites, community-based management approaches, drivers and motivations for illegal fishing, etc.) are a matter of ongoing research, even of international attention (Cepić & Nunan, 2017; Kantel, 2019; Nunan, 2020).

Our SHSA analysis of the Nile perch VC is particularly timely as it was conducted during a period when the VC, in general, and the business of most actors, in particular, faced drastic problems. Some of the mentioned problems include the dissolution of the community-managed BMUs in 2015 as a result of political intervention (Kantel, 2019), increasingly frequent and harsh harassment and corruption incidences involving the FPUs, and the fizzling out of the positive initial effect of law enforcement, the potential exacerbation of already-depleted fisheries by the fast-growing maw business (Bagumire et al., 2018), and fish kills due to lake eutrophication in the beginning of 2021 (JN3; Olokotum et al., 2020, 2021). In addition, the Covid pandemic has contributed to ubiquitous livelihood insecurity across society (UFPEA, 2021). Therefore, our study is not only a VC analysis specific to Nile perch, but can serve as a blueprint for strained VCs suffering under permanent resource overextraction (supply side) and insatiable demand (consumer side).

The current depression in the Nile perch VC has exposed many socioeconomic challenges in lake fishing communities. Lake Victoria fisheries are characterized by short-term benefits, high livelihood insecurity, and absence of community-based management regimes (Cepić & Nunan, 2017; Nunan, 2020). The latest strict interventions by the FPU may have provided a break to rehabilitate Nile perch stocks, but is unlikely to stop illegal fishing in the long run. Quite the contrary, illegal fishing might be a continued consequence of the interventions; that is, the interventions may invigorate the lack of trust between fishing communities and governmental institutions, the dialogue might even decrease, and make overcoming divisions a mounting challenge for policy makers and authorities. The development of a joint lake and resources management approach that involves the community could potentially provide a solution (see policy recommendations below).

While fishers are underrepresented in policy decision-making processes, industrial processors and gear suppliers have a strong lobbying position. A vivid example of their powerful position and their decoupling from the rest of the VC was their recent call for a ban on the domestic Nile perch trade. This proposal was motivated by the current fish scarcity and their desire to protect their own interests in the export business. Due to public outrage, the exporters apologised and rescinded their request (Fish exporters apologize over request to ban local consumption of Nile Perch, 2021; Fish exporters seek ban on local consumption of Nile Perch, 2021). Actions such as this led to frustration of upstream VC actors and a sentimental of betrayal by the government. This is one of the reasons why the sense of guilt in fishing communities is that low when illegal fishing methods are practiced (Cepić & Nunan, 2017)

In addition, the production stage's dependency on the few downstream industrial processing actors is very high because of limited market information access, processors' demands for loyalty, and a complex system of credits and investments to fishers negotiated by middlepersons on behalf of factories (see 6.3.2 Evidence-based indicator assessment; SHS 14).

These strong dependencies can be loosened by transparent information systems and microcredit schemes, e.g., using digital tools like the Abavubi[27] supported by GIZ. Furthermore, the promotion of artisanal processing and marketing on local markets could increase the variety of Nile perch purchasers and allow fishers more self-determined action. A higher focus on the local market would also enhance the diversity of livelihood opportunities at other VC stages, since the artisanal sector could create employment and entrepreneurship opportunities.

While our study gained insights into the above-mentioned challenges facing Nile perch VC actors, the by-product business remains a blind spot and was only assessed at one processing site and one key expert interview in our study. In other VC analyses, e.g., Kimani et al. (2018), the by-product sector is neglected, despite being a large and profitable business in the VC. Upcoming research should, thus, explore this part of the VC.

27 Abavubi is a digital service connecting fishers and consumers online. The application provides a digital fish auction platform, navigation and safety features for fishers, and accounting assistance. For further information also see https://abavubi.org

7.2 Sustainability and trade-offs in both VCs

In this section we discuss the degree that the two VCs can be classified as sustainable, if they have transformative potential to become more sustainable, and where we identify potential trade-offs along the VCs.

Considering potential trade-offs in environmental, social, and economic aspects enables a holistic assessment of sustainability performance in food systems and food VCs (Mausch et al., 2020; Vågsholm et al., 2020). Often these trade-offs or unaddressed impacts can operate against the sustainability of the VC as a whole (TEEB, 2018a). To promote sustainable food VCs, particularly from a strong sustainability perspective (see Figure 3c), it is crucial to consider trade-offs and synergies across environmental, social, and economic dimensions, including nutrition and health (FAO, 2018a).

Food-related program interventions often fail to take a systemic perspective where trade-offs appear, e.g., between poverty reduction, nutrition, and environmental sustainability, and often provide technological fixes to complex development concerns, which are commonly encountered along food VCs (Benton & Bailey, 2019; Hall & Dijkman, 2019; Mausch et al., 2020). Furthermore, many approaches to VC promotion have a narrow and linear focus on interventions[28] which rarely include and/or achieve societal goals and, thus, neglect the complexity of VCs (Mausch et al., 2020).

Building on this SHS assessment for the two VCs, we identified potential trade-offs that may arise, particularly when developmental approaches intend to maximize sectoral or "silo" performances that lack a comprehensive understanding of food production, processing, distribution, and consumption, as well as interactions between VC actors at each of these stages. Some potential trade-offs we identified in the two VCs are listed below.

Intensify or extensify potato production?

Low productivity is among the key challenges in the potato VC. Intensification of potato production is seen as a crucial element for improving the VC and farmer livelihoods; however, this might pose significant pressure on the environment.

28 According to Mausch et al. (2020), approaches to VC promotions such as "nutrition-sensitive VC" generally prioritise two intervention areas: (i) improving food security for smallholder farmers by increasing their income; (ii) making food more affordable to consumers to enhance their nutrition intake. The authors emphasized that these confined interventions could lead to trade-offs such as (i) increasing food price for consumer and (ii) reducing farmer's income, both of which could undermine "Zero Poverty" and "No Hunger" goals.

Currently, increase in productivity is achieved through expansion of arable land (CIP, 2021). If land is further extensified, this will lead to deforestation and land degradation. Yet, intensification of the potato production system comes with trade-offs in terms of environmental degradation (more inputs and less land vs. less inputs but more land). Agroecological intensification (AEI), i.e., through better incorporation of manure and compost and other crops, could improve current production levels, particularly when supplemented with phosphorous (phosphogypsum) and zinc (Kammoun et al., 2017; Taheri et al., 2011). In other regions of Uganda, AEI has shown great potential to improve on-farm biodiversity, nutritional yield, and relative profitability, e.g., in banana farming systems (Gambart et al., 2020).

Control of the two major Irish potato diseases in the region (late blight and bacterial wilt) requires high quality seeds (free from seed borne diseases) or chemical pesticides (Parker & Wauters, 2021). Techniques such as RAPs provide a technical fix (Parker & Wauters, 2021), but are rarely adopted by farmers and appear to be unaffordable, particularly considering farmers' low purchasing power (average savings of $25 US /month /household).

In a recent study on Uganda smallholder farmers (n = 4,000), Aragon et al. (2022) found that yields may not be informative for the relationship between farm size and productivity. Instead, they find that appropriate land markets, including strong and formal property rights, might be more effective at improving smallholders' agricultural productivity than other policies and interventions (Aragón et al., 2022); a fact that also deserves attention when designing VC interventions in Uganda.

Better access to Nile perch fishing activities for marginalized groups is socially desirable, but might increase the environmental pressure on the lake

Supporting people who have limited access to fish along the Nile perch VC is essential to improve regional livelihoods. Many women want to change their roles within the VC, however, this must be accompanied by capacity building (for all genders), political measures, and environmental education to negate the risk of competition over a limited resource.

Creating alternative livelihoods through aquaculture might not be ecologically sustainable on the long term

Rearing fish, particularly Nile tilapia, in nets in the Lake is seen by some stakeholders as an important approach to resolving fish scarcity in Lake Victoria. Aquaculture is likely to hasten eutrophication (Kipkemboi et al. 2007) and disease transmission and, therefore, might be a threat to other fish stocks (Murray et al. 2005). Moreover, aquaculture – which can only be conducted with Nile tilapia and not with Nile perch – is not an alternative for the export sector as it is focussed on Nile Tilapia, which is mainly a product for the domestic market.

Environmental crisis vs. jobs and livelihoods vs. food security

Different schools of thought exist as to whether local resource users (such as farmers or fishers) should generate higher cash incomes and use that cash to buy food or if they should produce more food to improve their own food security and quality.

As shown throughout the report, the Nile perch VC—as an almost exclusively export commodity—provides livelihoods to many Ugandans including fishers, processors, transporters, factory workers, and many others. Certainly, it cannot be claimed that Ugandans do not benefit from this VC; however, the export trade is mainly manged by non-Ugandans and that is where most of the profit is generated within the VC. In our study the average daily profit for fishers is 43,800 UGX ($12.50 US). Most fishers go out 3-4 times a week and still need to cover all living expenses. Their profit is higher compared to, e.g., an average rural Ugandan farmer who earns 303,000 UGX ($84.20 US) per month (UBOS & MAAIF, 2020).

While Uganda is a food insecure country (World Food Programme, n.d.), Nile perch is rarely consumed in Uganda. Cash returns from employment in the Nile perch VC, thus, only indirectly boost Ugandans' food security. Fish from Lake Victoria could represent a healthy local source of protein and Omega -3 fatty acids, among others.

As shown in this report, Lake Victoria is at a severe risk of overfishing and environmental degradation. If the lake ecosystem should collapse, the effect will be disastrous for Ugandans who will lose their jobs and food source (see also section 6.2).

The maw business: more local employment and food availability but more pressure on Nile perch stocks?

Another trade-off in the VC is the enhanced supply of Nile perch meat for the local population as a result of the immense growth of the fish maw business, particularly since the 2017 introduction of new guidelines that ease entrance to the maw extraction industry for artisanal processors (MAAIF, 2017; JN2). The new guidelines were put into urgent effect in response to illegal and unregulated maw extraction and smuggling by local fishers and mongers who saw that the old laws created monopolies that disproportionately benefitted a majority of Chinese-owned commercial entities (Bagumire et al., 2018; KY3; JN2). A positive impact of the new regulations is more employment opportunities for the local population as fish maw extractors, collectors, and traders. Additionally, the availability of Nile perch in the local market has increased: because gutted fish cannot be passed on to factories for export, it is sold fresh or to artisanal processors (KY3, JN2; MAAIF, 2017). This development can be clearly followed in the price structure for different Nile perch sizes. Following the VC analysis of Kimani et al. (2018), factory agents outbid the artisanal fish mongers on prices for small (48 – 76 cm) and medium-sized (80 – 98 cm) Nile perch. These tend to have a smaller swim bladder, are not very valuable, and, therefore, go to the factory. For large Nile perch (above 100 cm), the mongers outbid the factory agents, paying, on average, $0.09 US more per kg in order to extract large, valuable fish maws (> 80 grams) (KY3, KA5).

The perspective of making quick profits by extracting and selling maw attracted a lot of people, especially young men. The only prerequisite for market entrance is the issuance of a license at 500,000 UGX ($138.90 US) (KM2, KY6, KY9; Bagumire et al., 2018a). Besides the generally positive outcome of providing more employment opportunities in the sector, maw extraction activities increase pressure on large Nile perch stocks in an unsustainable manner (Bagumire et al., 2018). The chair of the national fishers organization AFALU complained in an interview that fishing on Lake Victoria has become "destructive", "unprofessional", and "unethically" (KM2) because of the growth of the maw industry. In fact, large Nile perch (>85 cm) are increasingly rare in Lake Victoria due to the hunt (JN3; Bagumire et al., 2018a). A foreboding glimpse into the future of the devastation of Nile perch stocks is offered by other swim-bladder-providing species (e.g., sturgeon or croaker) that are now endangered as a result of Chinese markets' insatiable demand for fish maw (Kaelin, 2018; LVFO & GIZ, 2020).

7.2.1 Is the Irish potato VC sustainable?

Though we identified some SHS within the environmental dimension, we conclude that the Irish potato farming system has a relatively low environmental footprint in Eastern Uganda. Local potato farming systems are extensive and rainfed, and in its current farming system potatoes require little land. Use of chemical inputs is currently relatively low, particularly compared to Europe or other countries. Still, losses due to bacterial wilt and late blight were frequently reported by the surveyed farmers and fertilizers and fungicides are locally used. Long-term use of inorganic fertilizers and pesticides may threaten long-term fertility and productivity of the regional soils and, consequently, have severe impacts on social and economic systems in the region. Surprisingly, there are no studies on the environmental impacts of these inputs yet in the region and therefore, require further research.

Bacterial wilt and late blight threaten potato production globally. More research could be done on integrated (organic) disease management; however, current research show that organic disease management in potato farming is difficult, complex, and requires sophisticated technologies (Finckh et al., 2015), whose adoption appears unrealistic in Eastern Uganda.

Certainly, as these diseases are seed-borne diseases, production of and access to clean potato seeds might be key for improving sustainable potato farming in Eastern Uganda to prevent dependency on pesticides. This is one of the key activities the GIZ is working on with CIP and IFDC; however, until now the adoption of RACs is so low that it cannot be evaluated in terms of efficiency or cost–benefit analyses. The goal should be that high-quality, affordable seeds (e.g., RACs) are locally produced and generate profits which lead to a self-sustaining market on the long term. Otherwise, such an approach will not become a sustainable innovation with social. long term impact.

In term of social sustainability, we identified difficult working conditions for hired laborers who often receive salaries below the poverty line and below the living wage. Salaries below living wages prevent workers from attaining "decent living", for example, meeting school costs for children, having a healthy diet, or living in housing that meet minimum international standards (Anker & Anker, 2017). This threatens the long-term perspective of potato farming through educated and healthy farmers. Yet, these conditions are not exclusive to the potato VC as most of Uganda's economy rests on poor smallholders and hired labourers who live far below the living wage (compare UBOS & MAAIF, 2020; van de Ven et al., 2020).

We also found that women and youth mainly do the labor-intensive work such as weeding and harvesting, even though it is often the men who decide what to do with the income generated through potatoes. This points to uneven distributions of workload and benefits and a gender gap in potato farming.

We observed that a large share (70 – 90 %) of the potato harvest is sold and the profit distribution from these sales may not be even: interviewees shared that some middlepersons exploit farmers. Given that farmers are geographically scattered, and their productivity is very low, a more thorough analysis of middlepersons' transactional costs is needed to support this conclusion. What is certain is that the potato farmers in the Mt. Elgon region live in absolute poverty according to both international standards (World Bank: $1.90 US/person/day) and national poverty estimates (UBOS: $0.88 – 1.04 US/person/day). A VC whose primary producers live in extreme poverty cannot be categorized as socially or economically sustainable. Moreover, the imbalance in profit distribution especially affects upstream VC actors and affects the economic sustainability of the VC.

Yet, the potato VC is mainly local and regional, has low transportation emissions, and contributes considerably to the food security of farmers and regional communities. Potatoes are a healthy food source when boiled; if fried and processed into chips, the opposite is true particularly in Uganda where the cooking oil is of poor quality, not filtered and too often reused (Snack vendors reusing cooking oil-Unhealthy, 2019). For this reason, increasing consumption of processed potatoes may expose consumers to various health risks like digestive disorders, cancer, and diabetes (Muraki et al., 2016; Snack vendors reusing cooking oil-Unhealthy, 2019).

Farmers groups, the UPP and ERPP provide a platform for information and knowledge exchange; however, we identified the linkages between actors as weak and unexploited. Consumers and processors are weakly linked to farmers and the overall VC sustainability could benefit from broader sector coordination. Farmers and processors would benefit from more direct links and cooperation as farmers struggle to find a market and many processors cannot find domestically produced potatoes. The domestic demand for potatoes is huge in Uganda, whereas many processors and fast-food chains import potatoes from abroad e.g., Egypt with a massive carbon footprint.

Also, inadequate quantity and quality of potato storage options counteract local production increases, price negotiations, and options for collaborative marketing.

In sum, we find that the potato VC and its promotion holds great transformative potential in Uganda, that is, it is likely to make the VC, different VC stages and potato farming more sustainable. The establishment of multi-stakeholder platforms encourages greater participation of actors from the regional and national levels and supports the co-creation and sharing of knowledge. This paves the way for further promotion of the democratic governance, agency, and knowledge systems that are crucial underpinnings for the transition to sustainable food systems.

Sector coordination, potato storage, and potato seeds are the main issues with transformative potential to improve the sustainability of the potato VC. Improved potato seeds likely lead to more potato production by farmers, storage leads to better marketing options and prices received for farmers as they don´t have to sell their harvests immediately after harvest. Thus, these interventions and activities also hold potential to reduce poverty of local farmers. These are also key features of the GIZ program. Yet, not all farmers/actors in the Mt. Elgon region benefit from these programs and some of the program goals could not be accomplished, mainly due to the lockdowns and restrictions implemented to control the Covid-19 pandemic, lockdowns.

As shown in SHS 12, the average annual net cash income was only \$86.57 ± \$72.42 per farming household and the monetary value of potatoes consumed at home was roughly between \$15 – 45 US per household per year. Even under optimistic assumptions of an increase of 300 % of potato yields (which has been reported as attainable in the region (Kagoda et al., 2013), and an assumed value of \$45 of home consumed potato, farmers would boost their net annual income to \$399 US, on average (assuming that production costs increase proportionally). Thus, interventions in the potato VC alone are unlikely to move these farmers out of poverty.

7.2.2 Is the Nile perch VC sustainable?

In the past century, the ecosystem of Lake Victoria has undergone dramatic changes. Currently, Nile perch catches are in severe recession and we identified many SHS in the environmental dimension indicating that Nile perch fishing in Lake Victoria is environmentally unsustainable. Overfishing is certainly a problem, though Nile perch as an invasive species (artificially introduced by colonial Britain, Pringle, 2005) must be fished since it has no natural predators and could extinct other species such as haplochromine cichlids. In fact, many local fish species are already extinct: Lake Victoria once was home to around 350 different fish species (Kudhongania & Chitamwebwa, 1995).

Protection measures to improve environmental sustainability should take an ecosystem-based approach rather than a species-based approach. This means that shoreline ecosystems (breeding grounds) need to be protected for the sake of all aquatic species. Nile perch/Nile tilapia fishing close to shorelines considerably contributes to unsustainable fishing in the region.

Illegal fishing is an environmental disaster since it thwarts all the strategies of long-term regenerative natural resource extraction approaches. Young fish are extracted before maturity and monofilaments are very persistent and often float as ghost nets under water.

Given the fact that Nile perch is almost exclusively an export commodity, the high levels of energy used for ice production and constant cooling and the long transportation routes for exporting Nile perch to Europe and Asia are unsustainable as they create a substantial carbon footprint. It has been documented that when Nile perch were initially introduced to Lake Victoria, it was preserved through smoking which, among other factors, contributed to deforestation around the lake (Reynolds et al., 1995). In turn, deforestation has led to more runoff of rainwater into the lake and subsequent water level rise.

In summary, under strong sustainability assumptions (see Fig. 3c) the environmental degradation and biodiversity loss in Lake Victoria are not acceptable; in fact, the lake ecosystem might be at risk of collapse (Marshall, 2018). If the lake ecosystem should collapse (Scheffer & Jeppesen, 2007), the basis for most of the economic activities in the shoreline communities would be eradicated.

The fishing and processing regulations and the joint institution of riparian lake states (LVFO) are quite progressive, but the propagation and implementation in the local fishing communities is often weak. Law enforcement in the production stage (fishers) is almost impossible because Lake Victoria is so large and difficult to control (roughly the size of Scotland). Fishers report losing trust in the government, partly as a result of violence perpetrated by the FPUs, which may render future interventions and collaborations difficult. Trust is a key component of effective governing of common pooled resources, such as marine resources (Ostrom, 1990). Fishers reported that the lack of direct communication between themselves and the government as well as their lack of opportunity to participate in decision making gives them the impression that the government owns the lake and that lake resources are being taken away from them.

Most of the interviewed actors agreed that is virtually impossible to control the lake via the military or police (JN2; JN3; KM4; KM5). Community-based regulation enforcement should be part of the way forward. However, we also noted fishers' lack of awareness of the connection between fish scarcity and fishing methods, thus, there is an urgent need for creating awareness of overfishing and investing in capacity building.

Economically, Nile perch is one of the most important VCs on the entire Africa continent (GIZ, 2021b) and creates many jobs and livelihoods. However, these livelihoods are also very fragile, as they are subject to the constant fluctuations of fish availability and many fishers are affected by a lack of independence (no boat and gear ownership), harassments by the FPUs and job hazards during night shifts and storms on the lake.

This has a dual effect. Since local demand for Nile perch is low because of consumer preference for other fish (Kabahenda et al., 2009), the high prices on the export market make the fisheries profitable. At the same time, many food-insecure local communities of fishers access only nominally improved livelihoods through the fisheries since the export industry's greatest profits are captured by a small group of (non-Ugandan) exporters. There are substantial entry barriers to industrial processing and the artisanal sector needs support to create more local value. Artisanal processing would lead to more fish for Ugandans and improve the food security of local communities. Also, artisanal processing would promote entrepreneurship and create small and medium enterprises.

Uganda´s population is growing rapidly. In fact, since 1960, Ugandan´s population has increased sevenfold and today Uganda has one of the youngest populations globally (World Bank, n.d.). Thus, a dual challenge of creating livelihoods while maintaining/improving local food security is a tremendous challenge.

Nile perch cannot be simply exchanged with other fish species and millions of livelihoods depend on its VC. What we observe is a typical fishing-down-the-food-web process (Christensen, 2015). . Until the 1950s, Lake Victoria was home to another 350 fish species (Reynolds et al., 1995). Nile perch, as an introduced predator, has eradicated many fish species in lower trophic spheres and other predators are rare (Marshall, 2018)..

A positive pattern of Nile perch consumption is that virtually all parts of the fish are used, which prevents waste.

In sum, the Nile perch VC has a large potential to be more sustainable, serve local food security, improve livelihoods, and create many employment opportunities. However, value addition must be shifted to the domestic market, awareness of overfishing must be raised, and community-based management approaches for fisheries are urgently needed for a transformation to a more sustainable Nile perch VC.

7.3 Agroecological framework and the need for contextualization

In this study we applied the agroecological framework suggested by HLPE (2019) and FAO (2018b) to reveal SHS in the Nile perch and Irish potato VCs in Uganda. This section summarizes the agroecological potential for VC promotion at large, and for the two investigated VCs, in particular. We draw on our empirical findings, literature, and lessons learned when translating the agroecological principles into practice.

We conclude that the agroecological categories present an all-encompassing framework for sustainability in the production stage. When inviting stakeholders to add categories, we found that, for the production stage, all suggested additions were already covered by the proposed agroecological categories (see Table 1). This was confirmed by the stakeholders themselves, including those who suggested the additions in the first place.

On the other hand, the agroecological framework with its strong focus on farming systems sometimes falls short of comprehensively addressing other VC stages such as processing and consumption, or non-agricultural VCs like the Nile perch. As an example, soil health as a category only applies to the production stage of potato and is not applicable to any other VC stages. Concerning Nile perch, we replaced "soil health" with the category "water quality".

Importantly, we also found that certain inherent normative assumptions about agroecology need to be adapted to the local context, e.g., when looking at "reduction of dependency of inputs". In fact, given that fertilizer use is rare in Eastern Uganda, potato yields remain far below what could be attainable (Kagoda et al., 2013). Farmers themselves also saw their lack of access to inputs, not their overuse or dependency, as one of the most pressing challenges and root causes of their low productivity (see Chapter 5.1). Thus, a strict application of agroecological principles might exclude beneficial approaches, such as promotion of fertilizers (e.g. through micro-dosing schemes or other sustainable intensification regimes) that have shown promising results in similar settings (CGIAR, 2021). Also, the promotion of agroforestry championed by agroecological approaches requires further research, as there is no clear data on whether potato farming in Eastern Uganda would benefit from its adoption and which particular tree species could be promoted (personal communication with CIT 2021).

Furthermore, when adapting a participatory approach which includes stakeholder rankings of the relevance of agroecological categories, researchers/practitioners should consider that these stakeholders will rank according to their knowledge, life realities, and most urgent needs. In our sample, poor smallholders prioritized social and economic categories, sustainability scientists likely would point to environmental categories. In the potato SHSA 2.0, for example, farmer stakeholders gave the highest relevance scores exclusively to categories in the social and economic dimensions. A fully participatory approach would, therefore, have had to ignore categories in the environmental dimension. We decided to comply with the agroecological/sustainability framework, however, and consider environmental categories. This led to the issue that we had to leave out other categories in the social and economic dimensions that received higher relevance scores (see Table 2). In the Nile perch VC, on the contrary, "biodiversity" received the highest relevance scores from all stakeholders as the natural resource base (Nile perch) fundamentally depends on biodiversity and provisioning ecosystems.

Thus, researchers and practitioners who apply SHSA through an agroecological lens, need to balance and negotiate smallholders'/fishers' needs and perspectives with the notion of sustainability and the connected dimensions and categories derived from agroecology (HLPE, 2019).

Since the challenges of both the potato and Nile perch VCs are numerous, and many farming and fishing practices are unsustainable, an agroecological approach might harness interesting potentials for VC interventions in Uganda. In the section below, we give a short summary of the dimensions and categories agroecology could benefit.

7.3.1 Potential for agroecological principles to address Irish potato VC sustainability

Input reduction

Farmers in this study who applied inorganic fertilizers reported experiencing challenges with adulterated inputs on the market. Counterfeit inputs are common in the markets in Eastern Uganda (Interviews with District Marketing and Production Officer). Both the prohibitive prices of fertilizers and presence of fake inputs could encourage farmers to adopt agroecology if sensitized and trained on how to recycle and apply locally available inputs on their farms, among others. There is substantial upscaling potential for farmyard manure application as almost all households own livestock. However, not all these households reported using manure (74 %) and compost (59 %) on their potato fields (70 % of those, SHS 1 in the potato VC). Organic inputs within agroecological production systems might thus be a suitable alternative to chemical fertilizers (or a complement), however, training of extension workers and farmers would be required. Also, further research is needed to investigate if the number of livestock owned by the farmers is sufficient to cover the quantities needed in applying manure and compost.

Late blight disease and bacterial wilt, however, can only be combated by chemical fungicides or clean seed material. RACs provide a technical solution (Parker & Wauters, 2021), however, the seed production quantity remains insufficient and prices are out of reach for ordinary farmers.

Soil health

Soil health can be improved through applying agroecological practices such as crop rotation, intercropping, cover cropping, and application of compost and other forms of organic manure to increase soil organic matter (HLPE, 2019). Inorganic fertilizers can cause soil and water pollution when excessively used or over longer time spans (Nortjé & Laker, 2021). In fact, many potato farmers report declining soil fertility as a key production constraint.

During the study, we found that few farmers practice mulching in their potato fields as a practice to minimize soil erosion and improve soil health. In the first weeks and toward the end of the potato crop cycle, the use of mulches can protect against soil erosion and reduce the risk of nitrate leaching, making the tubers healthier and less susceptible to damage at the harvest stage (Lutaladio et al., 2009). However, as confirmed by some literature (Mugagga et al., 2020) and farmers interviewed, mulching may not be feasible in potato fields due to the limited space between plants. Furthermore, mulching may trap excessive moisture in the soil and decrease soil temperature, which results in a delay of plant growth (Lutaladio et al., 2009). The feasibility and potential benefits of mulching Irish potatoes require further research in the Mt. Elgon region.

Potato farmers in the Mt. Elgon region commonly practice crop rotation with five crops, on average, mainly plantain, cabbage, beans, and to a smaller degree, cassava. Soil health could likely only be improved, however, if farmers receive training on GAPs (see Table 8). In summary, improving soil health through agroecological practice is a low-hanging fruit as it is simple, likely to be adopted, and achievable through available resources, regardless of purchasing power.

Biodiversity

Farming systems biodiversity can be increased through mixed farming, intercropping, alley cropping, and livestock integration (FAO, 2018b). Biodiversity in diversified agroecosystems improves soil fertility through nutrient cycling, pest and disease regulation, and nutrition and food security improvement (Altieri et al., 2015; HLPE, 2019). As we saw, farmers provide agrobiodiversity, and crop, on average, 11 different crops on their small plots.

Nutrient cycling

Nutrient cycling can be achieved through integration of livestock into farming systems. As shown u there is potential for nutrient cycling and farmyard manure application on potato fields with available resources.

Nutrient cycling can also be achieved when biomass from trees, crop residues, and cover crops in the cropping system are ploughed back into the soil to maintain soil organic matter. Virtually all potato farmers also grow beans and other leguminous crops such as cowpeas, which fix nitrogen in the soil. Also, Mucuna pruriens as cover crop has shown great potential for AEI in Uganda (Gambart et al., 2020). Another possible form of nutrient recycling is integrating alley cropping systems where trees absorb leached nutrients and make them available to crops through mycorrhizal fungi associations (Balakrishna et al., 2017). When leguminous trees are integrated on a farm (e.g., Acacia spp.), additional benefits of nitrogen fixation can be obtained (Fagbenro et al., 2015).

Agroforestry might hold potential in combatting the land degradation by erosion typically affecting the Ugandan highlands (Mugagga et al., 2010). However, there is limited information, guidance, and advice on the feasibility of agroforestry in potato production, in general, and the Mt. Elgon area, in particular. Currently, farmers have little awareness of suitable and sustainable tree–crop combinations. Integration of trees into potato fields could achieve a greater tree diversity, which might prove important as we observed a very low diversity with Eucalyptus spp. to be the most frequently planted species.

In similar farming settings in central and southwestern Uganda, Calliandra calothyrsus hedgerows improved overall farm sustainability indicators and farm profitability (Gambart et al. 2020). Endemic trees might hold great potential for agrofestry–potato systems and might create synergies between soil health, biodiversity and profitability.

Most farmers use crop rotation strategies, though more training may enable farmers to improve their crop rotation systems. Also, parameters on the exact application of manure need additional research.

Income diversification

Farm diversification reduces vulnerabilities to climate change, income shocks, and other shocks such as pests and diseases which are common under monocultures (Altieri et al., 2015; Seo, 2010). Farmers in our sample grow, on average, 11 different crops. When farmers integrate crops of different nutritional values and maturity periods, food nutrition and security can be achieved with minimum expenditure (Bezner Kerr et al., 2021). Also, income diversification buffers against price volatility (Bellon et al., 2020) and might spread cash income over the year, minimizing lean seasons.

Diversification on farms through agroforestry (Sebukyu & Mosango, 2012), crop diversification, and rearing livestock such as cattle, goats, sheep, and poultry is common among Ugandan potato farmers.

Yet, many lucrative income sources are off-farm in Uganda and there is a positive correlation between off-farm income diversification and wellbeing in Uganda (Dolan, 2004) as well as in Africa, in general (Barrett et al., 2001). However, many lucrative non-farm activities have entry barriers such as education, skills, and initial capital (Barrett et al., 2001).

Social values and diets

The diets of many urban Ugandans have changed and potatoes have become a key staple in the form of chips. Particularly in urban centres, fast food consumption is rapidly growing (Ugandan Bureau of Statistics, 2016). The increase in population and change in lifestyle have also increased the demand and consumption of potatoes (Bonabana-Wabbi et al., 2013). This market demand has driven many farmers to increase their potato production (Parker & Wauters, 2021). However, potato farmers themselves boil potatoes and the potato is a key staple food in rural parts of the country. Also, potato is a traditional food linked to identity, as it has been farmed for over 100 years ago in the region (PotatoPRO, n.d.-b).

Co-creation of knowledge

An agroecological approach involves farmer participation in knowledge creation which encourages sharing of farmer-to-farmer and farmer–expert knowledge (Jumba et al., 2020). In agroecology, experts ideally develop scientific knowledge based on indigenous and traditional knowledge (Berkes et al., 2000) which leads to innovations that are context-specific and tailored to the needs of the local communities (Jumba et al., 2020).

NARO is a research institution that breeds locally adapted planting materials and offers agricultural research information to farmers, farmer groups, and other agriculture-related institutions (Shinyekwa et al., 2017). The NAADs, which is currently known as Operation Wealth Creation, offers extension services to farmers (Shinyekwa et al., 2017). The existence of MAAIF is a great opportunity for improved agricultural production in Uganda. For the potato value chain, MAAIF works with a task force comprised of the International Potato Center, GIZ, and Seed Certification Service to improve potato production (Sharma & Sikinyi, 2021). The Integrated Seed Sector Development programme (ISSD) for instance works with NARO through the Zonal Agricultural Research and Development Institutes and District Agriculture Officers to identify and train producers of quality-declared seed (Mastenbroek et al., 2021). All these institutions and organizations are brought on board to identify, develop, disperse, and promote solutions to the challenges in the potato VC. Moreover, new platforms such as UPP and EREPP link many different actors in the potato VC, and might support the co-creation of knowledge.

Connectivity

Reinforced linkages are beneficial to all actors across the entire VC. Such linkages shorten food distribution channels and enable the growth of local economies (HLPE, 2019). One existing opportunity is the UPP which tries to bring all different actors to one table, and the regional EREPP with a strong regional focus. These are institutionalized foundations for addressing the challenges of each actor and VC stage and can develop strategies to overcome them. This might also help in establishing producer–consumer linkages.

Participation

The AE principle of participation encourages both producers and consumers of food to participate in decision making and to support decentralized governance and locally adapted management of farming and food systems (HLPE, 2019).

Uganda has a set of policies that aim at improving agricultural VCs (including potatoes) with designated strategies for participation. However, there are policy implementation gaps and failures in Uganda resulting from insufficient inclusion of local communities in policy formulation processes and communication gaps between national, district, and community levels (Ampaire et al., 2017).The two potato platforms UNPP and EREPP are lobbying for more participation of VC actors in the formulation of policies and standards.

In summary, agroecology holds a great potential for improving potato farming in Uganda. Under organic production, the two main challenges for potato farmers are nutrient and disease management.

Soil health, nutrient cycling, and biodiversity hold great potential and possible synergies might exist (Finckh et al., 2006). In fact, well-managed alley cropping systems with integration of leguminous trees into farming systems might be used as an alternative to inorganic inputs (Birhane et al., 2018). Yet, labor requirements to adopt such agroecological principles and cost–benefit analyses need to be taken into account and require further research.

We conclude that co-creation of knowledge and participation hold great transformative capabilities to improve not only potato farming but also the potato VC in Uganda.

7.3.2 Potential for agroecological principles to address Nile perch VC sustainability

Biodiversity

Biodiversity is a strong SHS for Nile perch production in Uganda. Restoration of biodiversity, ecosystems, and a sustainable catch are necessary to keep the Nile perch VC viable. Conservation of biodiversity and the natural resources base could directly improve food security and nutrition and maintain jobs at the same time.

Social values and diets

In terms of food and nutrition security for the fishing communities around Lake Victoria, Nile perch makes only a minor contribution as it has been compromised by the high export rate and consequently higher price of the Nile perch offered by the factory owners. This makes Nile perch, to a large degree, unavailable to local communities; hence, locals predominantly consume rejected fish or by-products from maw factories or other fish species (Aloo et al., 2017).

More should be done to enhance local community's nutrition and food security, not only indirectly through income or employment options. This could be done through the promotion of the small- and medium-sized businesses in the processing sector and a higher variety of Nile perch products, as innovative Nile perch products might create new markets.

Inclusion

The boom of the Nile perch business has benefited mostly men and youth, but women's traditional processing role has shifted to large-scale processors dominated by foreign men (Kayiso, 2009). Women still dominate small-scale processing activities such as frying, smoking, and sun-drying fish and providing manual labor in the form of salting, cleaning, and fileting fish for industrial. In addition, cultural taboos limit women's participation in fishing, e.g., the belief that women's presence brings bad luck to boats (Kayiso, 2009).

Economic diversification

Some locals fish and sell fish species such as Nile tilapia, mukene, and the haplochromine cichlids in addition to Nile perch for income (Odongkara et al., 2009). Most fishers focus exclusively on fishing and related activities at the landing sites, though a few have income generating activities other than fishing, especially those who own land. They carry out agricultural activities such as growing cash crops and rearing livestock to supplement their incomes during periods of low fish catches (Beuving, 2015; Kimani et al., 2018). There are other people who combine fish processing with other businesses (Kimani et al., 2018). Economic diversification and its promotion (e.g., aquaculture sector) are likely to benefit fishers, particularly given the current Nile perch recession and its vulnerable population dynamics.

Connectivity

Nile perch is foremost exported and consumed abroad, especially in Europe and Asia (Beuving, 2010; Constant et al., 2020). To a large extent, fishers and final consumers of Nile perch and its products do not know each other. Strengthening the local market would shorten part of the Nile perch VC as consumers, processors and fishers could have more direct links.

Responsible governance

To address the numerous challenges responsible for the decline of Lake Victoria's fisheries such as overfishing, invasive species, loss of biodiversity, and unharmonized policies, responsible governance is paramount (Njiru et al., 2018). Uganda has transitioned through several management structures on Lake Victoria. BMUs were abolished due to corruption and continued illegal fisheries practices (Nunan et al., 2018). This created a vacuum in fisheries management, which could not be filled by the FPUs that were tasked by the Ugandan president. Responsible Nile perch fishery governance on Lake Victoria is currently very weak. Many local fishers hope for community-governed fishing committees.

Agroecological principles show a development perspective for improving the Nile perch VC in Uganda. The improvement of biodiversity is an imperative. The category "inclusion" theoretically shows great potential despite traditional local gender norms.

Economic diversification holds prospects as well but requires investments in education and livelihood and business opportunities to achieve success. This is a niche that international cooperation could address more generously.

7.4 SHSA 2.0 method: Lessons learned

A Sustainability Hotspot Analysis based on the agroecological framework proposed by HLPE (2019) and FAO (2018b) can, in our view, capture a holistic and contemporary framework of sustainability. It covers its economic, environmental, and social dimensions and allows for inclusion of political aspects.

However, the comprehensiveness of the method also created problems, such as low comprehension by VC stakeholders, particularly regarding the distinction between relevance and impact. Also, the complex agroecological terminologies of the HLPE and FAO, at times, were hard to understand for academic and non-academic audiences and sometimes mismatched local realities (e.g., assessing water footprint in a rainfed farming system). In this context, we argue that these categories and principles should serve as suggestions which should be supplemented with additions, if deemed necessary. In our case, the agroecological categories covered all relevant aspects with some categories being adapted to the context in both VCs and some not being applicable in the Irish potato VC, according to VC stakeholders.
Clear advantages of working with pre-defined sets of categories within an established framework is that the research process is highly accelerated and results from many studies employing the same framework are comparable across space, time, and VCs (most crops are context specific). Additionally, the high level of transparency and structure in data collection makes the data collected an ideal baseline for measuring progress of interventions, e.g., as a foundation of an impact study after a given period.

A limitation of the methodology is the relevance and impact scoring from zero to three, which seems over simplified compared to the large and variable amount of information that the method incorporates and processes.

Moreover, balanced assessment must ensure adequate representation of stakeholders from all VC stages, despite difficulties in accessing some stakeholders. We found that farmers are easier to reach than middlepersons, industrial processers show limited willingness to disclose information. These factors may skew data. However, a lesson from the potato research sub-team is that special attention to the production phase might be justified and, in fact, required if most of the VC actors are located there and issues (e.g., low quality seeds) influence the entire VC downstream.

While the method has proven successful in integrating scientific and local knowledge in a participatory process, participation is time consuming and the less time is dedicated, the more biased and hence inaccurate results are. An important challenge rests with appropriate design of participatory processes. There are risks that certain "received wisdoms" or "environmental narratives", e.g. through NGOs (Leach & Mearns, 1996), are repeated by farmers who try to "satisfy" an academic audience. This points to the limitation of participatory instruments *per se* and shows that they need to be carefully designed and implemented. Most importantly, local colleagues who know and understand local contexts are key in supporting the research process.

Also, trade-offs must be made when balancing a high number of VC stages, categories, and participants within geographic, time, and resource limitations faced by any research and research participants. To this end, the selection of participants representing each VC stage is key in reducing potential biases and efficiently obtaining the needed information. To achieve this is particularly difficult for external consultants, who usually have limited knowledge about the local context as well as limited knowledge of and access to stakeholders. Additional bias might be created by the fact that the method does not *per se* capture power relations among different value chain actors.

In terms of accessibility and disclosure, largely informal economic activities, and, in the special case of the Nile perch VC, illegal activities are difficult to capture with this method.

Given the important role of indicators for the impact assessment, their identification, quantity, and level of detail require special attention. One issue in the identification of indicators the Irish potato team faced was the limitation to two indicators for reasons of feasibility, thereby limiting the informative extent of a category as well as the applicability of indicators across VC stages. However, while the team working on Nile Perch decided not to limit themselves to a certain number of indicators per category, they were faced with problems related to the representative nature of the hotspot analysis. With two to five indicators per category, the impact per indicator varied significantly, with each indicator contributing 20 – 50 % to the impact score of a given category.

Another feasibility and accuracy trade-off, as mentioned above, is using the same indicators across all VC stages or selecting different indicators per VC stage. In this context, the Irish potato research team encountered the issue of having four categories with a high relevance score in the consumption stage that could only partly be assessed with the indicators chosen (e.g., assessing co-creation of knowledge in the consumption stage with the indicator access to extension services).

Since this method tries to achieve an intricate balance of being neither too superficial nor cost-intensive, we advise conducting an *a priori* cost–benefit check of applying this method taking into account the quantity and quality of up-to-date literature available on the subject of investigation.

7.5 Policy recommendations

7.5.1 Potato value chain promotion

Recommendation 1

Existing information exchange structures and training opportunities (**extension services** and **farmer field and business schools**) should expand their curricula to include training on good practices in **post-harvest management**, **marketing,** and **finance**.

This recommendation addresses employees in local governments, partners in development cooperation, namely GIZ/IFDC, and National Agricultural Advisory Services.

The recommendation can be implemented via existing structures of extension services, farmer field and business schools, and/or technical solutions implemented in response to the pandemic threat. Content can be improved in quality and better aligned to the study's results. Since post-harvest management, marketing, and financing were identified as issues important to farmers that are currently only briefly covered by existing training opportunities, farmer participation in such programs is expected to be high. The creation of on-farm value addition and increased knowledge of marketing practices and financing options are expected to result in higher profits and hence improved living standards and the ability to reinvest in business opportunities. However, this measure needs to be accompanied by additional interventions in providing access to improved storage and/or transportation to generate results (see recommendation 4).

Extension workers need specific training to acquire and disseminate business-related knowledge to farmers, since their education is currently insufficient, many having basic vocational training only (Gildemacher et al., 2012; Semana, 2008). The possibility of developing and disseminating IECs (information, education, and communication materials) should be considered. Their design should meet the needs of illiterate farmers, given that almost a quarter of Ugandans above 15 years old are illiterate (World Bank Group, n.d.-b) and the illiteracy rate in our study was up to 31 %. In such settings, pictograms are particularly suitable (Wiseman et al., 2005).

Technology-based solutions like the SMS broadcasts implemented by GIZ's nutrition branch, however excluding illiterate and some economically marginalized farmers, as well as the dissemination of information via radio should be exploited. Given the limited investment resources in extension services combined with the infrastructural deficits in rural areas, hence limiting accessibility to farming households, a combination of the measures described above could represent a potential solution to tackle these challenges and leave no one willing to participate behind.

Recommendation 2

Contract farming between farmers and processors to improve connectivity and reduce production risks.

This recommendation can be implemented with the help of existing multistakeholder platforms, namely the Ugandan National Potato Platform and its regional branches, and suggests matching processors to farmers/farmer organizations.

Resource provision contracts (as a form of a contract farming arrangement) might help reduce production risks through the provision of appropriate inputs and technical assistance (Bijman, 2008). Contract farming arrangements can be beneficial to both parties in terms of freshness/quality, risk sharing, reliability, and projectability of profits/costs and, hence, increased commercial viability and ability to invest. The establishment of reliable commercial relationships may lead to a widening of product ranges purchased from farmers, thereby offering important income-generation opportunities. In this context, the strengthening of farmer organizations to act as joint bodies to pool agricultural outputs can reduce risk for both farmers and processors and make additional marketing channels (large-scale processors) available in the future (Velázquez & Buffaria, 2017).

There are very successful examples of such resource-provision contracts that lead to improved production, welfare, and food security for smallholder farmers, for example in the fresh bean production sector in Madagascar (Bellemare, 2010, 2012), which was also supported by the GIZ.

This intervention faces certain challenges since direct communication channels are not yet established. Also, the question of commercially viable transportation means for smaller quantities, as probably required by small- to medium-scale processors, need to be explored. In this context, farmer organizations can play an important role, such as cooperatives and associations.

Furthermore, ensuring adequate quantity and quality to increase security for both farmers and processors might require significant kick-off investments for high-quality inputs, potentially requiring advance payments from and, hence, risks for processors. Also, it remains unclear how farmers might ensure enforcement of a contract given their remote location and limited integration into administrative structures. In addition, unavoidable risks for both parties remain, e.g., crop failure due to weather patterns. To protect farmers from potential compensation payments, special consideration in contract design must be given to protecting farmers in the case of crop failures due to unforeseeable environmental factors or disasters.

Recommendation 3

Endorse the **construction**, regular **maintenance**, and sound management of high-quality **storage options** on the farm-/village- and market levels.

This recommendation targets partners in development cooperation and the government and is linked to the recommendation of making post-harvest management and marketing advice available to farmers.

The GIZ project final report suggested limitations of collectively managed bulk stores, with only one of five built ambient stores running at profit mainly due to management issues typical for collectively owned structures, such as unequal participation by members, low usage, and power imbalances. Also, trust among the actors and into the storage managers is required (GIZ, 2021c). These aspects need to be given special attention when designing such an intervention on the market level.

The GIZ project reported improved individual ambient ware potato stores could significantly contribute to farmers' livelihoods, including female-headed households. Individual "traditional" stores for up to 8 metric tons were described as cheap to build and, therefore, highly profitable as well as easy to maintain (GIZ, 2021c). The GIZ final report recommended creating financial products that allow farmers to build farm-level stores. In this context, a cost–benefit analysis for subsidized loans is recommended.

The potential benefits of this recommendation are numerous: reducing food waste, increased bargaining power (possibly resulting in a fairer profit distribution), reduction of price fluctuations, and potentially strengthened community structures.

Recommendation 4

Promote the development of the **certified seed production** sector along with the promotion of certified seed use via existing information exchange structures and training opportunities.

This recommendation addresses the National Agricultural Research Organization, UNPP, partners in development cooperation (namely GIZ/IFDC) and employees of local governments.

The implementation of this recommendation can build on existing interventions offered by development cooperation actors who show willingness to invest in this area as well as on government research institutions and other government agencies working in this field. The need for quality-certified clean seed is well known by farmers and a key hot spot for potato production improvement.

Dissemination might be a risk factor due to existing infrastructural deficits in rural areas where agricultural production takes place. In addition, the risk of fraudulent certified seeds needs to be combatted to increase trust and convince farmers that the benefits of certified clean seed outweigh their additional cost. While the intensification and expansion of clean seed production is capital intensive and high-tech innovations like the RACs do not seem to have taken off in Uganda, their potential benefits are substantial and include higher yields, improved soil health, and larger future uptake of potato production, contributing to reduction of the substantial national supply deficit (National Agricultural Advisory Services, n.d.-a).One way this can be achieved is by promoting clean seed businesses to the private sector and to increase training on RACs so as to increase commercial viability. The potential of public–private partnerships in this context should be further investigated.

7.5.2 Nile perch value chain promotion

Recommendation 1

The **demarcation of breeding grounds** on land and water and supervision of compliance must be advanced.

This recommendation specifically addresses policymakers on different levels (MAAIF/DiFR, district officers) as well as research units such as NaFIRRI. Such a measure includes identifying and mapping fish breeding grounds and demarcating them with buoys.

Having clearly delimited shoreline zones would protect the breeding Nile perches. It is a recommendation that is already partly addressed by GIZ, NaFIRRI, and DFiR but which must be expanded quickly. If breeding grounds are protected, mother fishes can find undisturbed breeding places to lay their eggs. This is a key basis for the survival of young Nile perches and, consequently, the overall recovery of stocks. It involves a surveillance mechanism which may be demanding and costly to implement.

Recommendation 2

Strict standards for gear (especially net) supply that include the traceability of inflows and tighter sanctions and enforcement for suppliers.

This recommendation requires strong collaboration between policymakers and national authorities across the riparian lake states, such as LVFO, MAAIF/DiFR, Ministry of Trade, Industry and Cooperatives, the Uganda National Bureau of Standards, and the Uganda Revenue Authority.

Strict standards can have an enormous impact on fishing on the lake because, if properly enforced, small-meshed nets and nets made from harmful materials (such as nylon) would be banned. Banning these nets would lead to fewer immature fish being entangled in nets; consequently, fish stocks could recover. Therefore, extensive surveillance mechanisms need to be implemented at the borders. If prosecution targets the net supply chain in its earliest stage, conflicts between fishers and law enforcement units could be reduced. Nevertheless, the harmonization of these national measures (and especially their enforcement) with the other riparian countries (including Tanzania and Kenya) might be a challenge. As existing standards for some gear (e.g., monofilament nets) can easily be circumvented, emphasis should be placed on prosecution. Thus, sanctions should primarily target the importers instead of exclusively the users.

Recommendation 3

Co-management structures at landing sites should be established and consulted for law enforcement and policy making.

This recommendation especially targets fisherfolk, but is a cross-cutting topic that should be considered by policymakers on all levels. Co-management structures at each landing site would be of benefit in many ways. They could serve as mechanisms to regulate fishing and related landing-site activities such as fisher registration, beach cleaning, infrastructure coordination, and receiving visitors. Such structures could also be actively involved in the implementation of laws, e.g., demarcation of breeding grounds and surveillance. Moreover, these management units could facilitate the formation of other organizations such as saving groups or women's associations. These structures should be consulted by policymakers as they represent fishing communities at landing sites. Furthermore, participation can be a tool to sensitize and empower fisherfolk while encouraging their ownership for environmental issues on Lake Victoria.

Nevertheless, the pitfalls of BMUs (a similar structure at landing sites which were abolished officially because of corruption issues) should be avoided. The new structures could be susceptible to corruption and imbalanced power relations. This risk must be addressed and counteracted. Moreover, a structure combining different actors with interconnected dependencies in one organization might raise conflicts over positions and should, therefore, be managed in an inclusive and representative way.

Recommendation 4

Programs for alternative livelihoods should be initiated to relieve pressure on Nile perch.

This recommendation primarily targets fisherfolk but also NGOs. Policymakers should provide funds for training activities and initiate incentives for the fishers e.g. the provision of land and reduce formal obstacles. As there is huge pressure on the lake, it is necessary to create livelihood alternatives in other agricultural sectors or in other VC stages within or outside the fishing sector. Uganda´s population is rapidly increasing (World Bank, n.d.) and the pressure on Lake Victoria is likely to increase too. If considerably fewer people rely on fishing for income, pressure on the lake and its fish stocks would be relieved. A challenge could be the implementation and appropriateness of incentives for different VC actors. Also, the threat of transferring the problem of overuse to other agricultural sectors should be considered. Lastly, investments in aquaculture require holistic sustainability assessments.

8 Conclusion

Both the Irish potato and Nile perch VCs in Uganda face several sustainability challenges. We found a great number of sustainability hot spots in the production stages of both VCs which threaten their contribution to the overall sustainability of food systems. In the potato VC, the main SHSs are a lack of quality inputs and storage facilities, soil health issues, potato loss and waste, and few economic benefits, particularly for farmers. Likewise, the majority of SHSs in the Nile perch VC are in the production stage (biodiversity, water quality, fishing equipment, access and use of resources, fairness, and economic benefits, among others) while three are in the processing stage.

We conclude that the SHSA 2.0 offers a practicable and rapid tool for the assessment of SHS, particularly as an *ex-ante* evaluation of VCs. It is well-suited for problem assessments, feasibility studies, VC development projects, and when data/ knowledge on target commodities is scarce. Yet, access to stakeholders and their mobilization are crucial for a successful implementation of SHSA 2.0. The high stakeholder participation within the SHSA 2.0 allows for co-ownership of the study and co-creation of knowledge between researchers and VC stakeholders, resulting in a higher probability of positive real-world impacts compared to, for example, top-down approaches (Mauser et al., 2013).

There is increasing agreement that a global paradigm shift in food systems and VC promotion is needed (Anderson et al., 2021). Agroecological principles and elements as suggested by HLPE (2019) and FAO (2018b) represent a suitable framework to tackle sustainability challenges, particularly in the production of foods, transformation of food systems, and fair distribution of foods. Yet, the agroecological principles must be adapted to local contexts as culture and local conditions matter. We find that, for the case of potato farming, the adoption of agroecological intensification holds great potential to overcome some of the sustainability challenges (particularly soil health, nutrient cycling, participation, and knowledge exchange), but their labor requirements and cost and benefits require further research.

Policy recommendations for improving the potato VC include training on post-harvest management, marketing, and finance for farmers; establishing contract farming structures between farmers and processors; construction, maintenance, and management of high-quality storage options; and promoting certified seed production. For the Nile perch VC, policy recommendations include the demarcation of breeding grounds to allow Nile perch stock rejuvenation, stricter standards for gear supply, the establishment of co-management structures at landing sites, and programs for establishing or supporting alternative livelihoods, that is, outside of fishing.

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10 Annex

All annexes are available online at https://doi.org/10.18452/24308 .

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