Czech University of Life Sciences Prague

Faculty of Economics and Management

Department of Economics

Master Thesis

Assessment of Freshwater Aquaculture sector in Georgia

Anna Tsenteradze

© 2022 CZU Prague

CZECH UNIVERSITY OF LIFE SCIENCES PRAGUE

Faculty of Economics and Management

DIPLOMA THESIS ASSIGNMENT

Bc. Anna Tsenteradze

Economics and Management
Economics and Management

Thesis title

Assesment of Freshwater Aquaculture sector in Georgia

Objectives of thesis

Broadly, the research aims to evaluate the current situation of aquaculture on a global basis as well as in Georgia. The diploma thesis is proposed to identify current strategies and innovations implemented worldwide in freshwater inland aquaculture. It will also review examples of successful countries around the globe. On the Georgian national level resources, history and institutions will be identified, after which the prospects and future possibilities are going to be assessed. In addition, The main objective of the thesis is to answer four research questions: Q.1. What is the present status of aquaculture on a global basis?
Q.2. What role will aquaculture play for the future and how important will it be for society, economy and environment?
Q.3. what is the real current situation in Georgian aquaculture
Q.4. What strategies and innovative techniques could Georgian Government implement to achieve better governance and industrial success?

Methodology

The literature review on the question of development of aquaculture is developed.

In order to assess the production level and the process of production, as well as the value chain of aquaculture in Georgian inland fish farms, the interviews were conducted. For the practical part of the thesis, two fieldworks (between March and August 2021) have been conducted. The fieldwork research includes over 70 interviews with different actors, 3 hatcheries, different fish farms, 2 feed processors and 10 retailers as well as 5 restaurants. Moreover, data has also been collected from consumption surveys both in the capital – Tbilisi, as well as in rural areas.

In the empirical part of the thesis, according to the collected information, the current major issues will be identified and recommendations will be proposed to decision making bodies.

The proposed extent of the thesis

70 – 90 stran

Keywords

Freshwater aquaculture, Georgia, Value Chain, Rural Development, Fish Farms, Social, Economic and Environmental Development, Systems Thinking, Open Innovation in aquaculture, EAFM approach, blue revolution, innovative strategies

---

Recommended information sources

Hishamunda, N., Ridler, N., & Martone, E. (2014). Policy and governance in aquaculture: lessons learned and way forward.

Khavtasi, M., Makarova, M., Lomashvili, I., Phartsvania, A., Poulsen, T. M., & Woynarovich, A. (2010). Review of Fisheries and Aquaculture Development Potentials in Georgia (Vols. FAO Fisheries and Aquaculture Circular – C1055/1). FAO, Georgia. Retrieved from fao.org: https://www.fao.org/3/i1735e/i1735e00.pdf

Lebel, L., Navy, H., Jutagate, T., Akester, M. J., Sturm, L., Lebel, P., & Lebel, B. (2021). Innovation, practice, and adaptation to climate in the aquaculture sector. Reviews in Fisheries Science & Aquaculture, 29(4), 721-738

Nekerashvili, G. (1999). Eastfish Fishery Industry, Georgia Vol.16. FAO/Eastfish. FAO Fisheries and Aquaculture Department. (2004). The State of World Fisheries and Aquaculture. Rome: FAO.

Nielsen, R., Asche, F., & Nielsen, M. (2016). Restructuring European freshwater aquaculture from family-owned to large-scale firms–lessons from Danish aquaculture. Aquaculture Research, 47(12), 3852-3866

Stead, S. M. (2019). Using systems thinking and open innovation to strengthen aquaculture policy for the United Nations Sustainable Development Goals. Journal of fish biology, 94(6), 837-844

Expected date of thesis defence

2021/22 SS – FEM

The Diploma Thesis Supervisor

Ing. Pavel Kotyza, Ph.D.

Supervising department

Department of Economics

Electronic approval: 21. 2. 2022

prof. Ing. Miroslav Svatoš, CSc.

Head of department

Electronic approval: 21. 2. 2022

doc. Ing. Tomáš Šubrt, Ph.D.

Dean

Prague on 31. 03. 2022

Declaration

I declare that I have worked on my bachelor thesis titled "Assessment of Freshwater Aquaculture sector in Georgia" by myself and I have used only the sources mentioned at the end of the thesis. As the author of the bachelor thesis, I declare that the thesis does not break any copyrights.

In Prague on 31.03.2021 ___________________________

Anna Tsenteradze

Acknowledgement

I would like to express my special thanks of gratitude to my thesis supervisor, professor Pavel Kotyza, who gave me the exceptional opportunity to participate in the research project, as well as supported and guided me while writing thesis. I would also like to thank Ludovic Andres, Nino Chobaniani, Giorgi Shubitidze, Thomas Ponsioen, Maurane Ribeiro, Anthony Lefebvre, Maëline Duconseil, and Tamar Tukhashvili.

Assessment of Freshwater Aquaculture Sector in Georgia

Abstract

The diploma thesis defines connections between global aquaculture sector and national perspective from Georgia's current reality. It describes the future of global aquaculture and its importance, as well as the resources in Georgia and how government policies and externalities are aligned with the future demand. The research includes different assessment models, coming from global standards of good governance as well as systems thinking approach. The focus of the study is freshwater inland aquaculture for trout and carp sub-chains.

Furthermore, various interviews have been conducted with farmers of different size and types of farms in both trout and carp chains. The data is analysed to define main differences between trout and carp sub-chains, costs, revenues, profit margins, ecological impact and social situation in Georgia, as well as the main issues that the sector is currently facing.

Keywords: Aquaculture, Georgia, Value Chain, Rural Development, Fish Farms, Social, Economic and Environmental Development

Hodnocení sektoru sladkovodní akvakultury v Gruzii

Abstrakt

Tato diplomová práce definuje souvislosti mezi globálním akvakulturním sektorem a národní perspektivou v realitě současné Gruzie. Popisuje budoucnost globální akvakultury a její význam, gruzínské přírodní zdroje a to, jak jsou vládní politika a vnější vlivy v souladu s budoucí poptávkou. Výzkum zahrnuje různé vyhodnocovací strategie, vycházející z globálních standardů dobrého vládnutí a systémového myšlení. Těžištěm studie je sladkovodní vnitrozemské produkční rybářství se zaměřením na chov pstruhů a kaprů.

Dále byly provedeny rozhovory s farmáři disponujícími chovy různých typů a velikostí. Data jsou analyzována s cílem vytyčit hlavní rozdíly v chovu pstruhů a kaprů, náklady, výnosy, ziskové marže, ekologický dopad a vliv na sociální situaci v Gruzii, stejně jako hlavní problémy, kterým odvětví v současnosti čelí.

Klíčová slova: Akvakultura; Gruzie; Hodnotový řetězec; Rozvoj venkova; Rybí farmy; Sociální, ekonomický a environmentální rozvoj

Table of content

1. Introduction

"*Aquaculture is the farming of aquatic organisms, including fishes, molluscs, crustaceans, and aquatic plants. Farming Implies some form of intervention in the rearing process to enhance production, such as stocking, fertilizing, feeding, habitat manipulation, and protection from predators. Farming also implies individual or corporate ownership of the stock being cultivated*" (FAO, 1991).

Unfortunately, Aquaculture is hardly ever included in the discussions about sustainable futures. When the strategies to combat the climate change is being discussed, and quell the ever-expending impact humans are having on this planet, we typically only mention renewable energy solutions or a material solutions like recycling, or biodegradable, compostable products etc. However, aquaculture accounts for 25% of out greenhouse emissions (Yuan, 2019), meaning that at least a quarter of our solutions to the crisis must involve rethinking how and where the food in grown.

Aquaculture is an extremely diverse industry; its scope extends well beyond production of commercial fish and shellfish. Aquatic farming, for example, includes the production of baitfish, ornamental fishes, special purpose fishes for biological weed control, mussels and macroalgae for therapeutical and biochemicals, pearl oysters for pearls, reptiles for food and luxury leathers, and microalgae for fine chemicals and biogas (Lucas, 2019). Finally, aquaculture encompasses the controlled production of a wide range of aquatic test animals.

The thesis, however, will mainly focus on land based and freshwater aquaculture, more precisely, on Carp and Trout production, starting from the governance of aquaculture to the management of fisheries. The purpose of the diploma thesis it to explore deeper the economic, social, and environmental factors that influence aquaculture production.

Assessment of the sector should be important not only for decision makers at the Georgian Government but for the actors at different levels, such as farmers, retailers, associations, and NGOs.

2. Objectives and Methodology

2.1. Objectives

Broadly, the research aims to evaluate the current situation of aquaculture on a global basis as well as in Georgia. The diploma thesis is proposed to identify current strategies and innovations implemented worldwide in freshwater inland aquaculture. It will also review examples of successful countries around the globe. On the Georgian national level resources, history and institutions will be identified, after which the prospects and future possibilities are going to be assessed. In addition, The main objective of the thesis is to answer four research questions

The following questions are addressed:

Q.1. What is the present status of aquaculture on a global basis?
Q.2. What role will aquaculture play for the future and how important will it be for society, economy, and environment?
Q.3. what is the real current situation in Georgian aquaculture
Q.4. What strategies and innovative techniques could Georgian Government implement to achieve better governance and industrial success?

2.2. Methodology

The literature review on the question of development of aquaculture is developed.

In order to assess the production level and the process of production, as well as the value chain of aquaculture in Georgian inland fish farms, the interviews were conducted. For the practical part of the thesis, two fieldworks (between March and August 2021) have been conducted. The fieldwork research includes over 70 interviews with different actors, 3 hatcheries, different fish farms, 2 feed processors and 10 retailers as well as 5 restaurants. Moreover, data has also been collected from consumption surveys both in the capital - Tbilisi, as well as in rural areas.

In the empirical part of the thesis, according to the collected information, the current major issues will be identified and recommendations will be proposed. The data processing will include consolidating the value chain accounts, computing total effects, such as net value added, gross operating profits, net operation profits, profit margins, total costs as well as cost analysis for each farm type. The formulas to be used are as follows:

- **Gross Operating Profit** = Total Production – Total Costs + Total Amortisation
- **Net Operating Profit** = Gross Operating Profit – Total Amortisation
- **Net Value Added** = Total Production – Total Intermediate Goods and Services
- **Profit Margin** – Net Operating Profit / Total Production

3. Literature Review

3.1. Global Perspective on Aquaculture

3.1.1. History and trends of Fresh Water Aquaculture in the World

Aquaculture has a tradition of about 4,000 years in China. In 1949 large scale aquaculture began, especially focused on cultivating Common Carp (Cyprinus Carpio), which is first cultivated species, Crucian Carp (Carassius Auratus) and Mud Carp (Cirrhina Molitrorella) (Beveridge, 2002). In 1958 the development of artificial spawning – Pig-Head Carp (Aristichthys Nobillis) and Silver Carp (Hypophthalmichthys Molitrix) have started (Beveridge, 2002).

Brackish water fishpond is the earliest fishpond. It originated in the island of Madura or in East Java (Herre, 1929). It was locally termed as Tmbak or Embankment and it started in the Philippines in 1521 (Herre, 1929).

Pond Culture is the earliest form of aquaculture, dating back to `400 – 1137 B.B. Pond was mainly limited to fresh water, therefore it is the earliest form of Aquaculture. It is considered to be most popular and most important fish farming culture system (Knud-Hansen, 1992).

Another type of farming is Valli culture, which is one of the most ancient forms of aquaculture in the Mediterranean region (Jenifer, 2013). It is used to exploit the seasonal migrations of some fish species from the sea into the lagoons by preventing the fish returning to the sea. Main target species for Valli culture are Eel, Sea Bass, Seabream, sole and mullet (Jenifer, 2013).

Brush – park is a traditional form of low-technology aquaculture which is practiced in coastal lagoons and brackish waters in many areas of the world (Béné, 2009). It is done by placing vegetation in water areas to attract fish, shrimps, and crabs. Another low-technology and seasonal type of aquaculture is Floodplain Fisheries, which is depended on the duration and amount of flood filling of low areas (Ghose, 2014). Therefore, it is properly timed to coincide with the seasonality of the water level in the floodplain.

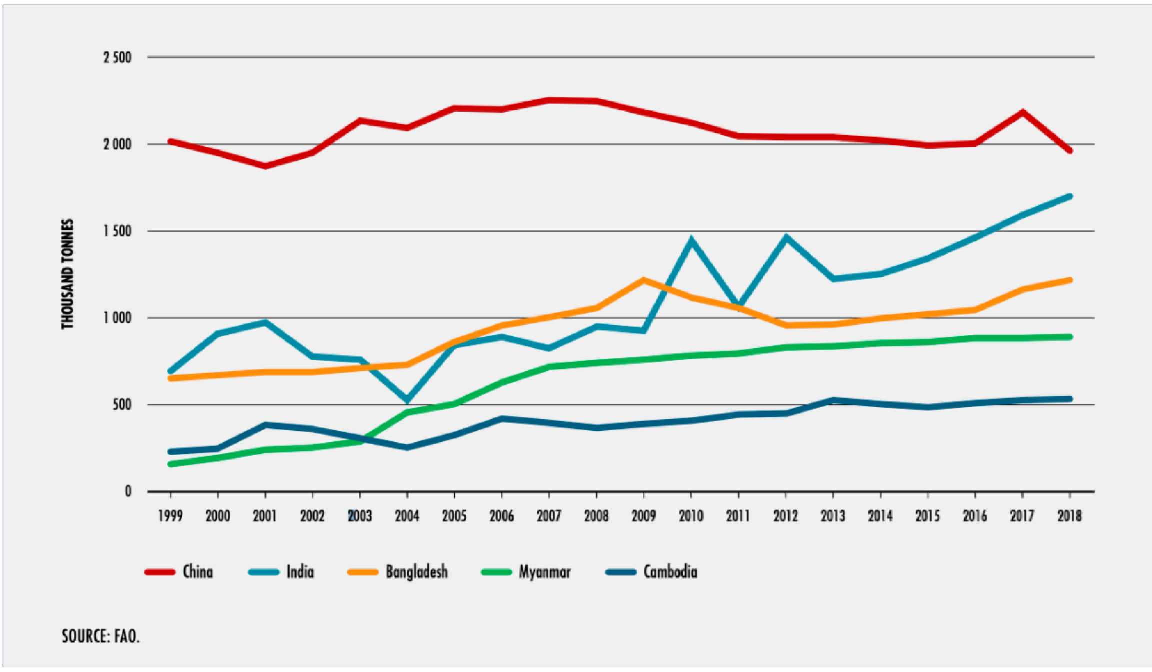
Aqua silviculture is other type of farming, that is popular especially in Panay Islands (De la Cruz, 1995). It is characterized by rearing and growing fish and other aquatic organisms is enclosed sections within mangrove areas to enhance fisheries production in the wild (De la Cruz, 1995).

Mariculture is widely known type of aquaculture, which involves the cultivation of marine organisms in seawater, including tanks, ponds, raceways, cages and pens (Craig, 2002). The cage culture that is a type of mariculture is an enclosure with bottom and sides of netting or bamboo etc., whether floating at the surface or totally submerged. Fist species cultured were common carp, introduced from Hong Kong in 1915 (Labatos Jr, 2014). In 1996 there first Norwegian cages for salmon in Sual Bay (Gjøen, 1997). It is considered to be aquaculture system of the millennium as the low input farming is practiced with high economic returns. Modern fish cages in Mariculture Parks are mostly made of high-density polyethylene (HDPE) materials because of its versatility, the relative simplicity in performance of the various farming operations, and the comparatively limited investment capital required (Gjøen, 1997). Technological improvements of HDPE cages are evolving with the availability of new materials and the various equipment items are needed to service all farming operations (Himaja, 2016). Fish Pen is a fixed enclosure in which the bottom is the bed of the water body (Delmendo, 1976). It began in 1968 as an experimental venture of the Philippine Bureau of fisheries and Aquatic resources in the freshwater lake, Laguna de Bay (Delmendo, 1976). Pen culture of Milkfish (chanos chanos) is the most important freshwater pen culture in the world (Delmendo, 1976). Fish Tanks type of culture is mainly a concrete or fiberglass type of enclosure that allows aquculturist to exert a relatively high degree of environmental control over parameters (Delmendo, 1976).

There are other types of fish capture or aquacultural production such as Sea Ranching, seaweed farming, cage culture, aquaponics, Integrated Multi-Trophic Aquaculture (IMTA) (Veldhuizen, 2018). Also, another interesting system in aquaculture is Recirculating aquaculture Systems (RAS), which implies on a technology for farming fish or other aquatic organisms by reusing the water in the production (Ebeling, 2012). Water exchange is limited, and mechanical & biological filters (biofiltration) is used to reduce ammonia toxicity (Ebeling, 2012).

According to FAO, global catches have reached over 12 million tonnes in 2018, which is the highest levels recorded (FAO, 2020). We can see that China is relatively stable in inland catches, averaging around 2.1 million tonnes per year since 1999 until 2018 (FAO, 2020). Cambodia is also stable and gradually increasing its capture together with India, Bangladesh and Myanmar (FAO, 2020).

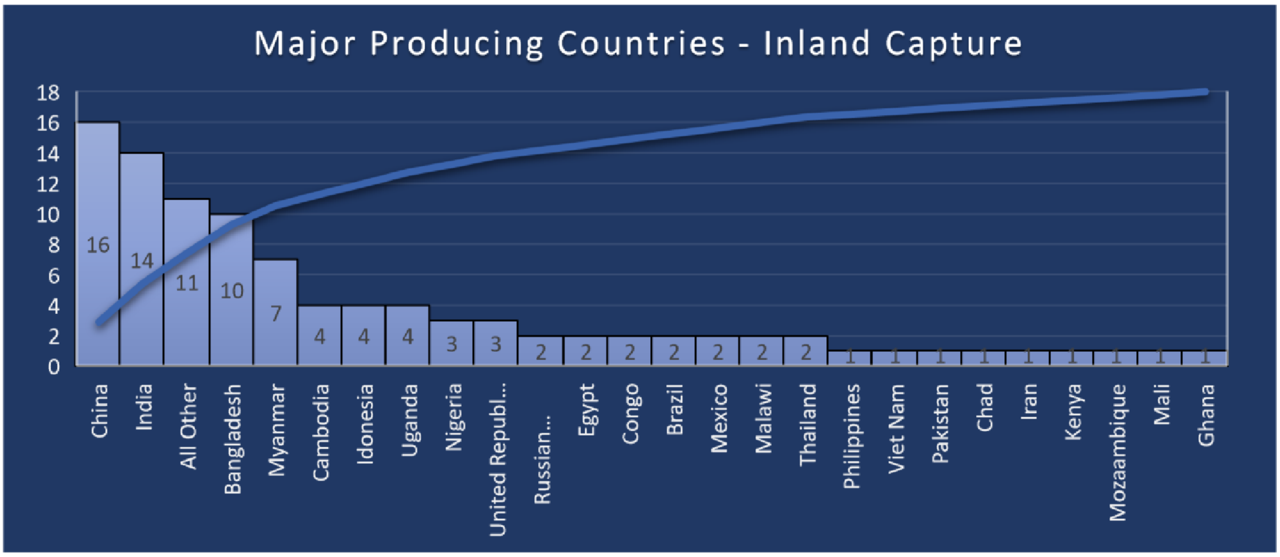
Figure 1: Top 5 Inland Water Capture Producers



Source: (FAO, 2020)

However, it is worth mentioning, that the data provided as well as statistics are not as accurate, As the data collection systems are not entirely reliable.

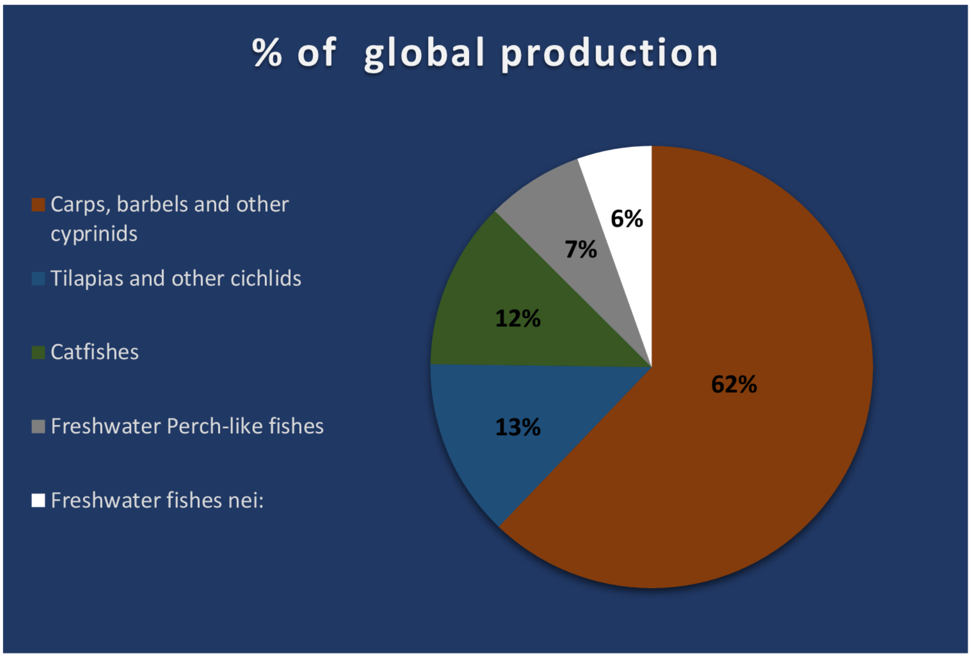
Figure 2: Major Producing Countries



Own Formation, Data source: (FAO, 2020)

According to FAO, in 2018, inland aquaculture produced 51.3 million tonnes of aquatic animals, accounting to 62.5% of the worlds' farmed food fish production (FAO, 2020). Which gives us a Most popular fish species to be caught were Anchoveta (7million tonnes), Alaska Pollock (3.4 million ton), Skipjack Tuna (3.2. Million tons) (FAO, 2020).

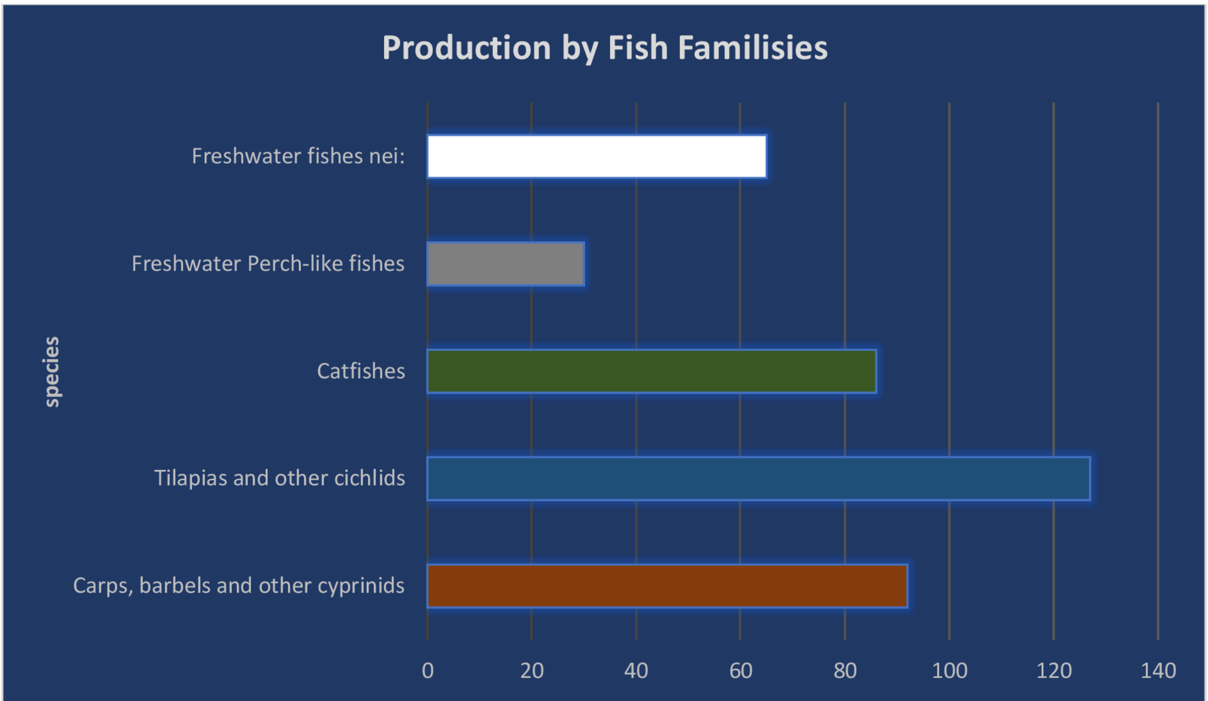
Figure 3: Global Production



Own processing, data source (FAO, 2020)

Fish species are divided by groups in global aquaculture. According to a report provided by FAO, the freshwater fishes are one of the common among the produced cultures. The most popular species in freshwater aquaculture are shown on the graphs 3 And 4. Carps, Barbels and other cyprinids are the most produced around the world. As it can be found on the report on species groups in global aquaculture, in 2017 the Carps accounted for a quarter of a global production (Junning Vai, 2017). They have been produced in 92 countries.

Figure 4: Production by Fish Families



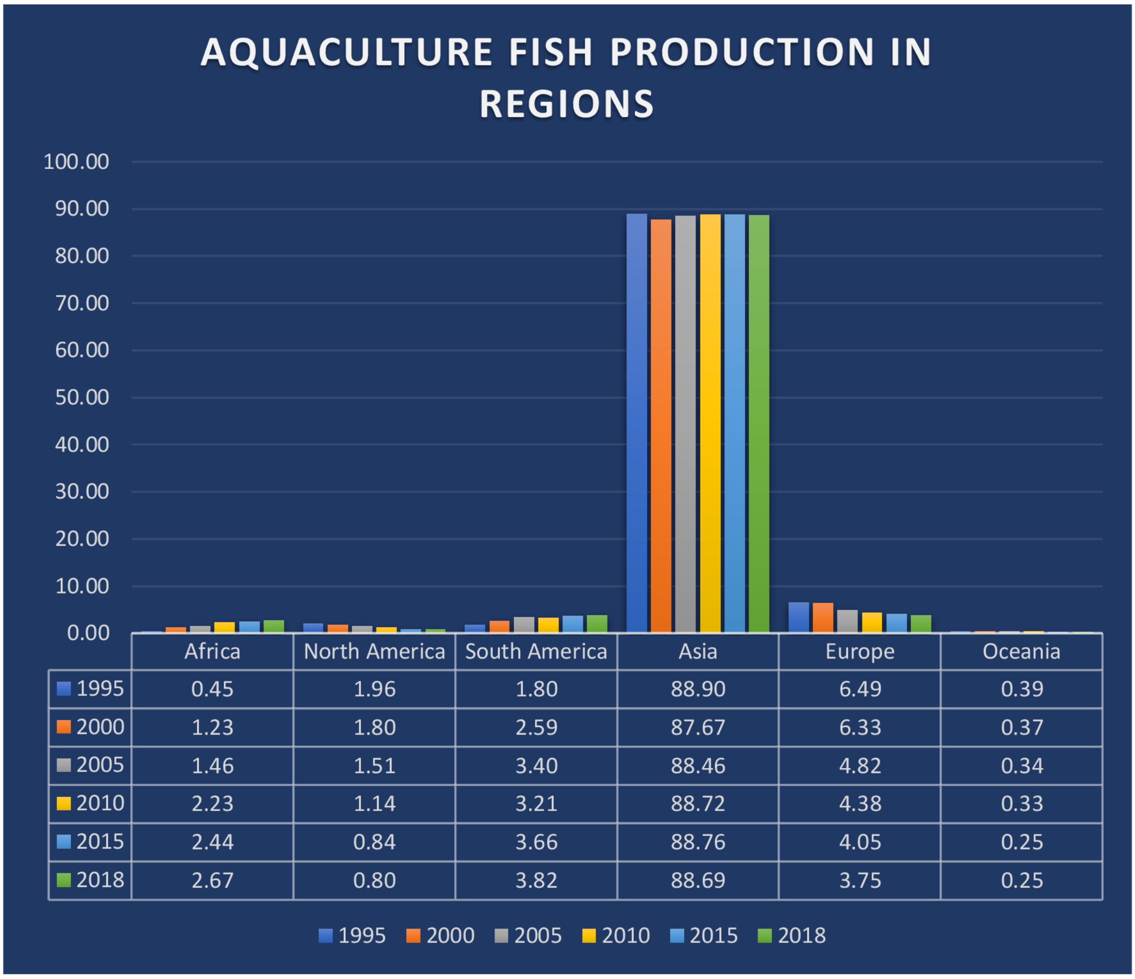
	Carps, barbels and other cyprinids	Tilapias and other cichlids	Catfishes	Freshwater Perch-like fishes	Freshwater fishes nei:
countries	92	127	86	30	65

Own formation, data source: (Junning Cai, 2019)

Production of freshwater fishes can be also analysed from a perspective of how widely they are spread. From this point of view, the Tilapias and other cichlids are most popular. They are produced in 127 countries accounting for 13% of the global production (Junning Vai, 2017).

It is also notable, that salmons, trout and smelts are not included in the freshwater aquaculture. Reason behind it is that they are categorized as Diadromous fishes, meaning that they spend their lived only partially in freshwater, and the other part in saltwater. However, in 2017 they were accounting for 3,11% of world aquaculture (Junning Vai, 2017). In the practical part we will see that trout and carp species are most common fishes produced in Georgia and their farming cultures are very different.

Figure 5: Fish Production by Regions



	Africa	North America	South America	Asia	Europe	Oceania
1995	0.45	1.96	1.80	88.90	6.49	0.39
2000	1.23	1.80	2.59	87.67	6.33	0.37
2005	1.46	1.51	3.40	88.46	4.82	0.34
2010	2.23	1.14	3.21	88.72	4.38	0.33
2015	2.44	0.84	3.66	88.76	4.05	0.25
2018	2.67	0.80	3.82	88.69	3.75	0.25

Own formation, Data Source: (Junning Cai, 2019)

It is interesting to see that Asia has been tremendously dominating the global production since 1995. In the African region, the production has been increasing gradually, in fact, it has increased by 2,22% since 1995. The tendency of growth is somewhat similar for South America, it also has 2,02% increase over last 23 years. Europe, North America, and Oceania, on the other hand, have been decreasing the aquaculture production. In addition, Oceania's' contribution by the year 2018 is only 0,25%.

3.1.2. Good Governance in Aquaculture

Importance of governance in aquaculture is demonstrated in many ways, one of which is the right allocation of resources. According to Keefer and Knack, up to 75 percent of the differences in per capita income between countries can be attributed to governance factors (Keefer and Knack, 1997). However, the main challenge and goal of a good governance remains reduction of risks to society and environment as well as the transaction costs on farmers' side. Moreover, poor predictability and security could be caused by lack of tule of law. With the given circumstances, farmers fear to risk or invest and as the rent-reeking becomes rational behaviour in resource use, little productivity is achieved (Nathanael Hishmunda, 2014). When thinking about good governance, one should not only consider the economic benefits of it but also social and environmental sustainability. On the global scale, aquaculture has a great importance for achieving the Millennium Development Goals by increasing the availability of food and especially the fish products as source of protein. Clearly, there are many challenges, and they differ in many levels.

With the rapid expansion of aquaculture, it has raised concerns over the environmental and social impact of seafood production. While progress has been made in addressing various environmental issues and social impacts, the challenge of thoroughly assessing the governance of the industry has largely been missing. Researchers at Mawgan University in the Netherlands and member of Monterey Bay Aquarium Seafood Watch programme have developed a framework to assess the aquaculture governance. The Aquaculture Governance Indicators – AGIs looks at the means by which change can occur. The AGI uses 4 main dimensions: (1) Legislation, (2) Voluntary codes and standards, (3) collaborative arrangements and (4) Capabilities. The framework has been developed in 2021, therefore it is still a fairly new mean for measurement. However, it will be surely useful for assessing the governance of aquaculture in Georgia in the practical part.

As it can be seen on the AGI – dashboard (Monerey Bay Aquarium Seafood Watch & Wageningen University and Research, 2021), Some of the criteria are as follows:

- Authority
    - Authority can be measured by the control of corruption in the selected country, regulatory quality, government effectiveness, political stability, and absence of violence, etc.
    - Accountability, cost-effective and efficient oversight could be also used in detecting a poor authority. Weak accountability could be detected if officials are sole decision-makers without transparent guidelines, if there is no opportunity to appeal decisions, in addition to public mistrust of government policy and no credible source of scientific information. To improve poor accountability government (or any other decision-making body) should

increase transparency of criteria, communicate benefits and costs of aquaculture, and reduce secrecy by industry. Cost-effective and efficient oversight could be seen in poor governance if there is over-regulation deterring investment and international competitiveness, conflict regulations, lack of support from communities and stakeholders, decisions made in ignorance of different contexts, long delay and heavy cost to obtain a licence, criteria for obtaining a licence unclear and left to official discretion and with multiple layers of approval for a licence. To improve the above-mentioned situation, there should be a lead agency established, as well as one-stop-shops, also wider participation should be encouraged and cost-benefit analysis of regulations required (Nathanael Hishmunda, 2014).

- Organization
  - Measured by implementation guidance and information transparency
  - Could be also measured by administrative procedure and its enforcement, human resources, the way licences and permits work, regulations etc. In case of poor enforcement, the constraint could be funding and lack of personnel, in this case the reforms that could change the situation would be to rely on codes of conduct and producer associations. For lack of skilled managers or other human resources, government should encourage cooperative training programmes (Nathanael Hishmunda, 2014).
- Enactment and learning
  - Commitment, continuity, attention for systematic and controversial issues and quality of learning
- Coordination with global regulation and policy
  - By commitment and intentionality, change in legislation,
  - Example of poor licence management would be lengthy and expensive procedure for which government might take examples and learn from successful practices. Having too many regulations could also constraint and prolong the reviewing process, therefore reducing redundant regulations could be a good solution.
  - Lack of political will
    - Availability of evidence fit for policy making that governments can use to balance decisions on generating economic prosperity when

deciding on which sectors to grow whilst maintaining good environmental health of aquatic ecosystems and realizing social benefits (Stead, 2019)

- Innovation drive
    - Initiative, leading by example, resource allocation etc.
- Informational processes
    - Precision and accuracy, coverage and salience of data, reputation and data sources, etc.
- Reflexivity
    - Willingness to reflect, engagement with knowledgeable others, organization of problem and solution identification
- Agility
    - learning-by-doing, training of staff and resource allocation

In addition to the AGI technique, the absence of governance in a sector is easily recognizable with a number of key symptoms: a failure to distinguish between what is private and what is public; a failure to establish a predictable framework of laws, or arbitrariness in application of laws and rules; priorities inconsistent with development, leading to misallocation of resources; nontransparent decision-making; and the lack of sufficient regulations, or the existence of excessive regulations, which encourage “rent-seeking” (World Bank, 1991).

Another, equally interesting idea developed by the Wageningen Centre of Sustainability Governance (WCSG) is area-based management (ABM) system (Bush, 2018). The approach was developed in order to address the issues sustainability issues. According to the research conducted by WCSG, currently most regulators manage the sector at the level of individual farms. As farms are integrated in landscapes, a farm-based approach struggles to maintain healthy ecosystems. In addition, it is also difficult to ensure every individual farm separately. ABM is very useful, as its approach manages risks across areas instead of individual farms. To be more precise, for insurers and banks ABM makes it simpler to assess the overall risk of an area as opposed to single farms. In result, it allows farmers to offset shared risks and collectively improve their production practices. Considering the mentioned factors, ABM can better enable sustainability (Bush, 2018).

Good governance does not only imply the government regulations, but it can also be applied to the farm level. Sustainably managing the farm is not only a responsibility but also an advantage, as it helps preventing the spread of diseases. If fish farms are managed in an environmentally friendly way – with as less water contamination as possible, fishes grow healthier resulting in the customer trust and loyalty is increasing and there is less damage to the production. There are many interesting innovative technologies for filtering the water, one of them is by bioremediation. The technology was developed by MBD, and it uses fast-growing macro algae to soak up the nutrient contamination.

It has to be emphasized that there is no single type of governance that could be called good or bad. The discussion above only demonstrates if the chosen governance works or not in a particular environment, region and country. For instance, the *"hierarchical governance"* that is explained in one of the FAO's reports, is considered to be more conservative way as it implies to top-down or command-and control type of governance (Nathanael Hishmunda, 2014). If we take same examples, in case of China, this type of governance proved to be most efficient and profitable, in comparison to Thailand, where it failed as laws became outdated and inadequate (Nathanael Hishmunda, 2014). Therefore, when choosing a governance type, countries and decision-makers have to make sure to keep abreast of new challenges of the industry.

Another type discussed in the same source is *"market governance",* which depends on supply – demand forces. The potential risks and challenges facing market governance are social disruptions and unpredicted environmental damage, which is mainly caused by the neglected importance of regulated external costs, as farmers pursued nearsighted profit-maximization (Nathanael Hishmunda, 2014). Therefore, one may assume that laissez-faire market governance could be dangerous if regulations by government are totally excluded. However, if intervened in a right way, with avoiding surplus and environmental protection as well as health and food safety, the market governance could be successful. A great example of this form of governance is Norway and its aquaculture act aiming to enhance industry profitability within the restrain of sustainability (Nathanael Hishmunda, 2014).

"Participatory governance" as explained in the Policy and Governance report by FAO, "extends from industry self-regulations using codes of practice, co-management of the sector with industry representatives and government regulators, to community partnerships" (Nathanael Hishmunda, 2014). However, the first two are the main forms of this type of governance. Examples of countries with participatory governance could be seen in Great Brittan and Northern Ireland, Canada, and Norway. One might presume that to be able to effort self-regulation, the environmental and social awareness in the country should be high to recognize consequences of erroneous decisions. For example, in poorer countries that priority for farmers could be not the sustainable environment but the profitability, in such case they will be less likely to be concerned about the water quality that leaves their farm. At National level, however, many countries, including Georgia, have codes of contact with incentive for farmers to acquire a certification of quality in case of meeting the requirements. The system, unfortunately, has its own share of disadvantages such as not excluding farmers that do not comply with codes of conduct. There are many different requirements and assessment standards around the world, starting with Good Aquaculture Practice by Thailand, to Hazard Analysis and Critical Control Point (HACCP) by Canada to ISO 14001 international standards. Those standards must be met by every farm in order to protect environment and assess the effect of drugs use and feed in the ponds (Nathanael Hishmunda, 2014). In addition to the shortcomings discussed above, there is another limitation to self-regulation and co-management of aquaculture, which is a short range of stakeholders, which could improve the legitimacy by extending the range of different party participation (Nathanael Hishmunda, 2014).

3.1.3. Future of Global Aquaculture and Its Importance

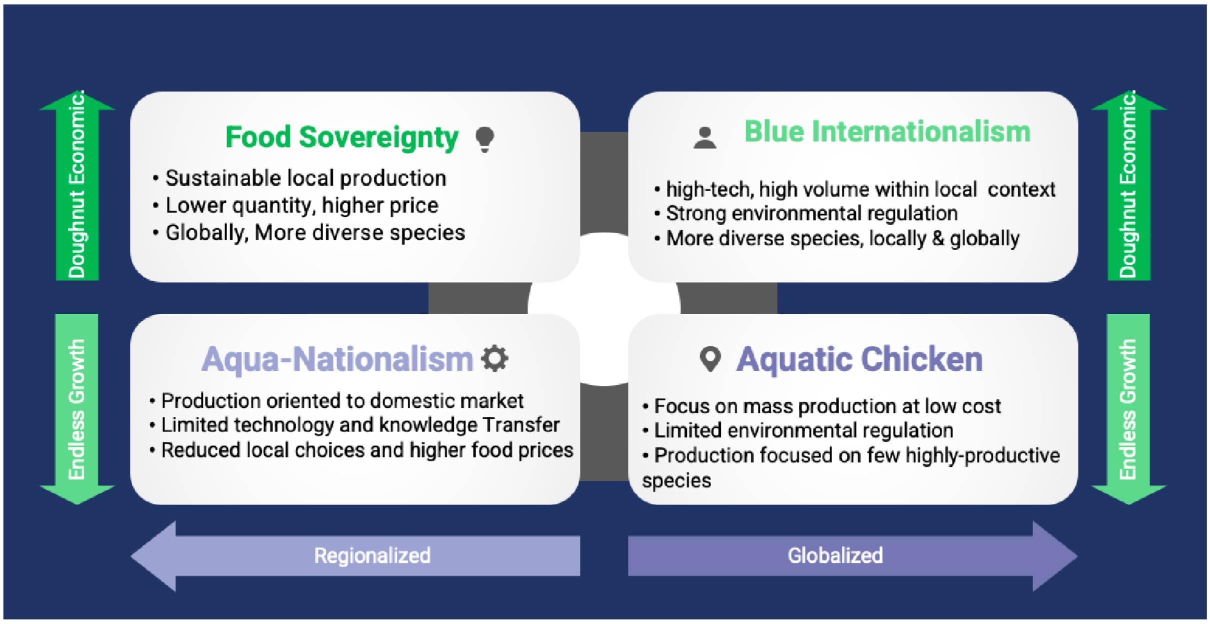
It is predicted that the global population by the year of 2050 will reach 9-10 billion, which naturally means the increase in food demand (Jessica A. Gephart, 2020). According to FAO and SOFIA statistics, from 1990 to 2018 there has been a 122% rise in total food fish consumption (FAO, 2020). The role in meeting the demand requires intensely increasing the Agricultural as well as Aquacultural production. Therefore, development of freshwater and marine sectors plays crucial role even on the global level. As almost any kind of mass production has an environmental cost, one must be careful about the way the development will evolve. In case of freshwater aquaculture, we should take into consideration that the process should be done in a sustainably respectful way. The emphasis should be placed on the energy use, feed and fertilizer input, water reliance and pollutant release etc. Supposedly, the environmental regulations will be stricter worldwide, therefore while developing the sector it is good to bear in mind the possible scenarios on required level of adaptability.

According to the FAOs future forecast, fish supply, demand and trade are expected to grow, however, the increase rate will not be persistent for the whole period, total fish production is expected to grow by 25 million tonnes by 2030 reaching 204 million tonnes, in comparison to 2018 where the production was 179 million tonnes (FAO, 2020). In addition, if we look at only the at the aquaculture production, it is expected to increase by 32% in 2030, which amount of 109 million tonnes (FAO, 2020). As a regional outlook, Asia is expected to keep the dominance in the aquaculture sector and will be responsible for more than 89% of the increase in production by 2030. The fisheries and aquaculture will be notably expended in Africa, by 48%, as helpful culturing capacity have been put in places in recent years (FAO, 2020). However, as the population will increase there is a food security concerns, especially in African region. Regarding the prices, taken into consideration, the natural inflation over the years, they are also anticipated to rise in future (FAO, 2020).

There are many other important sides of the aquaculture and fish as a source of food security. In general, it is most predominant single source of high-quality protein, providing ~16% of the animal protein consumed by the world as well as certain fatty acids, Long Chain Omega-3 fats, Iodine, vitamins D, iron calcium, zinc and other minerals (WOR 2 , 2013), however the nutritional contribution might vary between the fish species as well as what are fed, in addition to the environmental, social and economic context of production (Jessica A. Gephart, 2020).

Beyond the brief projection of future forecasts, it would be interesting to analyse how will the sector develop in upcoming years. There are many ways to look at the future of global aquaculture. One of the most interesting hypothesis and research was done by several authors in "Reviews in Fisheries Science & Aquaculture" journal. They have developed four possible future scenarios in which the sector could develop. The paper looks at two key drivers, *Economic Globalization* and *Economic Growth Trajectory* (Jessica A. Gephart, 2020).

Figure 6: Visual Representation of the Two Selected Axes and Four Resulting Scenarios



Own Formation, Source: (Jessica A. Gephart, 2020)

The geographical growth pattern describes the level of interdependency, connectivity, and integration in a food system where production and consumption occur either locally or geographically distant area. Therefore, the farms on the extreme left would represent farms that are mainly focused on household production and consumption, from that point on towards right, there are systems that include increasingly large geographic areas, such as trading blocs, trade unions, international trade associations and organizations etc. Farms positioned on the very right of the horizontal axis would represent a global market system, where the fish is produced mainly for export (Jessica A. Gephart, 2020).

The vertical axis describe different ways in which economies around the world may develop (Jessica A. Gephart, 2020). They have different approaches towards social and environmental development, different food system configurations and aquaculture growth patterns, however, both can improve economic well-being. On the lower side of the vertical axis, more capitalistic approach is presented, with the belief that economic growth can be endless as long as the governments provide the right investments in many aspects including innovation, infrastructure and human resources. The other half expresses deep concern for environmental boundaries, by establishing a safe and just operating space for humanity, creating a donut-shaped space for development (Raworth, 2012). This approach is characterized by socially (or state)-set standards by focusing on labour laws and unions to ensure gender equality, good working conditions and fair wages (Jessica A. Gephart, 2020).

The two axes that has been discussed above create four distinct future scenarios of how the aquaculture sector could develop. However, It is worth mentioning that perhaps all of those scenarios will happen, each in different continent, region or country. For example, in *Aquatic chicken* scenario the industry is developed through technological innovations and generic selection with limited environmental regulation. In this scenario, supply chains would be mostly vertically integrated allowing few companies to control key components of the supply chain (Jessica A. Gephart, 2020). In case of *Aqua nationalism* countries focus more on national level of production. Even though countries would support local production allowing them to meet the demand and produce sufficient amount, import barrier for feeds and limited technology transfer as well as underdeveloped regularity systems result in less effective production with higher prices. Reduced access to imported feed ingredients drives the costs of production higher (Jessica A. Gephart, 2020). In *Food Sovereignty* scenario focus is more on small-holder production, where the total production is relatively low. As there is limited efficiency and scale in production, investments also decreasing with fewer distribution technology. In result, there is moderate species diversity, only enough for local cultural preferences (Jessica A. Gephart, 2020). The fourth scenario is *Blue Internationalism* where the sustainable development is aligned with globalized food systems. There is a global trade and sufficient technology transfer, which lead to the global sector development. As the environmental boundaries are respected, the disease contingency is reduced, leading towards safer food and higher profits. In addition, in case of occurrence of spread disease, they can be time effectively resolved with cooperation (Jessica A. Gephart, 2020).

To conclude, the reviewed research paper offers very interesting insights on future of aquaculture development. in all of the scenarios there are details that can be seen in global tendencies already. As the analysis shows which case would lead to what result, it can be used to design future strategy for individual state as well as globally for the whole sector.

3.1.4. Systems Thinking and Innovation in Fisheries Management

Before applying systems thinking and open innovation to the aquaculture industry, the concept of systems thinking will be introduced, of which was learned at Grenoble Ecole de Management on a course called “Systems Thinking” by Professor Mark Olsthoorn. During the course I realized that systems thinking is based on synthesis rather than ordinary analyses, which works in reverse direction, trying to gain understanding of an entity through the context of its relations within a whole that it is part of. One of the most important lessons learned from systems thinking is the process of reasoning in a holistic manner, meaning that the main attention goes to the parts of something that are intimately interconnected and explicable only by reference to the whole. Thus, focusing on the relations between the elements. That is to say, the way those elements are put together or arranged into a functioning entire system.

In the book called The Signal and The Noise, Nate Silver wrote a chapter called becoming less and less wrong (Nate Silver, 2013). I think, we could use this title to describe the value of systems thinking, as the purpose of systems thinking is to help us to be clear about our assumptions to surface, make them explicit, test them and improve them so that overtime we become less and less wrong, which is very important especially in aquaculture field where the decisions must be takes frequently as discussed in a previous chapter. For a good aquaculture governance (and not only), it is crucial not to broke down the systems into its most elementary components and analyze them in isolation. The recombination of these components into the original system does not give us an efficient solution, it tends to ignore most important aspects as the relation in this type of analyses is not taken into consideration.

Many of the systems have a high level of inter connectivity and interdependency. Examples being ecosystems, computer networks, and many types of social systems as discussed over the course. These systems, in contrary, are primarily defined by the relations within the system and not the static properties of their elements (Turnbull, 2018).

Great example of a systems thinking solution in aquaculture would be an approach discussed in a previous chapter, area-based management (ABM). sometimes people tend to think about themselves while not thinking about the consequences, broader space, and time dimensions. When the area-based management is implemented, farmers start to think about not just their own space but the whole area. Which is the result of thinking about relationships and consequences of their actions in their ponds resulting in greater environmental responsibility. by implementing the systems manner, asking the right questions about the long-term effect, whole ecosystem, the dynamics of symptomatic solutions, they optimize benefits, in terms of environment as well as socio-economic aspects.

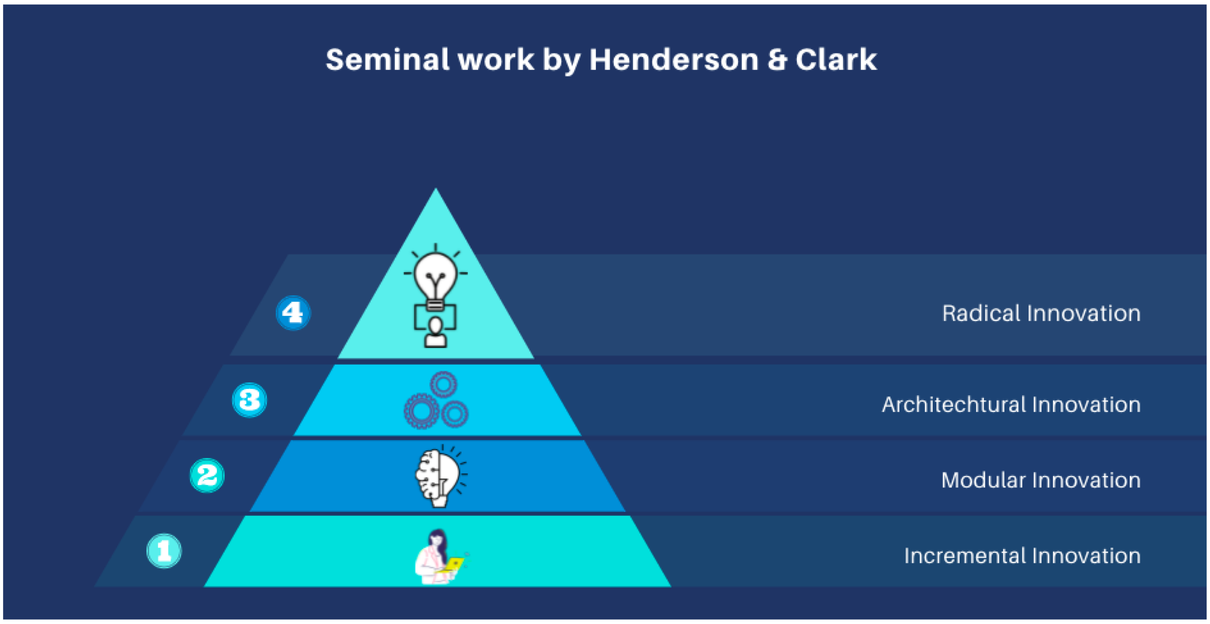
Selina Marguerite Stead argues that the systems thinking, and open innovation can help strengthening aquaculture policies and achieve one of the United Nations Sustainable development goals – to end hunger (Stead, 2019). Properly managing aquaculture, with the help of open innovation, we could achieve food security, improve nutrition and strengthen evidence-led aquaculture policies, which could be done by sustainably using the natural resources. In the same report, author mentions the best aquaculture management practices (Stead, 2019):

- Restocking
- Habitat enhancement
- Increase environmental quality

By using the systems thinking, one could explore inter-relationships, perspectives, and boundaries, as well as have broader look at the role of aquaculture for understanding. According to the author, there are great examples of Finfish as an environmentally responsible form of farming and a strategic solution to mitigating food insecurity. For instance, island nations, Seychelles, where it is a part of a national policy to focus on the blue economy, where marine aquaculture has been selected for investment to underpin long-term economic prosperity and social development in the islands (Stead, 2019).

In a report by Oliver M. Joffre and others on how innovation in aquaculture is conceptualized and managed, an interesting work is discussed. According to which, there is a seminal work by Henderson and Clark and it classifies four main levels of complexity of innovation (Olivier M. Joffre, 2016). The illustration below is based on this theory.

Figure 7: Seminal Work



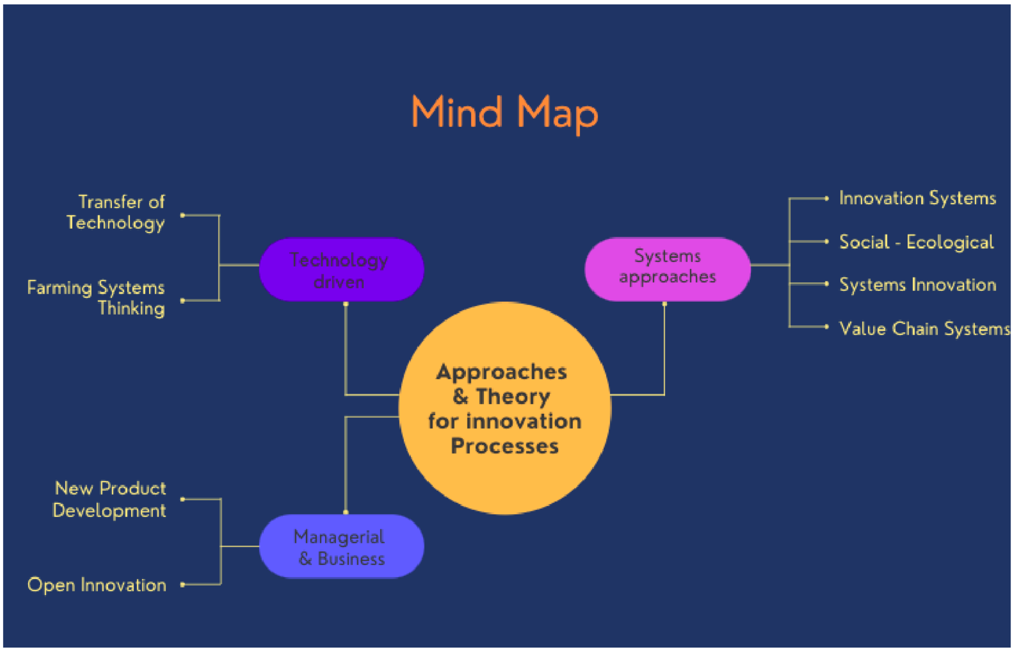
Own Formation, Source: (Olivier M. Joffre, 2016)

Based on the concept, the *Incremental Innovation* is based on the pre-existing technological knowledge and organization of the components; the *Modular Innovation* requires new technology but no chance in the architecture of the components; the *Architectural Innovation* is implemented by using known technology but requiring a change in internal organization and interactions between components; and in the *Radical Innovation* technology and organization is changed profoundly (Olivier M. Joffre, 2016).

Innovation and adaptation are equally important for the development of sector and its policies, with various driver forces and triggers, such as climate and environment. According to Anadon, *"innovation is a process in which significant and novel uses of ideas are generated, diffused and adopted"* (Anadon LD, 2016). There are different types of innovation, technological – which includes breeding systems, vaccines, feeds etc., and non-technological – which implies on organizational structure, governance regulations & frameworks, market stands (Olivier M. Joffre, 2016). The importance of innovation has been emphasized by many authors in almost every sector, regardless private or public, and its contribution to development in general. Moreover, it is clear for everyone that with the increase of climate resilience the dependance on innovation will also increase, as there is not many other ways or options to meet emerging new needs. However, what we mostly forget, or neglect is the fact that there are different types of innovations, the ones that are implemented for an already existing need and the ones for upcoming challenges. For the case of Georgia, however, it seems to be wiser to think about the adaptative innovation. This aspect of must be taken into consideration as according to Louis Lebel, "adaptation and innovation are time-bound" (Louis Lebel, 2021). To be more precise, before investing in innovation one has to make sure that the practice is not outdated or out of concept.

For deeper analysis of various types of approaches and theories for analysing innovation processes, mind map has been designed. The information is based on the article by Joffre and other co-authors (Olivier M. Joffre, 2016).

Figure 8: Mind Map for Innovation Process Theory



Own formation, Source: (Olivier M. Joffre, 2016),

Regardless of some similarities, there are many important differences between the approaches shown above and their sub-strands. The main differences are visible when looking at the main objectives, scope of analysis, as well as focus point, role of institutions in the analysis and desired outcomes (Olivier M. Joffre, 2016).

For wisely adopting the strategies, it is important that a country does not only look how an innovation advancement worked in other countries but to analyse the environment in a local level. Therefore, in the beginning the biggest challenges for a national sector should be identified. Other considerations should be drowned on practice types, who are the key players when it comes to innovation.

Table below is taken from the same source (Olivier M. Joffre, 2016), and is dedicated to greater and deeper analysis of all theories.

According to Louis Lebel and other authors, *"Novel technological and biological practices for the most common cultured species groups like salmon, shrimp and tilapia, are led by national and global experts with solutions based on science and technology; for local and less commonly cultured species, or less intensive systems, farmers draw more strongly on experiences in everyday practice as source of innovation"* (Louis Lebel, 2021).

Figure 9: Different Approaches in Aquaculture Management

Approach	Technology-driven approaches		System approaches				Managerial and Business approaches	
Strand within approach	Transfer of Technology (ToT)	Farming Systems (FS) Thinking	Innovation Systems (IS)	Social-Ecological Systems (SES)	Systems Innovation (SI)	Value Chain (VC) Systems	New Product Development (NPD)	Open Innovation (OI)
Main goal of innovation as defined in approach	Transfer, diffusion, and adoption of technology	Develop innovation adapted to local context and constraints	Enhance capacity to respond to change and orchestrate stakeholders	Transformation of systems towards ecological sustainability and resilience	Transition towards a new more sustainable system comprising production system's value chain, regulatory environment, and consumption system	Value chain supporting equitable and sustainable sectors	New product responding to user requirements	Source knowledge from outside a firm's boundaries
Main scope of analysis	Productivity increase	Identify constraints to innovation within specific context	Analyse how to organize change	Dynamic analysis of non-linear and uncertain changes in coupled social and ecological systems	Understanding how actors influence change through power struggles, co-evolution between technologies and social structures	Analysing value chain regulation and power relationships	Feedback from users and other actors to design ideal products	Understanding knowledge sourcing in R&D process
Analytical focus point	Technology packages	Locally adapted knowledge and technology	Analyse how support structures for innovation (e.g. research) interact with stakeholders in production system, value chain, and policy system	Interactions between human and ecological systems across different geographical scales	Interactions between diverse actors at different levels in production system's value chain, regulatory environment and consumption system	Structure, organization, and coordination of the value chain	Joint design process of technologies and their context – whole systems design	Sources of knowledge and collaborative approach to achieve collaborative innovation
Geographical scale	Local	Local	Local to national and global	Local to global	Local to national and global	Local to global	Local	Local to national
Domains considered	Production system	Farming system	Policy system and value chain	Ecological and social systems	Policy system and value chain	Policy system and value chain	Production system	Production system
Role of institutions in the analysis	External drivers of adoption	External conditioner of adoption	Institutional and political dimensions and their interactions with other dimensions under consideration	Ecological aspects are dominant Limited attention to political context	Political dimensions of innovation and power struggles are included	Focus on governance and institutional framework that regulates interactions in value chain	Integrates regulatory framework in analysis to identify point to improve to make product fit	Understands institutional context and regulatory framework to access knowledge
Regions of application (developed/developing country)	Both	Both	Both	Both	Both	Both	Both	Developed
Flow of interactions to create, improve, or scale innovations	Top-down, initiated and pushed by research Linear, no feedback from end-users	Top down, initiated by research but participatory in nature	Multi-directional, can be initiated and driven by research, companies, farmers	Multi-directional Initiated by companies, farmers, research	Multi-directional and feedback interactions between levels Niche actors generally initiate the change	Multi-directional, change initiated by consumers, research, private sector	Multi-directional, iterative, and joint design production between actors Initiated by research or companies	Multi-directional Initiated by companies, transversal information flow across firms and other actors
Desired outcomes	Gain in yield, income, and food provision measured at farm level	Efficiency gain, productivity, economic and environmental outcomes (related to livelihood portfolio)	Increased capacity to innovate and learn	Identifies economic and ecological thresholds and (non-linear) linkages between subsystems	Sustainable new system	Changes in regulatory systems, institutional framework, and more equal power relationship between actors	New technology design fitted to user requirements	Creates better product and new business opportunities (e.g. agri-electronics)

Note: Approaches in this table are not mutually exclusive, and elements of a given approach can sometimes also be found in other approaches.

Source: (Olivier M. Joffre, 2016)

There are also many barriers for innovations, such as costs, skilled human resources to perform a technical routine, as well as other capabilities and motivation to comply with institutional rules. Depending on a size of a firm, the issues vary. For larger farms with more complex ecosystems and structures, innovational technologies would be more likely seen as a mechanism for higher value species. On the other hand, smaller farms would be more concerned about solving high risks (apart from relocation of ponds) as it is more budget friendly. To make sure that innovation is properly implemented, attention should be given to who drives, who innovates, who impedes and for whom (Louis Lebel, 2021).

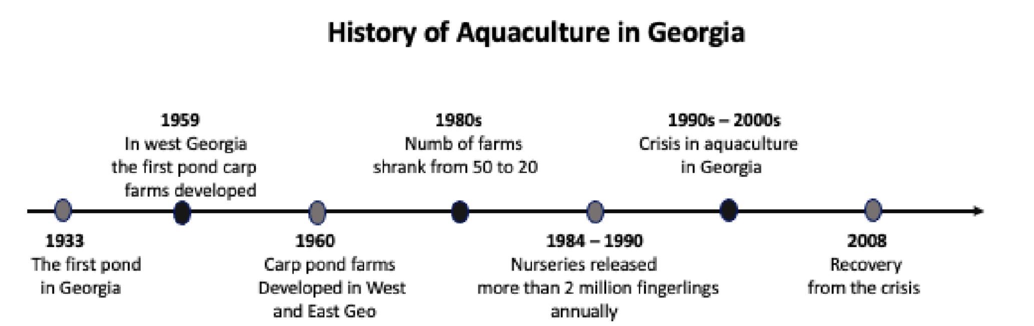
Furthermore, to get back to the concept of the systems thinking, it is important to note that the innovative practices are not adopted independently, they are interconnected to different part of the whole system. For example, a technological or biological improvement might lead to technical. If we take more practical example, a new aeration equipment would require skills for daily use routines, it would also be connected to additional costs of electricity and more work from labor. Similarly, genetically improved stocks would involve different type of disease control protocols, which in addition would require more skills and knowledgeable human resources.

3.2. Perspective from National Level

3.2.1. History of Aquaculture in Georgia

The beginning of the development of industrial aquaculture in Georgia can be traced back to the 1930s. In the period, Georgia was a member of the USSR. The Soviet government prompted fisheries and aquaculture production systems to secure the Soviet Union consumption (Varadi L., 2001). Fish was, in essence, a key contributor to the USSRs' economy.

Figure 10: History of Aquaculture in Georgia



Source: Own processing, Data Source: (Varadi L., 2001)

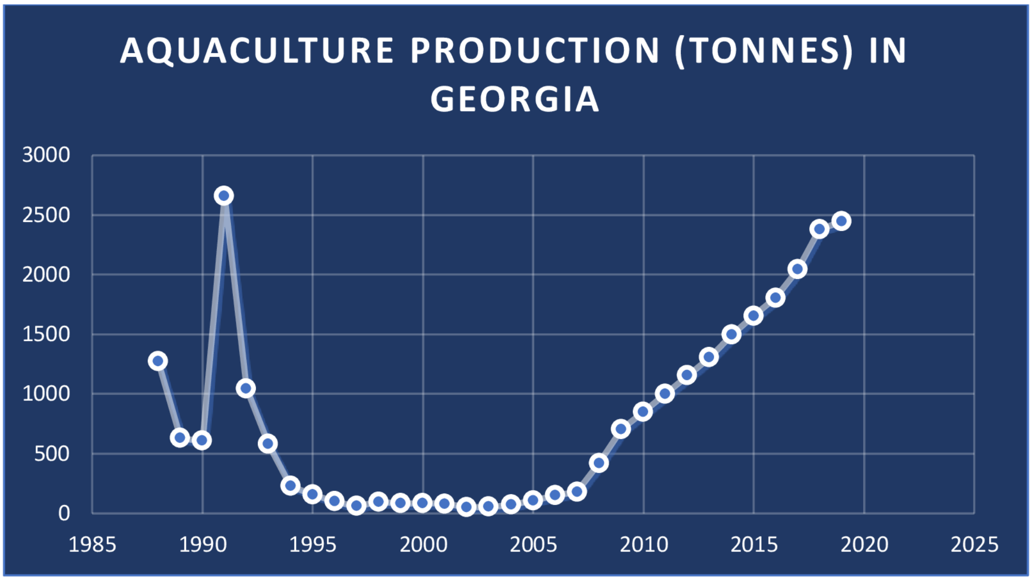
On the lakes Tabatskuri and Paravani, nurseries were created in 1933. In 1935, four industrial salmon farms were erected in the east of the country, while two more were built in the west. For Georgia, pond fish farming was extremely important. In the town of Japana, Western Georgia, the first pond farm was established in 1933 (Barach, 1962). there were approximately 50 farms with a cumulative pond surface area of 2 500 ha between 1930 and 1950 (FAO, 2021). In Western Georgia and Adjara A.R., pond carp farms were developed in 1959. Carp pond farms were developed in both Western and Eastern Georgia in 1960. In the country, there are 15 operational pond farms with a total pond area of 1,446.8 hectares. There are also many tiny ponds (1 - 20 hectares) with a total area of 500 hectares. The ponds' productivity ranged from 1500 to 3000 kg per hectare (FAO Publishing, 2021). 1980s - As a result of the active development of industrial fisheries in the ocean and the Black Sea, attention to aquaculture development from industry leaders waned, and the number of farms shrank from 50 to 20 (FAO Fisheries and Aquaculture Department, 2004).

Only in connection with a large-scale program in the USSR to restore the resources of sturgeon and salmon fish, in Georgia at the end of the 70s, nurseries for these fish species were built on the Rioni and Kodori rivers. In 1984 - 1990, these nurseries annually released more than 2 million fingerlings of these fish into the Black Sea (Barach, 1962).

The 1990s and early 2000s are characterized by a crisis in aquaculture in Georgia, which was mainly caused by lack of resources, inflexible banking, and credit policies, change in consumer market (exclusion of consumers from former USSR) etc. (FAO, 2005).

"The ocean-going fishing fleet was largely sold to Ukraine and the remainder of the fleet appeared to be non-profitable since access to fuel was restricted (because of high prices), as was availability. Container materials, nets and other gears and facilities for vessel maintenance were similarly limited" (FAO, 2005). Naturally, all factors stated above had a tremendously negative impact on the capture fisheries, and not only. The whole economic situation in Georgia has changed. The graph below demonstrates total aquaculture production in Georgia, data is provided by FAO statistics.

Figure 11: Aquaculture Production in Georgia

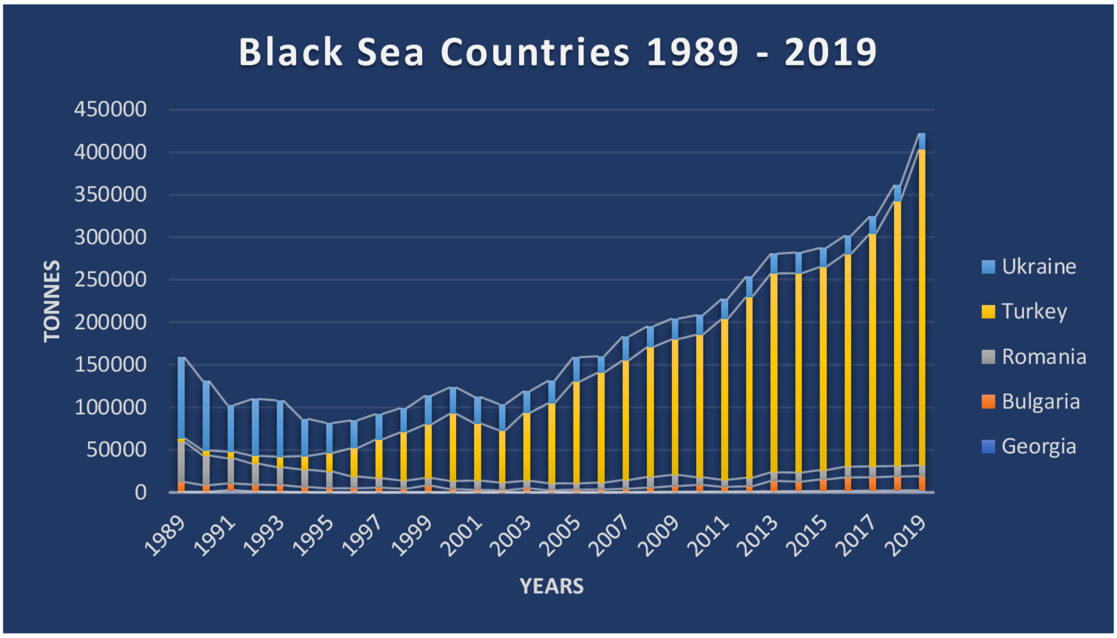


Own processing, Data Source: FAO fishery statistics, aquaculture production

As it can be seen, the highest fishery production was recorded in 1991 with 2 660 tones, then it started declining (due to facts stated before). The lowest production years started from 1997 (61 tones) and continued until 2004 (72 tones). In 2005 the numbers started to increase gradually (107 tones in 2005, followed by production of 150 tones in 2006 and 180 tones in 2007). In 2019, the total production has reached 2 444,7 tones.

2008 recovery in the country's aquaculture started. At the end of 2020, of total volume of fish in waterbodies used for aquaculture amounted to 2 929.7 tons, of which 60.2 percent was Cyprinidae, 26.1 percent - Salmonidae, 12.5 percent – Sturgeon, while 1.2 percent was Siluridae (FAO, 2021).

Figure 12: Aquaculture Market in the Black Sea Region



Own formation, Data Source: (FAO, 2022)

In the Black Sea region Georgia Turkey and Ukraine have been dominating the fish production. However, the marine captures are important part of their total production. According to FAO, "*since 1997 Ukrainian and Turkish vassals have started to fish again in the Georgian EEZ. The volume caught in Georgian waters increased from 1 400 tones in 1995 to 12 200 tones in 2003*" (FAO, 2005).

3.2.2. Georgia and Its Water Resources

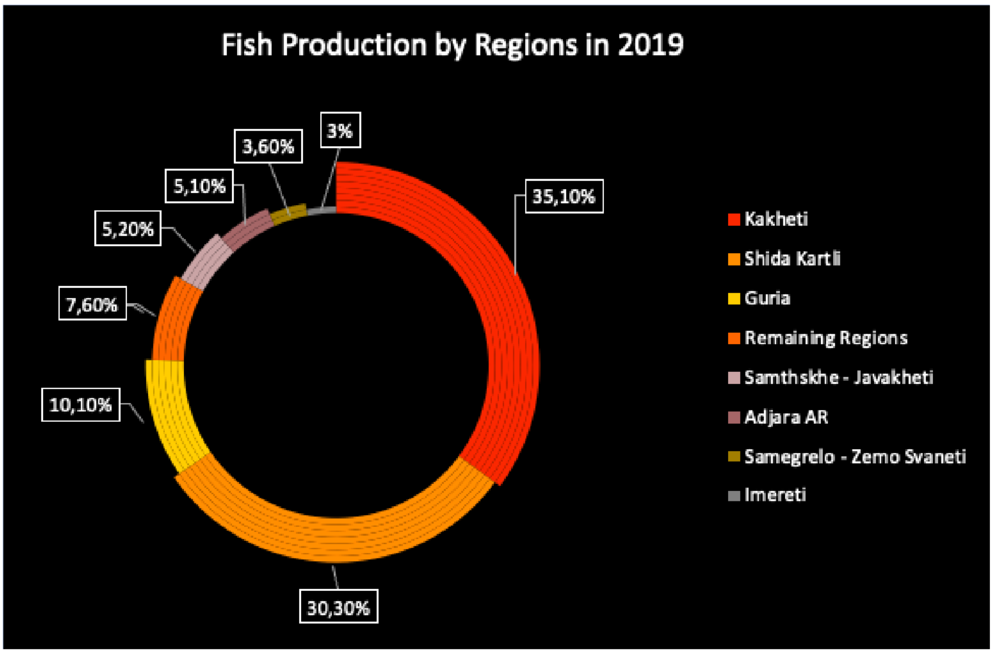
Georgia is a country in Eastern Europe, in the central and western parts of the Caucasus. The country's total area is 69,700 square kilometers, from which 34,132% consists of agricultural land (The World Bank , 2021). There is a very large variety of landscape, ranging from the subtropical Black Sea shores to the ice and snow of the crest line of the Caucasus (Djibladze, 2021).

Georgias' water basin is divided in two main regions: Black Sea basin and Caspian Sea basin. There are 26 060 rivers with total length of 58 987 kilometers (GWP, 2021). A base of hydrographic network are small rivers with length less than 25 kilometers and total length 50 480 kilometers. Total natural river runoff from the territory of Georgia is 56,4 km³ and to the territory of Armenia & Turkey – 8,74 km³ (GWP, 2021). Thus, total water supplies amount for 65,4 km³ (GWP, 2021). There are 850 lakes in Georgia which sums up to total area of 170 km². Regarding the water reservoirs, we can find 43 of them, from which 34 are for irrigation and 9 for power generation. Total useful capacity of all water reservoirs amounts for 2222.6 mln.m³ (GWP, 2021). There are 734 glaciers with total area 513 km2 on the Main Caucasus Ridge. Water supplies in glaciers, water reservoirs and swamps are 35km, thus total freshwater resources amount for 100 km³ (GWP, 2021).

There are 18 km3 of natural ground water resources in Georgia, with 67 percent in Western Georgia and 33 percent in Eastern Georgia. Geothermal resources abound in Georgia, which are concentrated in 44 deposits. Preliminary estimates put their heat power at 420 megawatts, with a maximum thermal energy elaboration rate of 2.7 million megawatt/hour/year. However, the majority of Georgia's 50 geothermal wells are of medium depth and provide water at temperatures ranging from 40 to 60 °C (Food and Agriculture Organization of the United Nations, 2003). Georgia's coastline stretches over 310 kilometers. Ajaria (Adjara) has a coastline of 57 kilometers, while Abkhazia has a coastline of 200 kilometers. In the Black Sea, Georgia has an Exclusive Economic Zone of 21,946 km2 (8,473 sq mi) (The World Bank , 2021).

According to the National Statistics Office of Georgia, fish production was the highest in Kakheti (35.1%) and in Shida Kartli (30.3%) region in 2019, followed by Guria (10.1%) and the remaining areas accounted for 24.4% (National Statistics Office of Georgia, 2019).

Figure 13: Fish Production in Georgia by Regions, 2019



Own processing, Data Source:

3.2.3. Institutions and Administration

The Main Institutions Involved in Fisheries in Georgia (According to FAO):

Table 1: Institutions and Administration of Aquaculture in Georgia

Institutions and their current activities with regard to fisheries	Definition of Resources	Issue Quotas	Issue Licences	Enforcement and Control	Development planning	Data Collection and Information	Increasing Abilities of training	Control of Output quality	Liasise with Stakeholders	Cooperetion with other governmental Organizations	Scientific Research	International Relationships
Ministry of Agriculture	0	0	1	1	2	2	1	1	1	2	2	1
Department of Fisheries	0	0	1	1	2	1	1	0	1	2	2	1
Ministry of Environment Protection and Natural Resources	1	2	2	2	2	2	2	1	2	2	2	2
Marine Ecology and Fisheries Research Institute (MEFRI)	2	2	0	0	1	1	1	0	1	2	2	2
Coastguard	0	0	0	2	0	0	0	0	0	1	0	0
Institute of Zoology	2	2	0	0	1	2	1	0	1	2	2	1
Maritime Transport Administration	0	0	0	1	1	1	1	0	1	2	0	2
Bucharest Commission	0	1	0	2	0	1	0	1	0	0	0	0
Associations	1	0	0	1	2	1	1	0	0	1	1	1
NGOs	1	0	0	1	2	1	2	1	0	1	1	1

Own processing, Data Source: (FAO, 2005);

Notes: 0 = no function in this field; 1 = partly involved; 2 = largely involved.

According to FAO, in 1994 the administration of fisheries has changed. The affairs were moved from Ministry of Agriculture (MoA) to the Ministry of Environment Protection and Natural Resources (MEPNR). The main reason stated in the report was synergies in management of biodiversity, fisheries, pollution and other environmental matters that play a role in fisheries existence and development. Therefore, as we can see from the table MEPNR is involved mostly in almost every activity and decision - making process (Khavtasi, et al., 2010) .

MEPNR has 4 fisheries related departments (Khavtasi, et al., 2010)**:**

- Biodiversity Protection Service (BPS)
- The Centre for Statistics Monitoring and Prognostication (CSMP)
- Licensing and Permitting Department (LPD)
- Inspection of the Environment and Protection Department (IEPD)

Except for the governmental and national bodies, the international support is also present in Georgian aquaculture development. The main figures supporting the sector are FAO and ENPARD (European Neighborhood Programme for Agriculture and Rural Development), with the financial and scientific research initiatives.

3.2.4. Development of Policies

According to the FAO report, prior to 2005, Georgia had no national policy on fisheries. Georgia's Economic Development and Poverty Reduction Program (EDPRP), which provided a general framework for national economic policy, did not recognize fishing as a priority sector. Between 2005 and 2020 the first Master Plan on the development of Georgian fishing sector was created. C.P. Matthew proposed a simple minimum fishery sector strategy for the period of 2007 – 2010. He suggested to sustain fisheries at 2007 level until the finalization of the first surveys of SAFMU - Stock Assessment and Fisheries Management Unit (Khavtasi, et al., 2010).

Aquaculture has its federal licenses and permits stated by the Wildlife Resource Division (WRD) of the Georgia Department of Natural Resources (DNR) and quotas set by the Department of Fisheries of the Ministry of Agriculture of Georgia. Some of the more relevant for this research are:

- AGRICULTURAL BMP'S FOR PROTECTING WATER QUALITY. –

Fish farms enter into this category of enterprise, and it is required for them to conduct their activities with BMPs (Best Management Practices), which are strategies for control and abatement of nonpoint source pollution resulting from agriculture.

- AQUACULTURE REGISTRATION. –

Aquaculturists have to register with the Department of Natural Resources (free) to be able to produce and sell domestic fish. It needs to be renewed every two years.

- NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM (NPDES) PERMIT.

"Any person discharging or proposing to discharge at least 30 days per year from a hatchery, fish farm, or other facility into the waters of the State may need an NPDES permit."

- STATE WATER QUALITY CERTIFICATION. –

  It is required for the Corps to send a copy of their application from the Watershed Protection Branch, to the Georgia Environmental Protection Division for State Water Quality Certification, before they take final action.

(Georgia Department of Natural Resources; Wildlife Resources Division, 2005)

Even though, the national policies did not exist before 2005, Georgia did have the conventions and agreements from 1994, they are listed in a table provided by FAO.

Table 2: Georgian Convention and Agreements, 1994 - 2001

Convention	Ratification
Convention on Biodiversity (CBD)	31.08.1994
Agreement to Promote Compliance with International Conservation and Management Measures by Fishing Vessels on the High Seas (Compliance Agreement)	1994
Bucharest Convention on Protection of the Black Sea against Pollution	1994
United Nations Convention on the Law of the Sea (UNCLOS)	12.03.1996
Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES)	12.08.1996
Convention on Wetlands of International Importance Especially as Waterfowl Habitat (Ramsar Convention on Wetlands)	30.04.1996

Convention the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and Contiguous Atlantic Area (ACCOBAMS)	03.2001
Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention)	06.01.2000

Own Formation, Data Source: (FAO, 2005)

According to the legislative herald of Georgia, new convention regarding aquaculture has been issued on 24th of June in 2020, according to which following principles must be observed in aquaculture activities (Legislative Herald of Georgia, 2021):

"A) use of ecosystem approach in the implementation of aquaculture activities, protection of ecological safety and safety of aquaculture products;
B) introduction of ecologically appropriate technologies for cultivation and / or growth of the aquaculture object and management of productive processes of the reservoir;
C) implementation of aquaculture activities in environmentally compatible places, efficient and responsible use of water and land resources;
D) safe design and placement of aquaculture construction; Taking into account the interests of other water and land users in the implementation of aquaculture activities;
E) Balanced and efficient use of artificial food in aquaculture activities, which ensures optimal growth of the aquaculture facility and minimization of environmental pollution;
F) management of the health of the aquaculture facility, prevention of its disease, reduction of the risk of disease spread and cases of epizootics;
G) use of best practices in technology, equipment and management;
H) taking into account the natural and socio-economic characteristics of the water body and its surrounding area when planning and implementing aquaculture activities;
I) to avoid or minimize the negative impact of agricultural and other activities for the purpose of cultivating hydro biota and / or raising livestock, placing it on the market for food consumption;
J) Preservation of biological resources of Georgian waters and protection of their quality;
K) fishing of natural reservoirs;
L) Carrying out environmental impact assessment during aquaculture activities in cases prescribed by law;
M) monitoring the use of hybrid form and invasive species in aquaculture activities;

N) reduction of possible negative impact of aquaculture on the surrounding ecosystem ecosystem and environment;

O) compensation for damage to the environment;

P) International cooperation in the field of aquaculture;

Q) scientifically based management and application of preventive approach;

R) data collection and production of statistics;

S) waste management;

T) Participation of interested parties (Legislative Herald of Georgia, 2021) *.”*

Other interesting parts of the new law concerns the legal permits for aquaculture activities. Before 2020, the inland fisheries did not have an obligation to obtain the legal permit, however the new law introduces this obligation as well. Which has many possible benefits, including the better statistical data.

It should also be emphasized, that from the side of state, the obligations include assurance of sustainable development of aquaculture, assessments of environmental impact and ordinance of the process of issuing the permit, together with other parts of the obligations.

4. Practical Part

4.1. Methodology and Data Collection

In addition to the general methodology, deeper explanation of methodology will be elaborated, particularly for the practical part. For this section of the thesis, data has been collected in 6 major regions for inland aquaculture production. The interviews have been conducted with different actors, farmers, retailers, restaurant owners/workers, feed processors and one institution. Data has also been collecting via surveys, both in rural and urban areas. The field works for interviews were divided in 2 main parts, 1st in April – May and 2nd in in June. However, between the major fieldworks there were other interviews as well, that took place mainly in Tbilisi (the capital) and Gori (in Shida Kartli region). The already mentioned fieldworks were also part of VCA4D project, which was focusing on value chain analysis of freshwater aquaculture in Georgia. The total outcome from the project were 153 interviews, 5 hatcheries, 2 feed importers, 90 fish farms, 1 food processor, 2 feed processors, 5 wholesalers, 36 retailers, 7 restaurants, 1 ichthyologist, 3 institutions (education and ministry), and 2 members of association. The data treated in this thesis is independent from the outcome of the project as the subject matters of two are different.

Map 1: Conducted Interviews & Production by Regions

Fish production by regions (tons)

	2017	2018
Georgia	2 041,7	2 381,1
Adjara AR	187,0	123,1
Guria	291,2	260,7
Imereti	58,8	96,8
Kakheti	717,7	661,1
Samegrelo-Zemo Svaneti	70,3	311,0
Samtskhe-Javakheti	101,6	124,4
Shida Kartli	543,5	719,7
The remaining regions	71,6	84,1

Own formation based on the interviews conducted, source for production data: (GeoStat, 2020)

Interview questions were both quantitative and qualitative (semi-structured), depending on the actor. Collected data from interviews will be mainly used of qualitative analysis. For bigger scale analysis, such as total number of production in Georgia, data will be based on two main sources, National Statistics Office of Georgia (GeoStat) and Food and Agriculture Organization (FAO).

The questionnaire structure for producers is as follows:

- General Questions (background of farmers, e.i. education, size of farm, stages of production, number of employees etc.)
- Fish stocking (origin, supply frequency, seasonality, quality, challenges etc)
- Sorting (frequency, mortality, on which stages, etc)
- Feeding (origin, types and composition, quantity etc)
- Health (main diseases, impacts on mortality, contingency, challenges, frequency, etc)
- Water quality (management, norms and regulations, on what point of the pond/pool – upstream, downstream, external control, etc)
- Harvest (fluctuation, average production, extra help, average production, etc)
- Selling (main customers, norms of quality, price differentiation, final destination, etc)
- Transportation and distribution channels (management, prices, contracts, etc)
- Regulations (formal laws and regulations, requirements, difficulty, norms for the production regarding fish quality and water, etc)
- Costs (investments, interest on bank loans, costs of intermediate goods and services, such as fingerlings, treatment, feed, transportation, equipment, taxes, wages for employees, amortisation and depreciation)
- Revenues (approximate production on a farm level, main markets, self-consumption, etc.)

The Questionnaire structure for customer survey aimed on the following information:

- Age, gender, occupation
- Consumption of fish in general (Yes/No question)
- Frequency of consumption per month

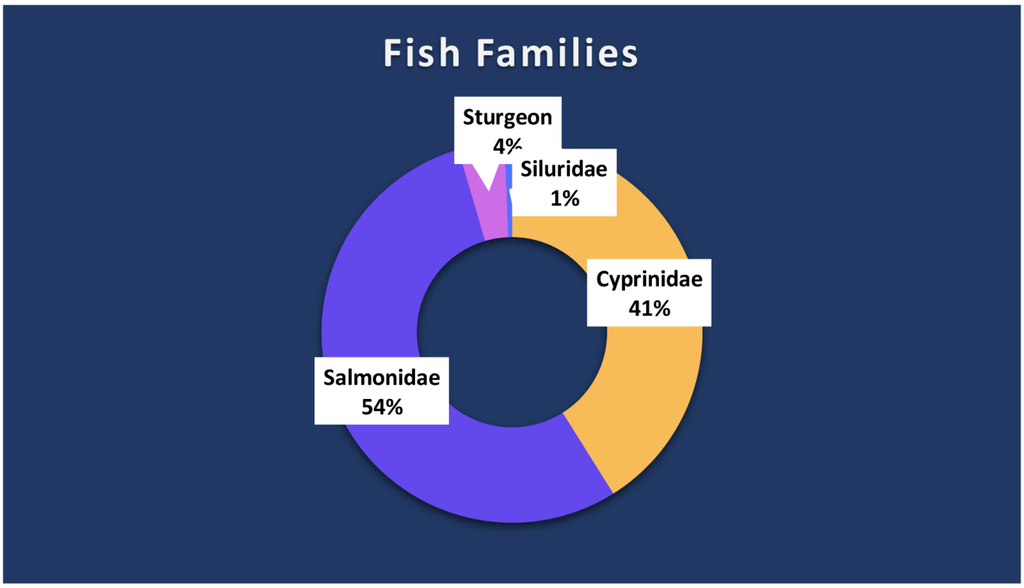
- Quantity (1 portion = 200 – 250 gr)
- Preferred location of product acquisition (Super market, local outdoor market, restaurant, fast food, fish farm etc)
- Region (from which the fish was produced)
- Scrutiny drown towards (e.i. freshness, price, size etc)
- Other comments

Regarding interviews with other actors and experts, the questions were tailored, as their background differed. Therefore, there was not a single structure of questionnaire.

4.2. Sector Definition

In order to define the sector of freshwater aquaculture in Georgia, the structure of the market should be considered first. As the country produces on relatively low scale, the sector is not rich with different varieties of fish families. According to National statistics office of Georgia, four most common on fish families were Cyprinidae, Salmonidae, Sturgeon and Siluridae (GeoStat, 2020).

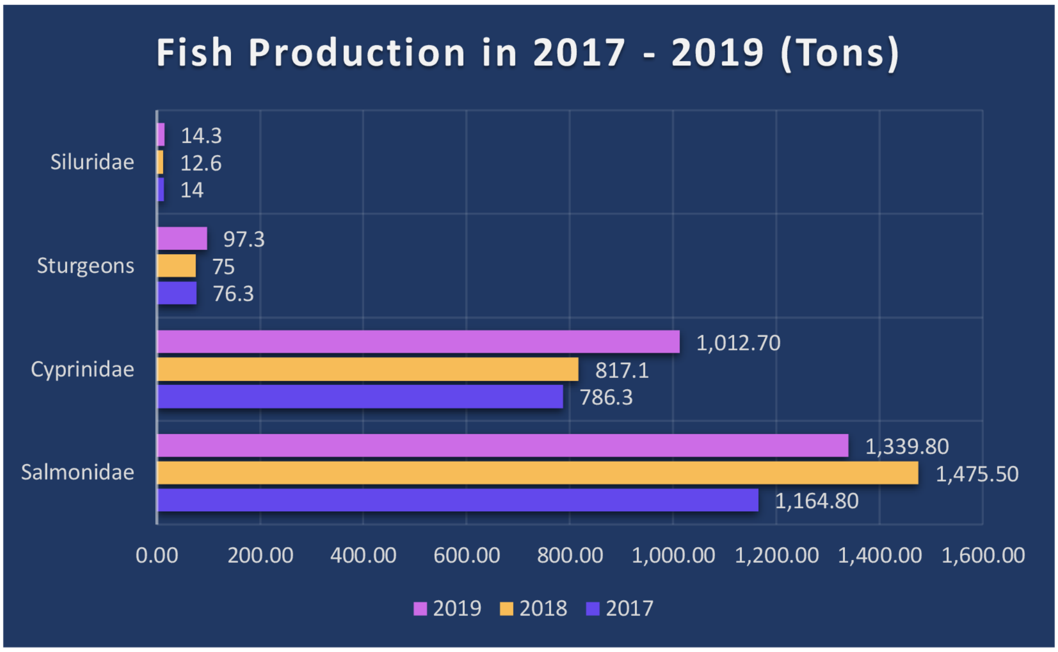
Figure 14: Structure of Fish in Waterbodies by Fish Families in Georgia, 2019



Own Formation, Data Source: (GeoStat, 2020)

There are different tendencies of growth and decline in fish production for each family. For example, Salmonidae had a significant growth from 2017 to 2018, however then declined in 2019 slightly. For Cyprinidae tendency over the 3 years were different with a gradual growth. For Sturgeons and Siluridae, on the other hand, 2018 was the least productive year as it declined from 2017 and then increased by 2019.

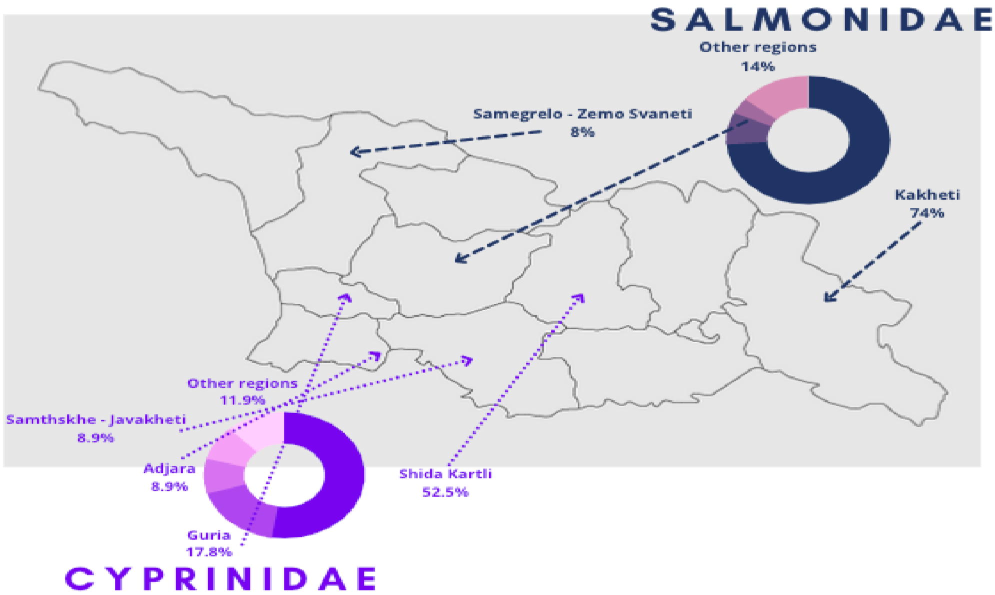
Figure 15: Fish Production in 2017 - 2019 (Tons)



Own processing, Data Source: (GeoStat, 2020)

As the water temperatures and climate conditions in the regions differ, Salmonidae (Rainbow trout, River trout, Lake trout Kizhuch) are mostly farmed in following regions: Kakheti 74%, Samegrelo – Zemo Svaneti 8%, Imereti 4%, and 14% in other regions. The Cyprinidae (Common carp, Mirror carp, Grass carp, Silver carp, Bighead carp, Scarper, Barbel, Common barbel) are more common in Shida Kartli 53%, Guria 18%, Adjara and Samthskhe – Javakheti 9% each, and 12% in the remaining regions.

Map 2: Production of Salmonidae & Cyprinidae by Region (%)



Own processing, Data Source: (GeoStat, 2020)

4.2.1. Differentiation between trout and carp farms

During the field works it became clear that there were many differences in the way the trout and carp farms are operated. The difference was not only the temperature of the water and the climate that the fish families preferred, but even the daily functionalities. The most interesting contrast was manifested in seasonality, costs of production, regions, and feed.

4.2.2. Seasonality

Naturally, speed of growth and overall life cycle for trout and carp are different. As observed in visited farms, trout mainly has 6 different stages of growth, where it reaches different sizes and mortality rates. The eyed eggs, from which the cycle begins, is on average 0,1 grams. Depending on the farm type, the eyed eggs are usually imported from different countries, such as Italy, Poland and others. The mortality rate in this stage is the highest, around 40%. According to the interviews, the farmers must separate the eggs and closely observe if there are any symptoms of diseases. When the eggs are tightly put together, the contagiousness is very high, and the spread of diseases could take only few hours. After the eyed eggs reach approximately 2 grams and 3 centimetres, they are on the second stage, becoming fingerling usually takes maximum 2 months. After up to 4 months it grows to 10 – 12 centimetres with weight of 10 grams. The mortality rate through following stages is only decreasing. The fish is most fragile in the begging before acquiring needed immune system. On the 2nd growing stage it weights 50 grams and is around 15 – 16 centimetres, with only 10% of mortality rate. After one month, on the 3rd growing step, it usually has 120 grams and grows around 3 – 4 centimetres, with decrease mortality rate of 5%. To reach the 4th growing step, it takes 1 more month and mortality stays at 5% rate. At this point the trout is ready to be sold, as the main customers are restaurants, the standard of serving is approximately 200 – 300 grams and 20 -25 centimetres. Some of the trout are usually chosen for breeding and placed in different ponds where they can keep growing and spawn when adult. Trout eggs are most commonly harvested between December and March and the whole process of reaching the selling point (200 – 300 grams) is approximately 10 months. However, if the process length could be different depending on the efficiency of farm and natural resources (such as water, weather etc).

In case of carp, as mentioned before, the stages are different. Carp does not grow when temperature is below 16 degrees as it stops eating. The most optimal degree that were identified by farmers is between 16 – 28 Celsius. Therefore, during summer period it is most actively consuming feed which helps them to grow. In comparison with trout, carp is not usually served as a whole fish in restaurants on one plate, and it is sold when approximately 3 kilogram is reached. Considering the fact of dependence on water and weather temperature, to reach 3 kilograms it takes between 3 to 4 years. Through the growing process, the mortality rate is high (over 80%) on the stage when the fingerlings are smaller than 200 grams. On the second stage after the hatchery for the fingerling to grow up to 600 grams it usually takes around 1 year. After which they are moved to another pond and grow till 2 kilograms. This stage is usually done until March and also takes approximately 1 year. On the fourth stage, they reach 4 kilograms. However, similarly to trout, the rate also decreases as carp grow. Change of pools is even more crucial for carp. As it has different stages, it is important to keep same size of fish in the same pond. Therefore, carp farmers tend to have at least 2 or 3 different ponds where they allocate the fish according to their sizes and approximate weight. As the farms are usually built near the natural bodies of water (e.g. rivers), problem of undesirable fish species tend to appear in ponds. There are several species, such as Murtsa, Carassin, Tsvera, Chanuri that swim to ponds through channels. The fish that come from outside the ecosystem cause disbalance of quality of water as it changes the consistency of oxygen, fertilizers and consumes feed. Therefore, farmers try to capture them as soon as possible to avoid their growth and reproduction.

Seasonality also effects the number of employees in farms, especially for carp. As the fish need to be allocated time from time into different ponds according to sizes, the extra help is also needed. Except for allocation on the seasons when it becomes ready to be sold, seasonal workers become essential. The number of the seasonal workers differ according to the size of farms. For example, in some large size farms, where they have around 20 regular employees, on the appropriate seasons they hired around 5 to 10 extra employees. In case of family farms, in some cases only 2 – 3 people worked regularly, and, on the seasons, they needed help another 3 workers.

4.2.3. Farm types

One of the major differences in farm types for trout and carp fish was the need for different farming techniques. Carps need the farming system that are more natural pond like, however it could also be artificial pools; trout on the other hand is reared in the systems where water is constantly flown-through.

On the images below one of the trout farms is shown. As seen, through the whole farm the water is being flown-through constantly and it is regulated with wooden plank.

The pictures below, were taken in one of the trout farms in western Georgia, Guria region, village Chkhakaura. The farmer had a small building for hatching trout. The different pools were given for different sizes of fingerlings. The farm was founded in 2005 and mainly was focused on rainbow trout and wild trout. He started with producing only fingerlings but in 2007 widened his activities. The farmer was part of a cooperative since 2014 and actively involved in different ENPARD competitions. *"Being in a cooperative is an advantage, especially in terms of bank loans, which are at low rates and which are also proof of trust for the banks"*.

Image 1: Example of trout farm

Image 2: Water flow in trout farm

Photos from fieldwork

Regarding the sizes and functionalities of the farms there are also distinct types of farms in trout and carp culture. The typology of farms was identified and distinguished at the end of the first fieldwork by one of the economic experts, Ludovic Andres. For carp there are four major types of farms:

- Family farms: production is relatively low as the sizes of the family farms are also smaller - approximately 1,5 hectares. In typical carp family farm, the fingerlings are usually acquired. They are only owned but also operated by family members.
- Integrated commercial farms: those kinds of farms include the production of fingerlings in their functionality. Biggest share of their realization is through the external / internal distributors that deliver the product to urban or rural marketplace. Approximately 10% of their production is delivered to customers through retailers.
- Extensive farms: In comparison to the integrated commercial farms, the main distribution channel is through retailers (approximately 70%), the rest is mainly being delivered by distributors and they (farms) also sell to markets themselves. The fingerlings are usually bought from integrated commercial farms.
- Integrated farms: main difference between the integrated and integrated commercial farms could be the production and realization of fingerlings. As for both of them distributors play biggest role for sales.

Image 3: Example of Carp Farm

Photo from fieldwork (credit: Pavel Kotyza)

It is interesting to see that approximately 2% of the production in every kind of farm was going to self-consumption or domination. Domination could imply to kind of bonus for employees or as a gift for relatives / family members. There are four main types of carp usually farmed in Georgian aquaculture: Common carp, Bighead carp, Grass carp and catfish. Common carp among the other types is most widely produced in all four types of farms. Catfish has the lowest share in production.

In case of trout and sturgeon there are six types of farms:

- Family / Small Farms: distribution is done either by wholesalers (in case of which selling price is lower ~9,5 GEL/kg), retailers (selling price for family farms to retailers is ~10,5 GEL/kg), and direct realization with tourists or restaurants, which receives the biggest share of supply from the small farms, as well as from other types of carp farms.
- Medium Farms: As for the family farms, medium farmers also sell their production to tourists and restaurants. Second largest part goes to retailers and smallest part to wholesalers.
- Big Farms: the production is largely sold to either restaurants or directly final customers. The rest of production is mainly supplied to customers by wholesalers. The selling price of products is the same for both actors. In case of big farms, retailers are not part of the distribution chain.

- Integrated Farms: from integrated farms the distribution is done equally through retailers or restaurants/tourists. Wholesalers play minor role in this particular chain.
- Trout and caviar Farms: there are two distribution chains, smaller part of caviar goes to wholesalers and the majority is sold to restaurants and tourists / final consumers (same price ~ 100 GEL). For trout, the supply chain mainly includes wholesalers and retailers at the same price ~ 11 GEL/kg.
- Trout and Sturgeon Farms: as for majority of the farms described above, the trout and sturgeon farms also sell their products to restaurants / tourists. The prices are relatively high, ~ 14 – 17 GEL.
- Hatchery: mainly the trout fingerlings are produced in hatcheries and a smaller part of brood stock. Apart from a very small quantity of farmers, mostly the eggs are imported from abroad. During the interviews, there were few farmers who expressed their concern about the imported eggs.

Image 4: Trout & Caviar Farm

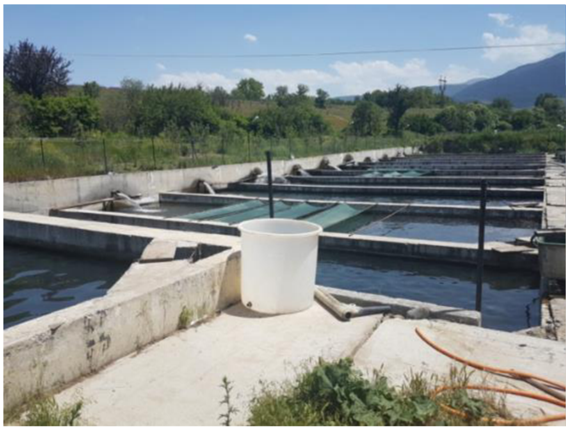


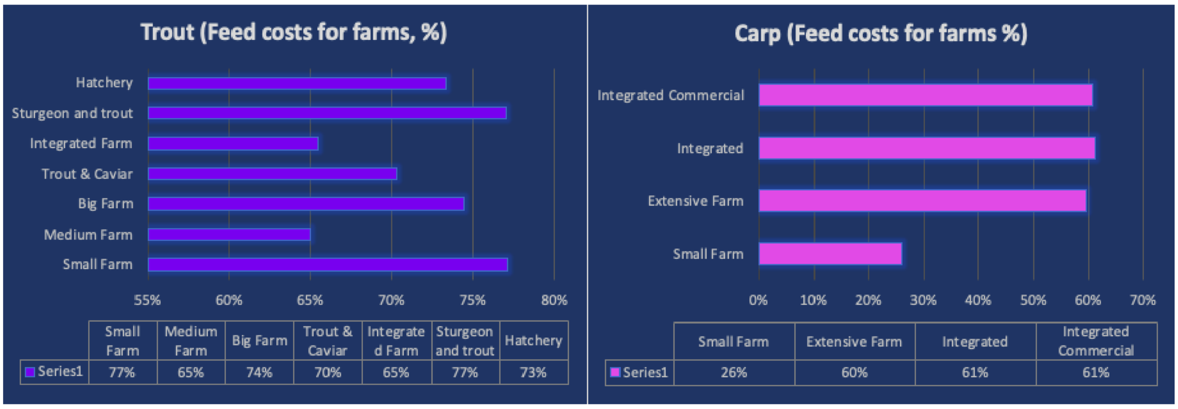
Image 5: Trout Farm, pond preparation

Photos from fieldworks (Credit: Pavel Kotyza)

4.2.4. Costs

Without a doubt, scale and structure of costs are different from carp and trout sub-chains. In addition, the conformation of costs also varies between the different types of farms. However, both sub-chains and all types of farms have feed as a main cost in common.

Figure 16: Feed cost comparison of trout and carp sub-chains

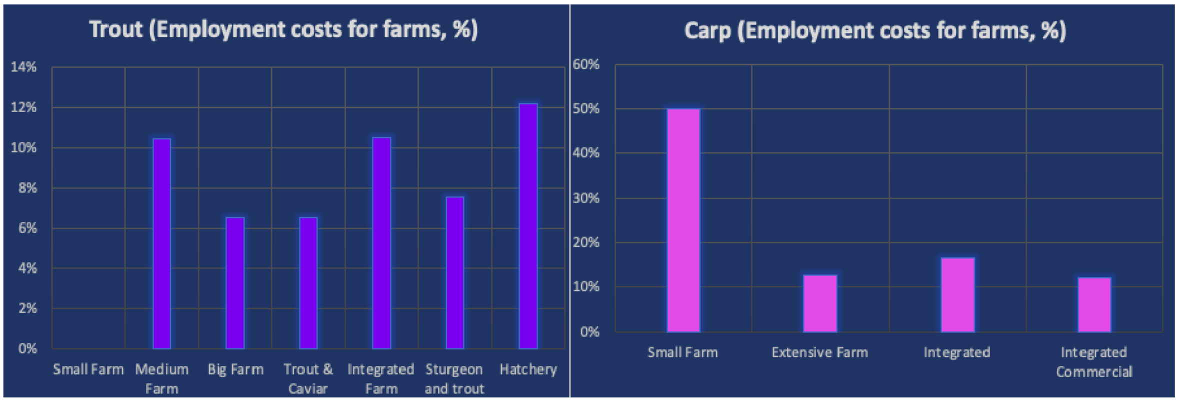


Own processing of data collected

On the figure above, the share of feed in total costs is shown for each farm type. In over 90% of the cases (10 out of 11), feed is more than 60% of the total cost. Small farm in case of carp has fewer spending on feed as carp does not necessarily need a compound feed and farmers prefer to feed them with grains. In some cases, farmers had wheat, barley and or maize fields alongside with the fishponds.

For majority of farms, excluding small farms in trout production, wages for employees are another important cost. It is interesting to see that the small farms in carp production have highest cost of wages. There are several reasons explaining this phenomenon, however, one of the key reasons is that they need guards to look after their ponds, additionally, they need seasonal workers for extraction of fish during high seasons (in terms of demand). Also, the other costs for carp small farms are relatively lower in comparison to other farms. For (interviewed) trout small farms the workers were mainly family members, therefore costs were non-existent.

Figure 17: Employment costs for trout and carp farms



Own processing of data collected

Other costs of farms included, but were not limited to fingerlings, medicaments and treatment, transportation, equipment and material for farm, maintenance, taxes and depreciation (or amortization in some cases).

Table 3: Costs of carp farms

CARP	Small Farm	Extensive	Integrated	Integ. Commer.
Fingerlings	8,3%	2,5%	2,0%	3,6%
Treatment	2,8%	3,3%	1,7%	1,2%
Transportation	4,9%	1,8%	0,6%	0,9%
Equipment	2,8%	0,7%	0,3%	0,3%
Maintenance	-	6,6%	4,3%	1,6%
Taxes	4,4%	5,8%	7,5%	7,5%
Amortisation / Deprec	1,0%	5,4%	3,5%	10,6%
SUM	**24,1%**	**26,1%**	**19,7%**	**25,5%**

Own processing of data collected

In case of carp small farms, the costs mentioned on the table, together with feed and wages, 100% of the costs is covered. However, for other farms, there are other costs. For example, credit interest (in most cases of integrated commercial and extensive farms – 1000 GEL ~1,07% of total costs; for integrated farms 5000 GEL ~ 5,3%) for and electricity.

For treatment of diseases farmers identified main medicaments: lime (1 gel/kg), chlore (500 gel/kg), and brilliant green (50 gel/kg).

Depreciation costs are relatively low for small farms as the equipment is not broadly used. The main materials identified here were scale and nets. However, for other farms, depreciation costs also included boat, vehicle, filters and hatchery.

In addition, depreciation in carp production sub-chain could be negligible as ponds are not depreciated similarly to agricultural land. While at the level of trout sub-chain there are pawns, pipes and other constructions which might be depreciated and therefore depreciation rate in long term is higher for trout sub chain.

Table 4: Costs of trout farms

TROUT	Small Farm	Medium	Big	Trout & Caviar	Sturg. & Trout	Integrated	Hatchery
Fingerlings	11,7%	8,6%	4,9%	12,7%	7,2%	4,9%	-
Treatment	0,3%	1,2%	0,7%	0,7%	0,7%	1,4%	1,5%
Transportation	0,8%	0,8%	-	-	-	-	-
Equipment	-	0,4%	0,1%	2,1%	0,2%	0,4%	-
Maintenance	1,4%	2,0%	1,2%	1,3%	1,1%	2,1%	2,9%
Variable Costs	0,6%	4,4%	4,6%	0,9%	2,8%	4,4%	-
Amortisation / Deprec	4,2%	3,7%	4,1%	3,8%	3,3%	4,3%	4,3%
SUM	19%	21%	16%	21%	15%	16%	9%

Own processing of data collected

Interestingly enough, in comparison to carp production, for some of the trout farms the transportation was not identified as a cost. Reason was the different distribution, as in majority of cases the distributors were either coming to trout farms to acquire the goods or some of them were selling near the farm, without the need of transportation costs.

Variable costs mainly included gasoline and electricity fees. Main materials that needed to be acquired on early basis were nets and suits. However, other equipment consisted of paddle when aerators, scales, pools, vehicle, incubators (in cases on big farms and integrated farms), pump and others. The equipment was cost especially in a sense of depreciation / amortization.

In addition, as mentioned before, the other actors of value chain have been interviewed, such as wholesalers, distributors, and retailers. All of their cost categories are presented in the table below.

Table 5: Costs of other actors

	Retailer	Distributor	Wholesaler
Fish purchase	95,9%	94,0%	95,7%
Equipment	0,7%	0,5%	4,4%
Transportation	0,8%	1,1%	-
Maintenance	0,6%	0,9%	0,7%
Wages	0,9%	2,7%	0,0%
Rent fee	0,5%	0,4%	-
depreciation	0,6%	0,4%	1,3%

Own processing of data collected

As seen, fish purchase is minimum 94% of the cost for all the three actors. Wholesalers usually did not have employees, they were mainly workforce themselves. The main equipment for them were oxygen bottles, tank for vehicle, vehicle itself, telephone and scale. For distributors, necessary equipment consisted of vehicle - small track, car tanks, bucket, battery for scale, oxygen bottles, etc. equipment of retailer contained similar items as wholesalers.

In addition, if we compare Georgian farms with Polish for carp production, in Poland, the biggest cost of farmers is stocking, and feed is the second largest cost (Lasner Tobias, 2020).

4.2.5. Revenues and Profit Ratios

Based on the data collected as well as according to the economic experts of VCA4D project, the approximate average amount for total product of each actors in both sub-chains have been identified. The profit margins vary in each farm and for carp value chain is the highest for extensive farms and integrated commercial farms. Table below shows more detailed information for each type of farms. Net added value is by distributors and integrated farms. For small farms value added are significantly lower in comparison to other farms.

Table 6: Profit Ratios and Net Value Added - Carp

CARP	Small Farm	Extensive	Integrated	Integrated Commercial	Retailer	Distributor
Total Production (GEL/Year)	11 639	117 246	390 816	176 708	417 513	1 664 458
Total Costs (GEL/Year)	7 205	60391	234 200	93 705	404 871	1 336 176
Gross Operating Profit (GEL/Year)	4 504	60 115	164 716	92 893	15 222	333 502
Net Operating Prodit (GEL/Year)	4 434	56 855	156 616	83 003	12 642	328 282
Net Added Value (GEL/Year)	8 419	72 265	226 066	112 343	20 822	374 302
Profit Margin (%)	38,09%	48,49%	40,07%	46,97%	3,03%	20,04%

Own processing, based on predictions of experts and data collected

For trout subchain, trout and caviar farms have lowest profit margin (in comparison to other farms). Sturgeon and trout farms have highest profit margin, followed by hatchery, small farms and big farms. Retailers and wholesalers have significantly low profit margin in case of trout as well. Sturgeon and trout farms also have the highest net added value, with big farms thenceforth.

Table 7: Profit Ratios and Net Value Added - Trout

TROUT	Small Farm	Medium	Big	Trout & Caviar	---
Total Production (GEL/Year)	50 404	181 484	2 238 446	190 957	
Total Costs (GEL/Year)	36 009	146 932	1 625 284	157 214	
Gross Operating Profit (GEL/Year)	15 895	40 052	680 315	39 743	
Net Operating Prodit (GEL/Year)	14 395	34 552	613 162	33 743	
Net Added Value (GEL/Year)	17 295	60 452	835 615	52 693	

Profit Margin (%)	28,56%	19,04%	27,39%	17,67%	
	Integrated	**Sturgeon & trout**	**Hatchery**	**Retailer**	**Wholesaler**
Total Production (GEL/Year)	181 467	1 713 113	96 800	376 700	298 125
Total Costs (GEL/Year)	145 893	902 524	67 892	355 800	273 889
Gross Operating Profit (GEL/Year)	41 834	840 339	31 812	21 200	27 719
Net Operating Prodit (GEL/Year)	35 574	810 589	28 908	20 900	24 236
Net Added Value (GEL/Year)	64 234	908 439	40 092	22 600	27 719
Profit Margin (%)	19,60%	47,32%	29,86%	5,63%	8,13%

Own processing, based on predictions of experts and data collected

For German carp such chain, the main source of income of farmers were predicted to be fish farm with 55% of their income followed by Agricultural farm amounting for 40% (Lasner Tobias, 2020). For smaller farms in Germany, structure is completely different, the main source of income is external with 63%, after which agricultural farm amounts for 21% of total income and the fish farm only 16% (Lasner Tobias, 2020).

In Poland, fish farms are main source of income for the farmers interviewed in the research paper, followed by public payments, both for big and smaller farms (Lasner Tobias, 2020). Additionally, small farms also have external income, which is approximately 9% of their gross revenues (Lasner Tobias, 2020).

In case of Georgia, in most of the carp farms they had the fields for crops, therefore agricultural land, which helped them in generating additional revenue, however, for small farms the fields of cereal were mostly for their own consumption for fish.

4.2.6. Regions

As shown before (map 2) according to the farms visited, as well as reviewed literature, fish from Salmonidae / trout is most common in the following regions, Adjara, Guria, Kakheti, Samtskhe – Javakheti and Shida Kartli. Cyprinidae / carp is mostly farmed in Imereti, Kakheti, Kvemo Kartli and Shida Kartli.

Kakheti and Shida Kartli are regions that have significant level of production for both carp and trout fish families. On the table below, it is shown that for trout the production has been declining since 2017 to 2019 in Adjara, Kakheti – but only for trout, Samtskhe Javakheti, as well as overall in remaining regions. For Carp family there is a different tendency of growth / decline. For example, in Imereti, Kakheti and rest of Georgia, there was a growth from 2017 to 2018 but the year after it declined, however, remained at higher level than the initial (2017) year.

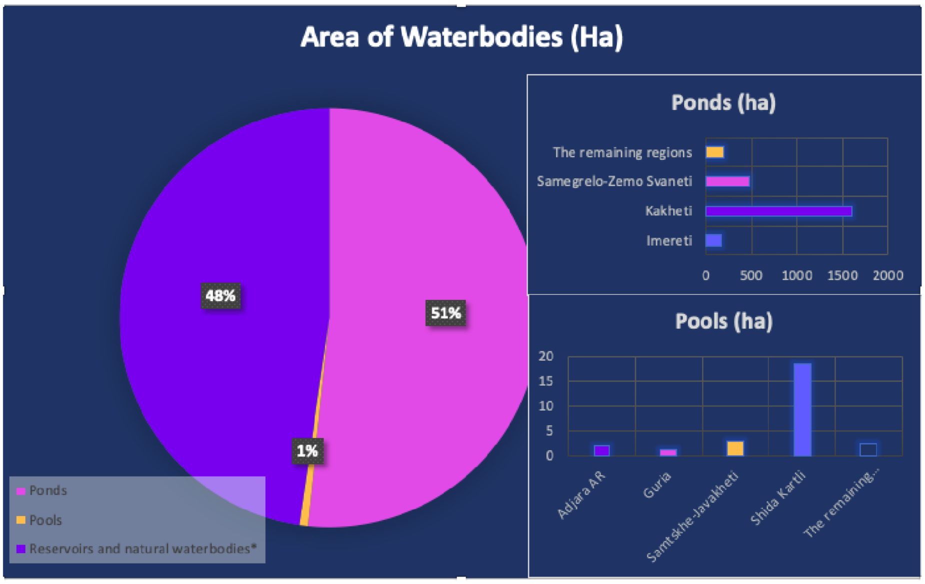
Table 8: Level of Production for trout and carp sub-chains

Trout	2017	2018	2019
Adjara AR	102,3	63,9	55,8
Guria	101,3	136,5	95
Kakheti	35,6	18,6	16,8
Samtskhe-Javakheti	96,2	77,6	62,2
Shida Kartli	284	232,9	268,1
The remaining regions	161,4	55,6	45,3
Carp	2017	2018	2019
Imereti	68	107	67,1
Kakheti	667,9	931,1	818,5
Kvemo Kartli	92,4	73,2	79,1
Shida Kartli	65,8	59,4	94
The remaining regions	169,8	258,6	217,7

Own processing of data collected

The physical area and geographic size is also different in regions. By 2019 there was total area of 4 503,1 hectares of waterbodies in Georgia, of which ponds have highest share (2 424,8 ha), then the reservoirs and natural waterbodies (2 057,1 ha) and pools(27,9 ha).

Figure 18: Area of Waterbodies in Georgia



Own processing, Data source: (GWP, 2021)

As we can see from the figure 16, Kakheti has the largest number of ponds for aquaculture by 2019 and it accounts for 1 603,6 hectares. Imereti, with 163 hectares has the smallest area in comparison to the other two regions, but still larger than the other regions in the country. As seen above, pools have as small as 1% share in the waterbodies and in total is less than 30 hectares. Shida Kartli contains 66,9% (18,6 hectares) of the pools for aquaculture in Georgia (GWP, 2021).

4.2.7. Feed

Trout and carp have different composition of feed as well. For carp it is usually only grains, such as wheat, barley and maize. Some of the farmers also mentioned consumption of fertilizers (both animal manure and / or chemical fertilizers) and in some cases, they also used a compound feed. Depending on the farm type, in some cases farmers preferred to have their own fields of grains as it is be cost efficient for the carp farming, in other cases, the cereal is purchased from local (Georgian) production, and in more rare occasions, farmers buy the grains that are imported from neighbouring countries. Another interesting fact was to see that the growth rate depends on the area where the pond is located. In some ponds the water consisted more insects, which is naturally preferable for the polyculture. In one of the farms in Shida Kartli a farmer had used a light bulb to attract some of the insects near the water, which made an additional food for the fish.

Trout feed is mostly compound and it is widely imported. Production of feed for trout in Georgia is still on a lower level as there are few producers and their own supply chain is not usually integrated vertically. There is a tendency of using the same feed importers in the same regions as the farmers do communicate with each other regarding the qualities. Feed is not the same throughout the whole life cycle of trout. The size of grain is proportionate with the sizes of fish. The imported feed for trout are mainly from:

- Turkey – Skretting
- Greece – Biomar
- Poland – Aller Aqua
- Italy - Skretting
- Smaller share from France.

Farm data on the feed convention ratio is not always stable as it depends on several factors, such as, composition of the feed and nutrition value (mineral composition, vitamins, protein, fat, amino acids etc.), water quality, safety from diseases, external factors (pests: birds, otters), weather conditions as it impacts the activity and consumption of feed by fish.

Some of the farmers also mentioned that for more effective utilization of feed, they have chosen a special corner of ponds where fish got used to be fed.

When having an interview with newly establish (project has started 2 years ago, the production began 10 months ago) feed producer in Georgia, some of the interesting points have been highlighted. Even though it is one of very few producers that produce feed in Georgia, *"As it is a new product, it is a struggle to get it n the market and be accepted by the farmers"*. In experimental farm they keep trout, carp, grass carp, catfish and few other fish species and feed them approximately 125 – 150 kg of feed in spring season, later by the middle of summer the amount is increased to 250 kg.

4.3. Production Level

Assessment of the whole aquaculture sector should be done from different levels, not from only one standpoint. Production side is where the whole value chain starts but it also continues and involves market level, distribution, customer behaviours. Producing agricultural or aquacultural goods have many considerations such as sustainability, environmental effects, social situation and naturally economic contribution to the country's economy. Therefore, it is important to understand what are the costs, benefits and value added.

As discussed earlier, the sector is mainly composed of carp and trout family species, such as Common carp, Silver carp, Mirror Carp, Grass carp, Bighead carp, Barbel, Rainbow trout, River trout, Lake trout and Kizhuch. If we compare the production of Salmonidae and Cyprinidae, according to FAO database, in 2019 (for more detailed overview, refer to figure 14 – sector definition) Salmonidae was 54,36% (1 339,80 tones) of the whole production and Cyprinidae amounted for 41,09% (1012,70 tones). The remaining 4,55% included Sturgeon – 3,95% (97,30 tones), Siluridae – 0,58% (14,3 tones) and other (0,60 tones: Pike, Clupea, European perch, Caucasian goby) (FAO, 2021).

However, the numbers slightly vary from different sources. For example, according to the National Statistics Office of Georgia, Salmonidae production in 2019 was 54,37% (1 164,80 tones), Cyprinidae 41,1% (1 012,70 tones), Sturgeon 3,94% (97,3) and Siluridae 0,58% (14,3 tones). Nevertheless, the difference is insignificant therefore it will not be highlighted in further analysis.

In addition, as a summary of previous discussion, it is important to highlight commonly used waterbodies for both family species. Cyprinidae, including catfish are most commonly produces in ponds and Salmonidae are generally farmed in basin or pool systems. Majority of farmers prefer to not only focus on one type of fish but to diversify their ecosystems. For instance, sturgeon farms usually produce rainbow trout as well, in different basins or pools. In case of carp they mix different types of carp as well as catfish. However, having trout and carp at the same farm seemed to be very rare as the optimal water temperature for trout is in the range of 7 – 18 °C and for carp is minimum 16 – 28 °C.

Regarding the fingerlings, there are hatcheries that produce trout but the share of the locally (on national level) produced fingerlings is lower than the imported supply.

4.3.1. Hatcheries

Having farms specialized for mainly hatcheries is more established for trout in Georgia. Geographically, most of the trout hatcheries are located in the western and southern parts. They mainly import eggs from abroad, usually from the southern or eastern Europe (including Italy, France, Spain and Poland). The safety of transportation is taken care of and controlled by veterinarian services of the countries of "origin". However, the quality of eggs is not monitored in Georgia. When talking with the farmers at hatcheries, they have emphasized that *"if there is a generic problem, it affects a whole litter of eggs each time, which results in loss of whole import"*. They have also mentioned that "*the first few days are especially enormously difficult as at this stage we have to work with the eggs extensively. If there is even one egg that looks suspicious, we have to check all of them to see if the disease has been already spread. Therefore, we separate them by hand to decrease the probability of transmissibility*".

Nevertheless, there are some carp hatcheries, which are part of the carp farms (usually carp hatcheries do not exist independently, they are more of complementary activity rather than individual production/business). According to the information acquired during the interviews, "the activity takes place in May and can be extended until April if the weather is not too hot". In each water container they deposit 150 – 200 grams of big head / mirror / grass carp eggs. Next, they wait for 5 to 8 days, during which the eggs are being hatched. For most cases, the farmers mainly produced the carp fingerlings for their own consumption but also sold little share from it.

The biggest costs for hatcheries are the feed, imported eggs, for some bigger hatcheries, wages are also large expense, followed by maintenance costs, equipment, and depreciation. More details on costs have been presented in the chapter above.

Image 6: Trout Hatchery in Shida Kartli Region

Photo from fieldworks (Credit: Pavel Kotyza)

Another important aspect for farmers (it is also a general problem for other farms, not only for hatcheries), is the exchange rate volatility. The instable exchange rate directly impacts prices of imported feed and eggs. Some of the hatcheries that have been visited looked as shown in Image 6 and Image 7.

Image 7: Hatchery in Adjara Region

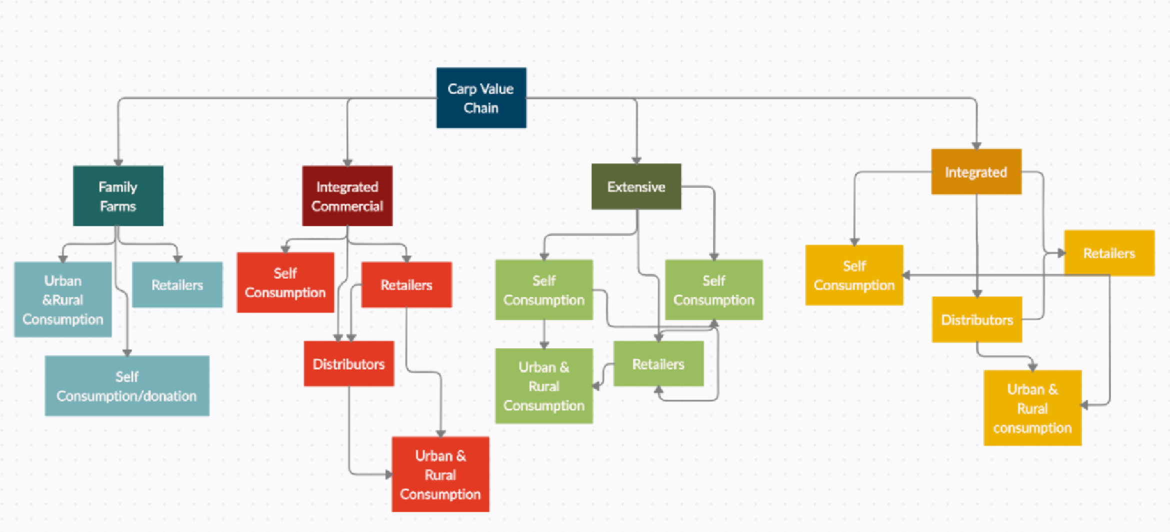
Photo from field visit

The second picture was also taken in the western Georgia, but in the Adjara region. The hatchery (as in the previous case) was part of the bigger farm. *"The fingerlings that are hatch in this hatchery are mainly sold in a different region – Shida Karttli, which is 6 hours away from the village"* – said the farmer. The farm has divided its production and realization of fingerlings into different shares. 65% of sold fingerlings weight 2grams, 20% - 3 grams. 15% - 5gram and approximately 10% - 15% of the whole production is used inhouse.

4.3.2. Value Creation

Value creation flow looks slightly different for carp and trout sub-chains.
The end consumers for carp production are mainly found at urban and rural markets. In the middle of the sub-chain the key players are retailers and wholesalers. Wholesalers are mainly working with integrated farms, extensive and integrated commercial farms. They sell at least quarter of the products directly at markets (final consumers) and the rest is sold to retailers.

Figure 19: Carp Value Chain Flow



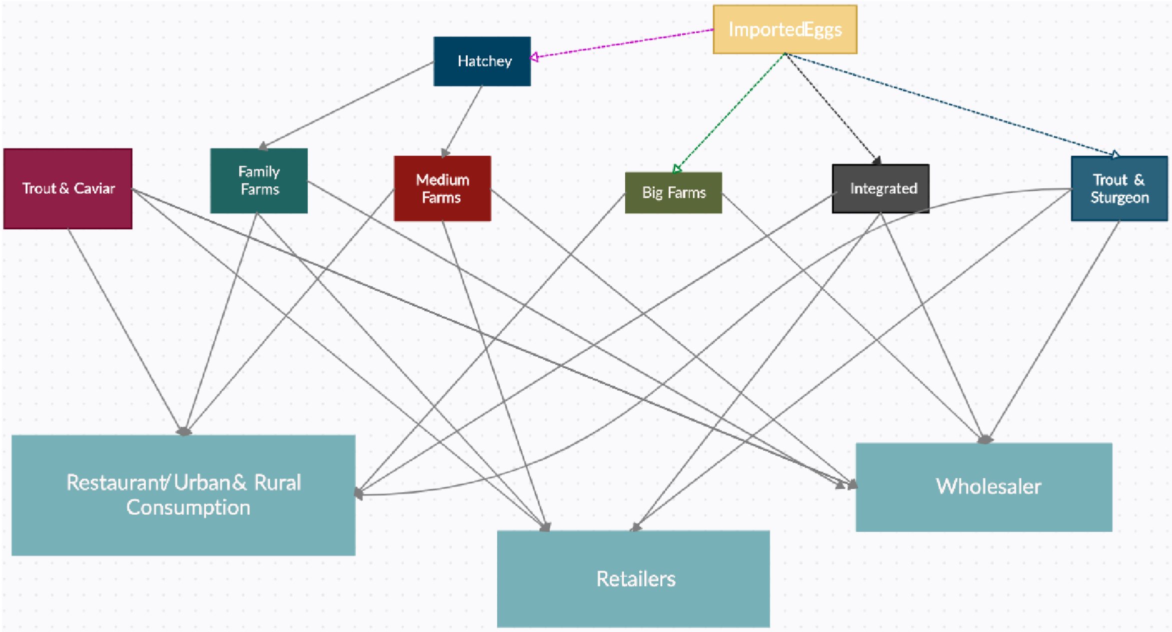
Own processing of data collected

Self-consumption did not amount for a large share and neither did the direct selling. In the majority of cases, the retailers and wholesalers acquire fish directly from the farmers. The frequency and quantity of acquisition is mainly depended on the demand on market, it is not agreed upon in advance.

The trout system is different from above-described carp value chain. The production range also varies between them, as trout farms produce not only livestock but caviar as well (in addition to the fingerling production). As opposed to the carp, part of trout farms do sell directly to the end customers. The main markets are the big cities: capital – Tbilisi on the eastern Georgia and Batumi and Kutaisi on the west. Those bigger markets receive products from the regions that are located geographically close to them.

As trout is often served in restaurants, they have an important role in the trout sub-chain. For the part of the farmers that do not usually sell products directly to the customers, the flow is mainly characterized by wholesalers buying fish from farmers and selling it to retailers.

Figure 20: Trout Value Chain Flow



Own processing of data collected

To be more precise regarding the distribution, approximately third of the whole production is gone through retailers. Some of the retailers sell the products directly, without involvement of the wholesalers. The retailers sometimes have their own list of contacts with restaurants or celebration halls, which mainly depends on seasonal demand.

4.3.3. Cooperatives

As seen on the field interviews, for carp trout and sturgeon development of cooperatives are at different stages. In case of carp farms, cooperatives almost do not exist, for rainbow trout it is still on the development stage, as there are few cooperatives but not a significant amount and for the sturgeon and other species of trout the cooperatives can be found more frequently. Interestingly, the existence of cooperatives also have corelation with the regions of the farms. In the western part of Georgia, especially in Guria and Adjara, as well as on the north, in Svaneti region, we can see that it is more usual. For Shida Kartli cooperatives are very rare, perhaps even non-existent.

There are several actors that have a major role in terms of having initiatives to establish cooperatives. There is a government support scheme, USAID and ENPARD (European Neighbourhood Programme for Rural and Agricultural Development). Those bodies have important role as they, (especially ENPARD) support the cooperatives through different ways. They provide competitions and support farms in the cooperatives financially. USAID plays a different role, as they provide trainings and other activities for farms, which has a positive impact as the awareness and knowledge help farms to develop more.

According to one of the farmers that formed a cooperative several years ago, *"competitions take part in different sectors of agriculture and aquaculture, for example, for strawberries, tea, fish and they are competing at regional and national level".* In a different region, a different farmer noted that *"farm does not belong to a cooperative, because of the social aspect. People here are not ready for the moment to set up cooperatives, Even though I [the farmer] would like to share certain things".*

4.4. Ecological Impact and sustainability

Ecological impact has high substance in agriculture and aquaculture as well as in every other sector. Impacts on sustainability can be measured from different angles and it is important to highlight at least some of them. For example, water quality, ecosystem quality damage, biodiversity loss through emissions of substances, ecological impact of wild fish depletion, greenhouse gas emissions from energy and fertiliser use, wastewater treatment, diseases, etc.

According to Thomas Ponsioen, one of the experts in the VCA4D project, *"organic waste and nutrient pollution is a very relevant issue for trout and sturgeon tank system, as urine and uneaten feed is washed away continuously, however, for carp pond system, it is expected to be relatively low as discharge is not frequent".*

Regarding the greenhouse gas emissions, he also noted that *"ecosystems, human health and human welfare in general, are effected by climate change. In addition, land occupation, fertiliser use, and pesticides use are causing ecosystems to lose quality; It is relevant for both carp and trout systems as there is a significant use of fertilisers, irrigation, land occupation and transformation mainly for cereal and oilseed crops. Also, escapes of farmed fish to natural ecosystems can have negative generic impact to wild fish populations. Some species of escaped carp cause concern of damage, on the other hand, imported trout and sturgeon species do not seem to survive in the natural circumstances.*

In addition to the above-mentioned challenges and issues, the use of antibiotics is also an actual problem. The use of medical treatment has a toxic effect especially in farms where the same water drain goes to several holdings. As it was founded from interviews with farmers, the water quality is not regulated by state or other bodies. It is left up to farmers to monitor the quality and respect the regulations. In some cases farmers do check the water quality, however, it is mainly for the upstream (where water comes to their farms). Spread of diseases therefore is also a very strong threat as water is not regulated or filtered after usage. The systems of farms using same water stream as net of water supply is very common in Georgia, especially in Kakheti and Shida Kartli.

Water quality is on different levels in different regions, partially because of the water source and also depending on how the farm is utilized and equipped . In some cases, farmers said *"the pH standard is monitored once in every 3 months, the samples are taken from the upstream and inside the pool (not on the downstream point) and sent to the laboratory in nearest bigger city"*. For some farmers "*there are no regulations of government, nobody comes for checking and they do not have any trainings"*. In some cases*, "there have been few trainings with ichthyologist"*.

4.5. Social Conditions

According to the Georgian social expert, Mr. Giorgi Shubitidze, *"Georgia has ratified eight fundamental conventions of International Labour Organization (ILO), as well as the International Covenant on Civil and Political Rights (ICCPR) and International Covenant on Economic, Social and Cultural Rights (ICESCR). However, Georgia has not ratified the fishing convention of ILO"*. Also, *"Despite the clear demands of the labour code, in most of the farms do not have formal contracts with the employees; this applies to both permanent and seasonal workers"*. As farmers and workers do not usually have formal contracts, they agree on the working conditions, salary, and main activities orally.

As seen on the field, there is a difference between the trout and carp systems, in terms of social conditions. Having a social life seems to be relatively more difficult for the workers at carp farms as the farms are located off-road, where they stay during the night as well. The employees usually have few days of holidays, once per week or 4 days per month. Workers at trout farm have slightly better conditions as the trout farms are usually located near villages and they do not always have to stay in the night.

There is an important distinguishment to be made between the bigger farms with employees and self-employed farmers. In case of many small and medium sized farms as well as family owned (for carp), the labour is not usually hired externally. Only the owners work, with the help of their very close family members (children and spouses).

Regarding the wages, it is approximately half of the average salary in Georgia. However, in the villages, jobs related to agriculture are similarly low. There are also seasonal employees that help during the high season to capture the fish and clean channels in ponds. The seasonal workers are paid daily and usually also receive some benefits, such as free lunch and cigarettes.

The aquaculture sector is heavily polarized in terms of gender. In the farms, mostly men are active, leaving women to the housework activities mainly. However, in hatcheries women are more active and usually take the lead when they are the owners, nevetheless for females that are employed, they mostly do manual activities, in such cases, they are usually hired only as temporary members. Cornering wages, we can see the gap between genders, especially in case of carp, for permanent unqualified female workers, wages are 25% lower than for permanent unqualified male workers. More details are presented in the table 6.

Table 9: Employee wages in carp & trout farms

Type of Employees	Salary (GEL) TROUT	Salary (GEL) CARP	Time Unit
Permanent Qualified Female	-	-	Month
Permanent Qualified Male	1500	1500	Month
Permanent Unqualified **Female**	-	450	Month
Permanent Unqualified **Male**	600	600	Month
Temporary **Female**	20	20	Day
Temporary **Male**	30	30	Day

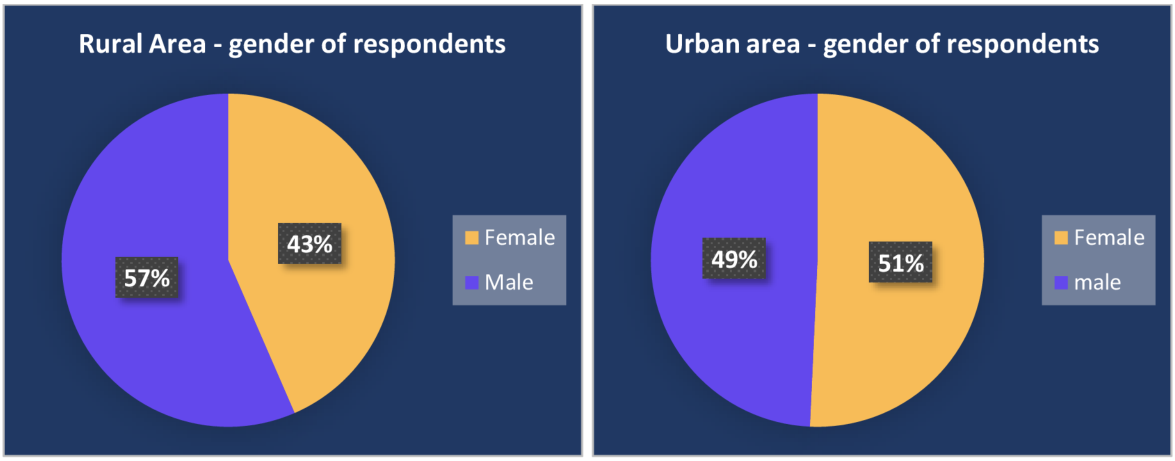
Own processing of data collected

It can be said that the living and conditions need to be developed greatly in the aquaculture and agriculture sector.

4.6. Market Level

For assessment of market level, consumer survey has been conducted in urban and rural areas. Data collected from the consumers in rural and urban areas showed slightly different results. Before moving to the results, general information about the sample will be introduced.

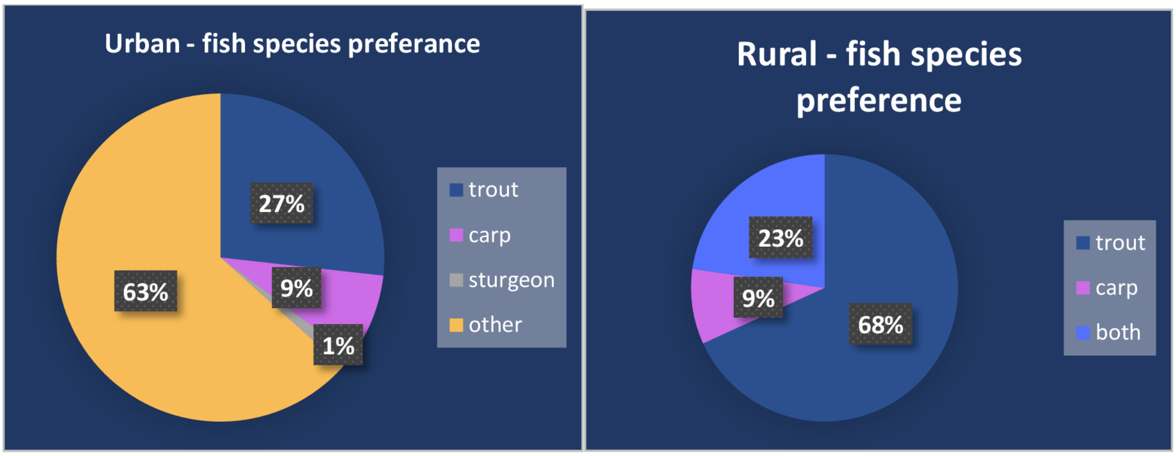
Figure 21: Gender of respondents in rural and urban areas



Own processing of data collected

In the rural areas 43% of the interviewees were female, in the urban area, 51%. The range of age of respondents was 16 to 69 years old, with the average of 43 years. In the urban survey, respondent were in the range of 13 to 90 years with the average of 31. In rural consumption survey, some of their proffesional occupation included, but were not limited to – nurse, student, house keeper, taxi driver, trader at the local market, enterpreneurer. In case of the urban survey – political activists, students, sales people, enterpreneurers, technician, musician, retired, sportsman, fisherman, chief, etc.

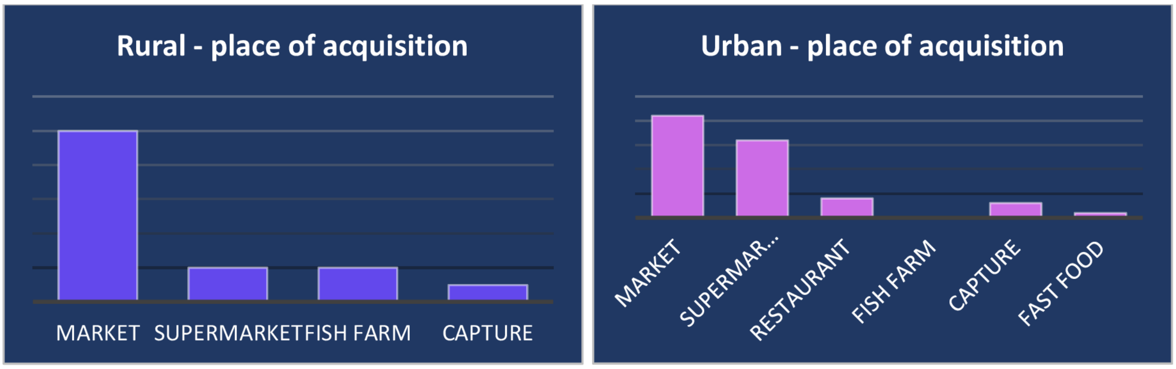
Figure 22: Fish preferences in urban and rural areas



Own processing of data collected

There were also other differences, such as preference of fish species and places where they usually buy fish products. On the chart above we can see that in urban and rural places where the interview were conducted trout was more popular than carp. Also, it is interesting to see that markets in both areas have highest preference when it comes to the place where they usually buy fish.

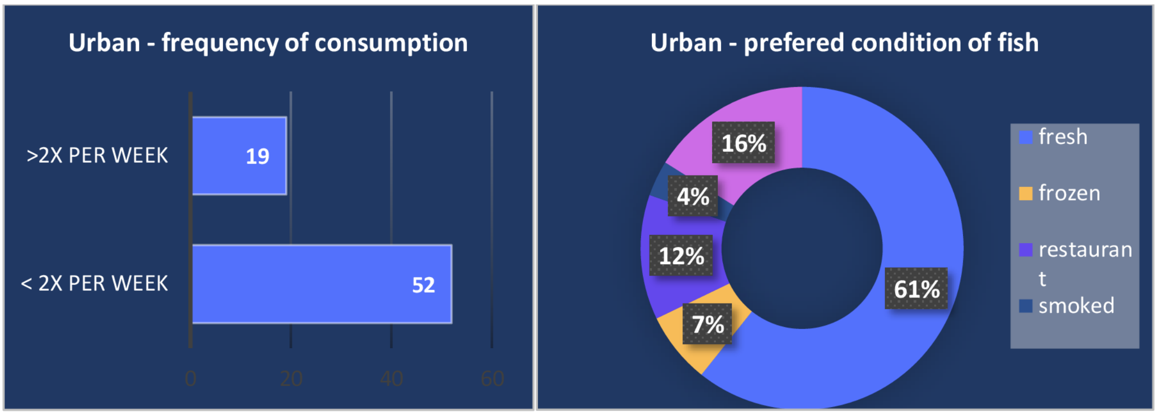
Figure 23: Market places for fish purchase in rural and urban areas



Own processing of data collected

Eating fish at fast food restaurant was very rare even in the city, and no respondent consumed it in villages. Also, it was more common to buy fish directly from farmers in the rural areas, and almost no one from the urban sample mentioned it. There were few cases in both places when the interviewee was a fisherman and they caought the fish themselves without need of buying it.

Figure 24: Frequency of Consumption



Own processing of data collected

In urban areas majority of respondents said that they consumed fish products at least two times per week as it was an important source of protein, fat and vitamins, and 26,8% consume it more frequently.

61% of the respondents preferred to buy fresh fish in the local markets and only 7% in a frozen state. There was also 4% that preferred smoked fish and 12% eats fish at restaurants.

4.7. PESTEL analysis

On the table below the PESTEL analysis has been conducted, which gives a summary of key factors – political, economic, sociological, technological, environmental, and legal aspects that influence the aquaculture sector from outside, as external factors.

Generally, there are economic and political stability in the country. However, the pandemic situation had a negative impact on the country's economy, increasing the already high unemployment rate. As discussed previously, there are some important government regulations and new laws that Georgia is adopting currently. MEPA, which is Ministry of Environmental Protection and Agriculture of the country, is working on elaboration of new systems that will potentially help the sector.

Table 10: PESTEL analysis

P	E	S	T	E	L
POLITICAL	ECONOMIC	SOCIAL	TECHNOLOGICAL	ENVIRONMENTAL	LEGAL
- Overall political stability - government regulations and policies to help sector - government and intergovernment as well as european grants for aquaculture sector - low corruption - labour laws (however not 100% complied from agro and aquaculture sectors - no trade restrictions	-overall economic growth but decline in 2019 - 2020 - slight exchange rate instability, which affects prices of imported feed - higher unemployment than other countries in europe - credit availability and support market competition with imported feed - disability of producing fish feed in sufficient amount	- Population Growth - social living standards of people l working in the industry is relatively low - the sector is not attractive for young generation - health issues - farms fo not cover insurances for employees - customers are aware of benefits of fish products and the demand is growing	- Emerging Technologies worldwide - Technological improvements need to emerge in the country - lack of information access through higher institutions is another barrier for technological utilization - urgent need of promotion of scientific reseach and implementation of corresponding technology to support sector	- Climate change and increased need to change to sustainablility - need for supply chain intelligence - Environmental impact which is caused by importing feed - overall impact on environment is tolerable - weather dependency of the sector - need for waste reduction / minization	- new laws and regulations in the sector - employment and labour laws - health and safety laws - MEPA is in process of developing documents and by-laws regarding technical regulations for aquaculture, procedure for issuing permits and conditions - law considers the public engagement council

Own processing of data collected

Also, it is important to mention once again, that intergovernmental support, more precisely, from EU is a major player as it gives stimuli to the farmers to get funds and create cooperatives and to participate in some competitions. Also, "Produce in Georgia" programme is a great motivation for farmers, as it allows them to have lower credit and sometimes to receive grants. During several interviews, they (farmers) mentioned that *"without this help from government on credits at low rate, it would be possible to start the business and establish farms".*

As already discussed, feed is mainly imported from other countries (especially for trout as it need compound feed more than carp), for this matter no trade restrictions are beneficial for farmers. However, if the local companies decide to produce feed in the country the barriers should be changes as the competition with already established brands with better prices would drive local production out of market.

Technological improvements are still at low level at this point. Farmers working in aquaculture usually receive education from practice, perhaps also by talking to neighbouring farmers. Nonetheless, they have no opportunities to get awareness about new technology (other than internet) and neither do they have financial access to such tools.

Environmental awareness is also lower in the sector. The climate change has a tremendous impact on aquaculture as fish need to have specific water temperature. Weather conditions are also important when capturing the fish from ponds and pools. During the distribution of products from farms to markets, retailers usually use a small van with a pool inside with connection of oxygen. The technique usually works but there have been accidents when fish couldn't survive as the whole road. Therefore, better technical sufficiency is needed for transportation and more sufficient transportation on the supply chain is needed.

Population growth and awareness of consumers about the benefits of fish products increases demand. On the other hand, living and working conditions of employees at farms need to be improved. In most of the cases farm owners do not provide any health benefits and insurance for workers. Also, especially for carp farms, people working as guards or permanent employees have serious lack of social life with very small holidays while staying further from village 6 days per week. Which, most likely, effects physical and mental health.

4.8. Problems

4.8.1. Electricity and Water Supply

Without a doubt, dependency on the water and electricity supply for inland fisheries is extremely hight. Generally, the country is rich in water supplies, especially in mountainous regions. However, accessibility is not equal in every region. Some of the visited carp farms, which were located further from villages in the middle eastern part of Georgia, the issue was more acute. They struggled with hot weather as some of the waterbodies that were their main sources of water got dry. Therefore, in the geographic areas where the water sources were not secure for all year long sufficiency, the farmers utilized dams as a source from underground waters. While it does solve the problem, the temperature is not easily controllable. In addition, after careful observation on the field, some of the farms that use dwelling system are not well equipped in carp farms and water pipelines are not well complied with sanitary requirements. On the other hand, medium and large commercial trout farms as well as bigger carp farms are in better condition and they have better facilities of dwelling, allowing workers and farmers having better work and living conditions.

For trout the water should be oxygenated, for which several bigger farms use oxygenators that work on electricity. Some farms located their ponds in a way that the water stream comes through rocky surface and the water naturally gets richer in oxygen. However, in some places where the farms are not located in the strategically best places (in terms of water supply) they are more vulnerable for the resource. Additionally, some farmers reported issue of amelioration as they get technical problems which disables them to receive water. Lack of oxygen and water supply, the process of farming is naturally complicated and sometimes farmers have to wait with farming fingerlings.

Electricity in addition, is crucial for farms. Some of the employees have to stay outside the villages in the farms, where they need heating, fridge and light, not mentioning the technology for farms. Historically, in rural areas main source of space heating used to be fuelwood. Unfortunately, even with the government initiative for gasification that allowed a significant number of households to switch to gas, it is still necessary for some rural areas. In addition to the discomfort, most wood for fuel is harvested unsustainable and used inefficiently, which might, if not already, lead to forest depletion and other environmental problems. According to an article by International Energy Agency, *"fuelwood still accounts for 22.4% of energy produced from domestic sources"* (iea, 2019).

4.8.2. Economic barriers

Some of the major economic barriers touch the issue of food security in the country. Some of the causalities include climate condition instability and change, manufacturing sector, which is not well developed yet, scarcity of raw materials and high dependence on the imports. However, people in difficult economic situation are still capable of having enough food, as there is a reliance and capability of homegrown food. Lack of income due to high unemployment is also present.

None of the interviewed farmers and employees had food security problems at their households. Fish seem to be a good source of protein for them, therefore, we can assume that the aquaculture sector contributes to rural food security. In most cases of small farms auto consumption is very important. During the analysis some of the questions were related to the self-consumption. To be more precise, approximately 1 – 3% of whole production goes to auto consumption in most of the farms. In this share the fish given to the relatives are also included. It is, definitely, part of Georgian culture to share a harvest with family relatives and close friends and it is usually (but not necessarily) done on the national holidays.

As fish products are not essential ingredients in Georgian culinary and hence the customers tend to be price sensitive. The price of the fish is partially depended on the exchange rate stability as the major cost of production is feed expenses. Therefore, developing more feed manufacturing facilities in local level would be safer, more price-friendly and help the sector to develop. Nonetheless, majority of customers interviewed tend to include fish in their diet (unless the prices are too high, in which case they would buy frozen fish which is usually relatively cheaper).

In addition, the interviews with the farmers confirm that the preferential agro credit programme was very important for the development of the farms. In case of fish production and fish meal factories respondents indicated that without the Governmental support it would not be possible to establish factories and start operating them.

4.8.3. Social and Environmental issues

The aquaculture sector has several environmental impacts. The most important one is created as a result of the feed production and importation. However, transportation of live fish and use of antibiotics are also significantly important.

Without generalization of impact or summarizing them into a whole, it is also important to distinguish the difference between footsteps of small and bigger farms. As the smaller farm produce less, the contribution is smaller compared to larger farms. Another reason for it is also marketplaces where farms sell their products. For smaller farms it is usually in a local scale, near the village. The large size farms distribute the fish mostly in the capital or large cities. Therefore, greenhouse gas emissions and air pollution is higher for those types of farms. Additionally, the transportation is done by small older vans which are even more pollutant.

As trout farms are mainly depended on compound feed that needs to be imported, it is naturally causing more environmental damage.

Antibiotics and medicine usage is another issue as it might have damaging effects on quality of ecosystems. Most of the farmers stated, they use manganese and brilliant green for cleaning ponds and pools and sometimes for fish disinfection as well as chlorine for basins. The polluting substances can be a risk for ecosystems. As water is usually go with flow from one farm to another or at least to a river from a farm, the chlorine and other substances are spread and could easily pollute the environment as well as the wild fish in the ecosystem. The scale of utilization however is not wide as the Georgian aquaculture is relatively small.

Even more problematic concept in this matter is the knowledge and skills to cure and diagnose diseases properly. There is a notable scarcity of skilled labour in the field, few ichthyologists and experts. Misdiagnoses of diseases has a natural effect on mortality rate in the farm and in the neighbouring farms as well. Especially, given the circumstances of no systematic regulations from external bodies (such as government). It is still possible to send analysis into a laboratory. It was also mentioned by farmers, that sometimes, if illness is common in several farms at the same time, they invite ichthyologists from abroad, which is financially difficult and also time costly. Diseases have impact on feed production increase and therefore have impact on environmental contribution, as fish consume more feed when they are in this condition

Regarding the social aspect, majority of the farms have agreement only informally, guided by cultural norms. There are rare exceptions too, where they have formal contracts. Naturally, all the sub-aspects of working conditions are also informally agreed, such as holidays, safety issues, salary negotiations, complementary benefits etc.

As the salaries are low and manual work conditions are not attractive for youth, many farmers are concerned. There was an exception in Guria, where farmer said that he works with his son who *"got very interesting in fish farming as he sees the outside farm activities, when I [the farmer] participate in some trainings or competitions "*(as part of the ENPARD programme).

There were other social issues observed on the field, such as lack of participation of socially vulnerable groups and a significant gender gap in the sector. As the social expert, Giorgi Shubitidze said, *"there were no cases when people with disabilities or internally displaced persons (IDPs) were involved in the farm or other links of value chain. However, ethnic minorities living in Georgia are actively involved in the aquaculture. This mostly applies to ethnic Armenians who are densely populated in Samtskhe-Javakheti Region in the south of Georgia".*

As briefly introduced in other chapter previously, there are specific activities in which women are more involved as well as some activities where men are involved less. For example, farming procedures, such as capturing fish to relocate them into another basin, or to take care of the whole farm, the wholesalers are also mainly man (with some exceptions). Nonetheless, they are active in hatcheries. Men on the other hand are not usually involved in household activities in the farm (unless they are alone and obliged). On the market there is an equal representation from both genders.

There problems related to living conditions in the farms are relatively low as there is no significant problem related to the food security. One of the reason could be fish being a source of protein. However, the problems related to water and electricity accessibility is important, especially water scarcity and worsen quality (lack of oxygen) in summer.

On the positive note, farmers are not limited to extend farm as long as it is financially feasible for them.

Level of social capital, there is a significant difference between small / family and large / commercial farms. The owners of larger farms have more resources and sometimes other businesses in agricultural sector, which increases their financial capability and decreases dependency on minor issues.

For further development of the whole sector, involvement and emergence of association in the field is required. The skills and education should be more accessible for the farmers as well.

To conclude, value chain is partially socially sustainable, it allows farmers, retailers, wholesalers and other actors to sustain their livelihoods from income. Nevertheless, vulnerability of workers towards employees, having low salaries and disbalanced work-life conditions hinder quality of life. Additionally, involvement, education and motivation should be increased for youth.

4.8.4. Education and trainings in Aquaculture

Importance of education and training has already been emphasized and will be more elaborated in this chapter. Lack of qualified professionals has major impact on the development of the sector. Farmers face difficulties with precise symptom identification and disease treatment, which imposes a risk of high mortality. The experience and in some cases, pharmacists are the main guides for treatment. In addition, there is absence of specialized laboratory, which would be able to diagnose the disease with certainty. High prices of medicine and its availability are hindering development even more.

The educational sector involves two vocational educational centres and a collage. However, there is no higher educational institution. Absence of which is crucial for future perspective, as it would help to increase demand from students to apply for such program and increase prospects for future professionals. The majority of field experts existing in Georgia have gained education during the Soviet Union in USSR countries, where programmes and specializations on aquaculture and / or fisheries existed.

However, establishment of the vocational centres and two colleges ("Aisi" on the eastern part of Georgia and "Phazisi" on the west with branches in two different cities) is promising. During the interview with the principal of the college "Phazisi" she mentioned interesting facts. The college has three programmes in aquaculture: "Farming in fisheries", "Fish processing", and "Laboratory work in fisheries". The principal also mentioned that *"programme was elaborated with the funding of Millennium Challenge Corporation (MCC) in Georgia, which was aiming to establish such programme. The preparation of teachers for the programme was conducted, some teachers were sent to abroad for qualification and training, as well as field visits. Study materials and syllabus were also prepared. Project supported technical equipment acquisition for the college".* As seen in the collage, it is well equipped with processing materials as well as teaching laboratory with a potential to provide high-level practices for students. On a side note, the college also had workshops for other programmes, such as crafting, suing etc. *"Students also have practical learning on the farms, in which they are employed, where they learn hatchery, larvae, fries and fingerling growing process as well".*

Demand in 2020 for program enrolment was low, however it could be because of the covid pandemic situation or as it is still relatively new, people could be unaware of its existence.

In the table below the demand and capacity in each program is shown for year 2020 in college "Phazisi".

Table 11: Demand and Capacity of Aquaculture Programme at College Phazisi, 2020

Programme	Applicants	Capacity
Farming in Fisheries	5 students	15 students
Laboratory Work in Fisheries	6 students	30 students
Fish Processing	8 students	30 students

Own processing of data collected

The representative of the college also noted that awareness raising campaign has been conducted for potential students and the allocation of maximum capacity is expected. According to her, several students are employed in the fish meal factories in Poti, some of the graduates also found work in fish farms. According to the representative, *"college plans strengthening cooperation with farmers to increase possibility of employment for students"*.

In addition, based on the information given by representatives of the Ministry of Environmental Protection and Aquaculture during online conference, *"there are approximately 9 collages that provide general veterinary courses in Georgia, which cover issues related to fish and other organisms, including animals. However, the courses are more general, without specialization and focusing on Ichthyology"*.

4.8.5. Equipment and technology

Generally, the farms visited mainly utilized equipment such as nets, boats, shovels, wetsuits for entering basins, fridge, oxygenators, and smaller items - buckets, knives, scissors, plastic bags etc. Some farmers stated that they built boats by themselves several years ago.

In majority of family and other smaller scale farms the equipment was old and overdue. For purchase of new equipment, they need financial resources and they try to use the existing ones for as long as possible. However, the equipment was relatively new in big commercial farms. Characteristics of hatcheries were also low-tech, as it was mainly built by the owners. Some of the important items for hatcheries consists of pumps, oxygen cylinders, bags, and nets. When working with fingerlings the equipment should be even more carefully chosen since they do not have enough immunity. Therefore, old manually built equipment could be another reason for such high mortality rate in early stage of fish life.

Farmers were asked about the depreciation costs as well, for how long do the use some of their assets. For nets, usually renewal is done after 3 to 4 years, there were different sizes of nets, wetsuits were different in farms as some of them needed to change it more often, approximately 7 – 8 times per year for each employee, and some of them more rarely. One of the farmers said that he bought very high-quality net 5 years ago and took takes care of it very well, therefore there was no need to renew it. In general, as calculated on average, depreciation costs are approximately 3% of the farms revenues. Table below show more detailed information regarding the depreciation and equipment costs.

Table 12: Equipment & Depreciation for Trout Farms (GEL/Year)

Trout	Equipment	Depreciation
Small Farm	paddle wheel aerator, scale, pools, vehicle (10% usage), others	1 500 GEL/Year
Medium	paddle wheel aerator, scale, pools, vehicle (40% usage), others	5 500 GEL/Year
Big Farm	Paddle aerator, scales, pools, vehicle, incubator, laboratory, fish separator, PVC, others	67 153 GEL/Year
Trout & Caviar	oxygenator, scale, pools, vehicle (50% usage)	6 000 GEL/Year
Integrated farm	paddle Aerator, scale, pools, vehicle (40%), incubator, pump	6 260 GEL/Year
Sturgeon & trout	Paddle aerator, scale, pools, vehicle, incubator, pump, others	29 750
Hatchery		2 904
Retailer	Scale, Aerator, vehicle (20% usage)	300
Wholesaler	Scale, tank for vehicle, vehicle	3 283

Own processing of data collected

As seen from the table, in trout sub chain big farms have the largest cost of depreciation, followed by sturgeon & trout farm. Except for the basic equipment, they use pump, fish separator, incubator and in case of big farm laboratory as well.

For carp subculture on table 12, depreciation costs are highest for integrated commercial and integrated farms. Small farms only use very basic equipment such as wetsuit, scale and net.

In general, we can say that trout farms are more utilized than carp farms. Even for small farms in case of trout the depreciation costs were 1 500 GEL compared to 70 GEL for carp.

Table 13: Equipment & Depreciation for Carp Farms (GEL/year)

Carp	Equipment	Depreciation
Small Farm	wetsuit, scale, net	70 GEL/Year
Extensive Farm	wetsuit, boat, vehicle, net, scale	3 260 GEL/Year
Integrated	wetsuit, boat, vehicle, net, filters, hatchery, scale	8 100 GEL/Year
Integrated Commercial	wetsuit, boat, vehicle, net, filters, hatchery, scale	9 890 GEL/Year
Retailer	battery for scale, plastic bags, bucket, oxygen, vehicle - van, scale, can tanks	2 580 GEL/Year
Distributor	battery for scale, bucket, oxygen, vehicle - small truck, scale, can tanks (2)	5 220 GEL/Year

Own processing of data collected

There are several technologies and equipment that farms could use to improve their production and productivity. For example, technologies such as eFishery, that helps monitoring the hinger level of fish and helps farmers to feed them accordingly. Such technology would be also beneficial for environment, given the fact that feed production contributes most in the whole value chain. In addition, feeding fish only, when necessary, would help reducing costs as feeding is the biggest contributor of expenses.

5. Recommendations

First of all, based on the lessons learned from the theoretical review of the thesis, the governance of the aquaculture should be aiming for Blue Internationalism with high technology, high-volume within local context, strong environmental regulations and more diverse species, locally as well as globally.

From the perspective of the systems thinking approach, Instead of looking at the sector with a focused on single parts separately, they should be seen in connection with each other, not only looking at one single farm but the whole neighborhood, whole region that is connected with each other and linked through the same stream of river, if people in each farm does not only think about their own territory but the whole region then they start taking care of not only the water quality upstream but also the downstream – they control the quality of water that is going out from their farm. In this way, not only revenues of a single farm is increased but the whole production. Therefore, the cooperatives and such communities should be encouraged as much as possible.

Concerning the main issues, there is a need for infrastructure development in some of the rural areas. For water security, irrigation systems must be developed more in the areas where households and farms are mainly depended on the natural waterbodies. From the government, it is also important to stabilize the exchange rate, as it affects the most important costs of the production – imported feed.

The social conditions should also be improved. There should be qualification trainings for farmers available, to increase their awareness for better practices, which would help their production and hopefully the payment of wages. The gender gap should be regulated and fought against, in this aspect NGOs could be more involved.

Education is extremely important for the young generation as well as the existing farmers. Colleges that already operate could have bigger network where more students could have an opportunity of half or full time jobs. Also, farmers need to special trainings regarding the treatment of diseases, as there is a high uncertainty during diagnoses. Perhaps, the colleges could have master classes from ichthyologists for farmers, and associations and NGOs could increase awareness of such lectures in addition to their own trainings. Also, from the interviews, it became clear that even though the training happens, it is definitely not regularly and not for every farmer. Ministries should be supporting such programmes, their organization and regularity as much as possible.

Technology and equipment have already been emphasized to be lacking at farms, which should be developed as well.

6. Conclusion

In the theoretical part of the thesis, we saw the development and history of aquaculture, how is it governed worldwide, what are the future prospects and how important is the sector for food security, what is systems thinking approach and how can innovation help in the field. Moreover, aquaculture has been reviewed on Georgian national level, it's history, resources, governance, and current policies.

First fisheries were found in China 4,000 year ago, since then it developed many branches, such as, freshwater inland aquaculture, mariculture, Valli culture, seaweed farming, cage culture, etc. China is still the biggest producer in the world, with over 2.1 million tonnes per year (FAO, 2020). In terms of fish families, Cyprinidae (carp, barbels, etc) are most widely produced.

If we integrate the theory reviewed with reference to good government, and integrate it with the results from practical analysis, we can see that the sector in Georgia needs to be developed more. To compare the criteria of good governance and current situation, the aquaculture sector lacks focus on implementation guidance and information transparency, for example, as seen from interviews with farmers, significant share of them was not aware of the water quality regulations. Other weak points were absence of innovation drive, as majority of inventory and equipment seen were significantly low-tech, there is a need for enhancement and learning institutions, and agility. On the positive side, there is a sense of accountability, coordination with global regulation and policy – as seen from the new regulations aiming to comply with Sustainable Development Goals of United Nations, the level of corruption is low, country is interested in different international projects conducting researches in the field for future improvements and is open to recommendations (80% of farmers said they have been interviewed by different foreign researchers in over the past years), and, there is also a reflexivity – adaptation of new laws, engagement with knowledgeable others for solution identification.

The future global trends, naturally, effect the situation in Georgia. The predicted world population rise will affect living standards and demands in each country. Fish products are well-known for their nutritious value and will be a key nutriment for population. In the theoretical part four possible scenarios were also discussed. From food sovereignty, blue internationalism, aqua-nationalism and aquatic chicken, Georgia seems to be closest to aqua-nationalism at this moment, with limited technology and knowledge transfer, production oriented domestic market and reduced local choices and higher food prices.

For assessment of the state of affairs from systems thinking outlook, Georgia is trying to be on adaptation level with almost no place for innovation. Another problem is that there are many chances that are being missed, such as adaptative innovation both in terms of technologies – with breeding systems, vaccines and medicine, feed production locally, and governance – market stands, more transparency, more flexible organizational structure etc.

To shortly summarize the findings from literature regarding national level, the first pond was found in 1933, and since then the sector has developed significantly. There were crises during 1991 and 2007, however the production is only increasing since then. Still, in the Black Sea region, Georgia has the lowest production, and Ukraine and Turkey are leading. From the aspect of the water resources, country is rich in both inland and underground water supply. The Kakheti region is the leader in producing freshwater fish products, the western part of Georgia is more concentrated about mariculture on black sea.

From administrative point of view, there are many important bodies, such as MoA1, MEPNR2, MEFRI3, associations, NGOs, etc. They are involved t different levels; however, every actor has a significant contribution.

One of the most important regulations that was adopted in 2020 is focused on defining significant aspects within aquaculture activities and regulates activities in Georgia's territorial waters and specific zones. The law aims to ensure implementation of compliance according to sustainable development goals.

There are significant differences for trout and carp sub-chains in seasonality, farm types, costs, and regions where they are produced and feed. The production of each has different stages, carp usually takes 3 to 4 years as it is grown up to 3 kilograms, for trout the period is up to 1 year, it is usually sold at the weight of 200 – 300 grams. Most important cost for both sub-chains is feed, however, for trout it is higher as it needs compound feed. In more than 90% of all types of farms, feed is more than 60% of the total expenses. Other important costs are wages, equipment, transportation, medicine, fingerling purchase, taxes, etc. For other actors, such as retailers, distributors and wholesalers, the largest cost is fish purchase. For trout, feed is mainly imported from Turkey, Greece, Poland, Italy and France. For carp, farmers usually produce their own cereal, some of them buy grains from Georgian production, others buy imported grains and in big farms they also consume compound feed.

Cooperatives have been supported by international programmes such as ENPARD, USAID with funding and training. There are more cooperatives in western part of Georgia while on the east it is very uncommon.

---

[1] Ministry of Agriculture
[2] Ministry of Environmental Protection and Natural Resources
[3] Marine Ecology and Fisheries Research Institute

In the assessment of practical part, three main aspects were emphasized: environmental impact, social conditions, and economic performance. From environmental point of view, on the scale of total impact of the country, the contribution is not significant. However, there are potential causes in terms of impact on biodiversity loss. The main contribution throughout the whole value chain in both carp and trout sub-chains is done during the feed production. However, naturally, for the carp sub-chain it lower. Water quality is another issue related to the environmental aspect. The main problem with it is regularity of water quality monitoring and lack of initiatives from governmental, associations and other bodies to make sure the farms are aligned with regulations.

In the social conditions, most important aspect is the average wages that are lower than minimum wages of the country, which makes working in the sector very unattractive for young people. In addition, there is a gender gap in terms of salaries, in case of permanent unqualified workers, women receive 25% lower wages, and they are mainly hired for manual activities and / or housekeeping.

For the market level, the customer survey showed different results in urban and rural areas. They have different preferences in fish species, share of marketplaces where they buy fish, preferred condition of fish (frozen, fresh, smoked, etc.).

The main problems identified were concerning electricity and water supply, economic barriers, social and environmental issues, education, and training, as well as equipment and technology.

Finally, to answer the research questions more concretely and briefly:

Q.1. What is the present status of aquaculture on a global basis?

Global aquaculture has grown dramatically, countries are developing and advancing in fish production. China has historically been the leader of the market and maintains its production on high level stably. As seen from the literature reviews, the whole Asian region is producing over 88% of the world aquaculture production, while Europe is only responsible for 3,8%. By 2020, Cyprinids (carps, barbels, etc.) were breaded in 92 countries with 60% of the world freshwater production.

Similarly, to most of the sector, aquaculture has also gone through challenges during pandemic period. However, it already started healing.

Q.2. What role will aquaculture play for the future and how important will it be for society, economy, and environment?

Today, more than ever, there is an increased urge to reduce carbon emissions, to ensure food security and regionalized production. As discussed earlier, fish products are significant source of protein, and it plays major role in some country's diets. As global population is expected to grow up to 10 billion, demand for agricultural and aquacultural products will have even more substantial importance.

Furthermore, according to Jessica A. and Gephart, there are four possible scenarios of how future of aquaculture will be and what impacts will it have on social, economic, and environmental aspects. Countries could decide to focus on environmental production which would imply on lower quantity but higher quality and price, or they could reduce their environmental regulations and mass produce, with lower price but higher quantity. They could choose to produce for global scale or more regionalized. in addition, different technological improvements are expected to occur.

In any case, aquaculture is escalating its importance in all three directions, especially for food security and for fight against global hunger

Q.3. what is the real current situation in Georgian aquaculture

The sector has developed over past 30 years, there are more fisheries and production is increasing. Covid-19 pandemic had a negative impact on the small farms, many of them had to leave the market. However, the ones that managed to survive the crises try to increase their production.

There are several economic issues in the Georgian aquaculture. One of them is the dependability on the exchange rate from farmer's side. The feed is produced mainly abroad, and the price depends on the stability of local currency. As seen from profitability tables before, some of the ratios are lower than they should be. Added Value also varies between sub chains as well as between farm types. Feed is the largest cost for every type of farm, especially for trout sub-chain. There are few local feed producers, however, they are relatively new and their market share is still significantly low. Some economic incentives from government and international organizations help farmers with finances. They have mostly emphasized the help of "Produce in Georgia Programme" and ENPARD funding.

Regarding the socio-environmental situation, the most significant issues are regarding water quality monitoring, low wages, lack of ichthyologists, gender disbalance and salary differences and work-life balance. As national production is relatively low, in comparison to global production, the carbon emissions are not significantly high. The biggest contribution occurs during the feed production level.

In addition, technological situation is also worth mentioning, it is on a low level and needs improvements.

Q.4. What strategies and innovative techniques could Georgian Government implement to achieve better governance and industrial success?

First of all, it should focus on the trainings and educations of the existing farmers as well as of future generation. There needs to be a programme which would be systematic and inclusive of all regions and farms. Farmers need to have deeper knowledge of what are best practices, how to diagnose a disease correctly, what are ecological ways to cure the ill fish. How can they make sure that it is not spread to other fish and into other, neighbouring farms. In addition, investing in better equipment and technology importation as well as education on how to use them would increase the efficiency of each holding.

Secondly, water quality monitoring should be necessary, especially in the regions or neighbourhoods where they are connected with the same river stream. As of today, it is up to farmers to monitor the water quality, but compliance with norms is necessary.

Lastly, if the systems thinking would be adopted in practice, national production could increase significantly, in addition, water pollution would decrease. For example, if there was a funding based on assessment of 5 – 7 neighbour farms, it would motivate them to take care not only of their own farms but others around them as well. Model would have several similarities with cooperatives, but there would be assessment of it which would include environmental, social and economic performance of the “cooperative” without singling out any of the farm in it. As seen, in some of the regions there was a psychic distance for farmers to be part of cooperative, the initiative could motivate them to form one.

7. Bibliography

FAO. (1991). *Fisheries Circular* (Sv. (813/Rev.1, 821/Rev.1)). (F. a. Nations, Editor) Rome, Italy, Rome, Italy: FAO.

Junning Vai, X. Z. (2017). *Top 10 species groups in global aquaculture 2017.* FAO.

Varadi L., B. S. (2001). *Aquaculture development trends in the countries of the former USSR area.*

Barach. (1962). *Black Sea Salmon.* Tbilisi: Publishing Academy of Sciences of Georgia.

FAO. (2021). *National Aquaculture Sector Overview - Georgia*. Načteno z fao.org: https://www.fao.org/fishery/countrysector/naso_georgia/en

FAO Publishing. (2021). *National Aquaculture Sector Overview - Georgia*. Načteno z fao.org: https://www.fao.org/fishery/countrysector/naso_georgia/en

FAO Fisheries and Aquaculture Department. (2004). *The State of World Fisheries and Aquaculture.* Rome: FAO.

FAO. (2005). *Fishery Country Profile.* FAO.

The World Bank . (2021). *Agricultural land (% of land area) - Georgia*. Načteno z The World Bank Data : https://data.worldbank.org/indicator/AG.LND.AGRI.ZS?locations=GE

Djibladze, M. L. (29. September 2021). *Georgia*. Načteno z britnnica.com: https://www.britannica.com/place/Georgia

GWP. (2021). *Republic of Georgia - Global Water Partnership*. Načteno z gwp.org: https://www.gwp.org/globalassets/global/gwp-cacena_files/en/pdf/georgia.pdf

Food and Agriculture Organization of the United Nations. (2003). *Review of World Water Resources by Country.* Získáno October 2021, z fao.org: https://www.fao.org/3/Y4473E/y4473e.pdf

National Statistics Office of Georgia. (07. July 2019). *Survey of Aquaculture Holdings.* Načteno z geostat.ge: https://www.geostat.ge/media/32473/Survey-of-Aquaculture-Holdings_2019.pdf

Khavtasi, M., Makarova, M., Lomashvili, I., Phartsvania, A., Poulsen, T. M., & Woynarovich, A. (2010). *Review of Fisheries and Aquaculture Development Potentials in Georgia* (Sv. FAO Fisheries and Aquaculture Circular - C1055/1). FAO, Georgia. Načteno z fao.org: https://www.fao.org/3/i1735e/i1735e00.pdf

Jessica A. Gephart, C. D. (2020). Scenarios for Global Aquaculture and Its Role in Human Nutrition. *Reviews in Fisheries Science & Aquaculture*, 122 - 138.

FAO. (2020). *The State of World Fisheries and Aquaculture*. Načteno z Food and Agriculture Organization of the United States: https://www.fao.org/state-of-fisheries-aquaculture

WOR 2 . (2013). *World Ocean Review*. Načteno z The Future of Fish - the Fisheries of the Future: https://worldoceanreview.com/en/wor-2/fish-and-folk/fish-as-food/

Raworth, K. (2012). *A safe and just space for humanity: can we live within the doughnut.* Oxfam Policy Pract Clim Change Resil.

Nathanael Hishmunda, N. R. (2014). *Policy and Governance in Aquaculture, Lessons learned and way forward.* Rome, Italy: FAO Fisheries and Aquaculture Technical Paper .

Monerey Bay Aquarium Seafood Watch & Wageningen University and Research. (December 2021). *The AGI Dashboard*. Načteno z Aquaculture Governance Indicators: https://www.aquaculturegovernance.org/agi-dashboard

Stead, S. M. (2019). *Using systems thinking and open innovation to strengthen aquaculture policy for the United Nations Sustainable Development Goals.* Stirlingshire, UK: FishBiology.

Bush, S. (15. August 2018). *Solving complex problems in the aquaculture sector requires integration between actors that don't normally interact.* Načteno z Wageningen University & Research: https://www.wur.nl/en/blogpost/Emerging-components-of-area-based-aquaculture-governance.htm

Nate Silver, R. F. (2013). *The Signal and the Noise.* Interfaces.

Turnbull, L. (2018). *Connectivity and complex systems: learning from a multi-disciplinary perspective.* Applied Network Science.

Olivier M. Joffre, L. K. (19. December 2016). How is innovation in aquaculture conceptualized and managed? A systematic literature review and reflection framework to inform analysis and action. *Aquaculture, 470*, 129 - 148.

Anadon LD, C. G. (2016). *Making technological innovation work for sustainable development Excerpt From: Louis Lebel. "Innovation, Practice, and Adaptation to Climate in the Aquaculture Sector.* "Proc Natl Acad Sci U S A" .

Louis Lebel, H. N. (2021). *"Innovation, Practice, and Adaptation to Climate in the Aquaculture Sector" Excerpt From: Louis Lebel. "Innovation, Practice, and Adaptation to Climate in the Aquaculture Sector".* Reviews in Fisheries Science & Aquaculture. Taylor & Francis Group.

GeoStat. (2020). *Survey of Aquaculture Holdings.* National Statistics Office of Georgia.

iea. (2019). *Report extract - Energy security*. Retrieved from iea.org: https://www.iea.org/reports/georgia-energy-profile/energy-security

Yuan, J. X. (2019). *Rapid growth in greenhouse gas emissions from the adoption of industrial-scale aquaculture.* Nature Climate Chang.

Lucas, J. S. (2019). *Aquaculture: Farming aquatic animals and plants.* John Wiley & Sons.

Beveridge, M. C. (2002). *The history of aquaculture in traditional societies.* Ecological aquaculture. The evolution of the Blue Revolution.

Herre, A. W. (1929). Bangos culture in the Philippine Islands. *Philippine Journal of Science*, 451 - 509.

Knud-Hansen, C. F. (1992). Pond history as a source of error in fish culture experiments: a quantitative assessment using covariate analysis. *Aquaculture*, 21 - 36.

Jenifer, M. R. (2013). "Isolation of siderophore producing bacteria from rhizosphere soil and their antagonistic activity against selected fungal plant pathogens. *nternational Journal of Current Microbiology and Applied Sciences*, 59 - 65.

Béné, C. a.-O. (2009). Social and economic impacts of agricultural productivity intensification: the case of brush park fisheries in Lake Volta. *Agricultural Systems*, 1 - 10.

Ghose, B. (2014). Fisheries and aquaculture in Bangladesh: Challenges and opportunities. *Annals of Aquaculture and Research*, 1 - 5.

De la Cruz, C. R. (1995). *Brackishwater integrated farming systems in Southeast Asia. owards sustainable aquaculture in Southeast Asia and Japan: Proceedings of the Seminar-Workshop on Aquaculture Development in Southeast Asia, Iloilo City, Philippines.* Aquaculture Department, Southeast Asian Fisheries Development Center.

Craig, R. K. (2002). *The other side of sustainable aquaculture: mariculture and nonpoint source pollution.* Wash. UJL & Pol'y 9.

Labatos Jr, B. V. (2014). Freshwater fishes of Tikub Lake, Tiaong, Quezon, Philippines. *Asian Journal of Biodiversity*.

Gjøen, H. M. (1997). Past, present, and future of genetic improvement in salmon aquaculture. *ICES Journal of Marine Science* , 1009 - 1014.

Himaja, P. H. (2016). POTENTIAL AND FUTURISTIC PROSPECTUS OF CAGE AQUACULTURE IN INDIA. *Journal of Aquaculture in the Tropics* , 179.

Delmendo, M. N. (1976). Laguna De Bay Fish Pen Aquaculture Development-Philippines. *Proceedings of the annual meeting-World Mariculture Society, 7*(1 - 4), 257 - 265.

Veldhuizen, L. J. (2018). Fish welfare in capture fisheries: A review of injuries and mortality. *Fisheries research*, 41 - 48.

Ebeling, J. M. (2012). Recirculating aquaculture systems. *Aquaculture production systems*, 245 - 277.

FAO. (2020). *The State of World Fisheries and Aquaculture.* Rome: Food and Agriculture Organization of the United Nations.

Junning Cai, X. Z. (2019). *Top 10 species groups in global aquaculture 2017.* Food and Agriculture Organization of the United Nations.

FAO. (2022). *Aquaculture market in the Black Sea: country profiles.* Rome, Italy: Food and Agriculture Organization of the United Nations.

GeoStat. (15. Jul 2020). *Survey of Aquaculture Holdings.* Načteno z geostat.ge: https://www.geostat.ge/media/32473/Survey-of-Aquaculture-Holdings_2019.pdf

Marina Khavtasi, M. M.-P. (2010). *REVIEW OF FISHERIES AND AQUACULTURE DEVELOPMENT POTENTIALS IN GEORGIA* . Rome: FAO.

Legislative Herald of Georgia. (15. Dec 2021). *Law of Georgia on Aquaculture.* Načteno z matsne.gov.ge: https://matsne.gov.ge/en/document/view/4901055?publication=0

GWP. (2021). *Water Resources of Georgia and Their Use.* Načteno z gwp.org: https://www.gwp.org/globalassets/global/gwp-cacena_files/en/pdf/georgia.pdf

8. List of pictures, tables, graphs, and abbreviations

8.1. List of pictures

8.2. List of tables

8.3. List of Maps