Issues related to UN SDG (2) on food security in the republic of Burundi

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Abstract. In the UN's humanitarian response plan, the Food and Agriculture Organization (FAO) calls on countries to: support small-scale farmers so that they can increase food production. At the same time, among the 17 goals to transform our world, one of the most important is goal 2: Eliminate hunger, ensure food security and improve nutrition, and promote sustainable agriculture. The main goal of the development of the main sector of agriculture – aquaculture is to provide the population with a variety of safe and environmentally friendly fish food products available to people with different income levels, as well as to meet the needs of neighboring industries in technical products. The fisheries sector plays an important role in the economy of any country. In Africa, aquaculture develops with varying degrees of intensity depending on the region. This review article examines the prospects for the development of sustainable aquaculture in the East African Republic of Burundi, a landlocked developing country that has its own history and traditions in aquaculture. The results of the study of soil characteristics of pond reservoirs that are of fishing significance in the country determined the further development of commercial cultivation and promising aquaculture facilities.

1. Introduction

The history of aquaculture in Africa is very changeable, and since the 1950s, its development has focused on pond systems that provide only a living wage. The aquaculture business in the region has not been commercialized and is thus developing slowly [1-2]. Thus, at the initial stage, pond and cage farming in Africa may have been intended so that fishermen could keep the necessary amount of fish caught alive before sending it to the market [3-5].

In the FAO report "The state of world fisheries and aquaculture", the development of aquaculture can be traced in countries where measures have been taken to promote sustainable development and increase the level of agricultural production, for example, China - since the beginning of the 90s, cultivates fish products more than in the rest of the world. Aquaculture is also developing in Africa, and it is expected to increase the volume of fish production by more than 45% [6-7].

So, the largest producer of aquaculture in the world is China, which occupies more than 60 % of world production. The Asian region produce almost 90% of the world's aquaculture. In Africa, aquaculture is developed only in Egypt and Nigeria (table 1) [8].
Table 1. Aquaculture production by region of Africa, thousand tons.

| Regions | 1995 | 2000 | 2005 | 2010 | 2015 | 2016 |
|---------|------|------|------|------|------|------|
| Egypt   | 72   | 340  | 540  | 920  | 1175 | 1371 |
| Nigeria | 17   | 26   | 56   | 201  | 317  | 307  |
| Total:  | 110  | 400  | 646  | 1286 | 1772 | 1982 |

Globally, Egypt is the ninth largest producer of fish products and the first among African countries, the second- Nigeria, in other African countries, aquaculture is only gaining momentum [6]. In Africa, aquaculture is practiced in a variety of fish farming systems, including extensive, semi-intensive, and intensive production in ponds, cages, and tanks. The possibilities and prospects for the development of the fishing industry in the Republic of Burundi will be discussed in this article.

Current state, history and prospects of aquaculture development in the Republic of Burundi.

Burundi is a country located in East Africa. It borders Rwanda to the North, the Democratic Republic of the Congo to the West, and Tanzania to the East and Southeast. In the southwest, it is washed by Lake Tanganyika.

Water resources are represented by the main rivers: Ruzizi, Malagarasi and Ruvubu. None of them is navigable. The water of the Malagarasi and Ruzizi rivers is used for irrigation in the Eastern and Western parts of the country.

On the territory of Burundi there are rivers that form the borders, Akanyaru and Kagera divide Burundi and Rwanda, Malagarasi forms most of the southern border. Lake Tanganyika is located in the south and west of the country, and Lakes Cyohoha and Rweru are located in the north-east of the country [9, 10].

Thus, the Republic of Burundi has sufficient opportunities for the development of pasture and commercial aquaculture, since this country has a significant hydrological potential, as well as optimal climatic conditions (25-29°C), which are an important factor for the development of this area in the country's fisheries sector. However, due to the lack of financial support and specialists, fish farming is still poorly developed.

The history of fish farming in the Republic of Burundi shows that the cultivation of fish in aquaculture began in the 50s of the 20th centuries, that is, during the colonial administration. For this purpose, small ponds were used - from 0.25 to 0.50 ha. In total, by the end of the last century, there were approximately 352 such reservoirs, and two fish farms were built. The Karuzi fish farm, which has been operating since 1952, had 73 ponds with a total area of 13 hectares. Tilapia (*Oreochromis niloticus*) were grown on this farm. The Isale fish farm has ponds with a total area of 0.63 ha. The operation of the fish farm provides the population with tilapia fry, which are grown in private ponds.

In the early 90-ies of the last century, some foreign organizations participated in sponsoring the development of aquaculture in the country, including the optimization of technological processes, so the US Agency for international development (USAID) conducted financing in 1988 – 1991, the African Development Bank financing in 1998-1999. However, after the termination of cooperation, the development of aquaculture in the country entered a phase of stagnation, after which it completely stopped. At the same time, the population did not receive proper practical skills for growing fish in artificial conditions.

A new rise in aquaculture occurred in 2002, when the country launched the project «Development of aquaculture and fisheries», in the framework of this project, the population was trained, after which students received the position of a fish technician. As a result, the number of specialists in the field of ichthyology and fish farming has increased to 7,000 people. Along with this, fixed assets were used in the fish farming infrastructure: up to 2426 ponds with a total area of 51,365 hectares. The fish productivity of the ponds was up to 120 tons per year, which corresponds to 2,352 tons per ha. This project was eliminated in 2002 due to the socio-political crisis and later replaced by the creation of a new center «National center for aquaculture and fisheries development», which operated from 2003 to
2008. The state of fish farming in 2009 is presented in table 2, in accordance with the data of the study «Directorate of Waters, Fisheries and Aquaculture».

| Province   | Active ponds | Productivity in kg/ha | Unused ponds | Workers | Number of women |
|------------|--------------|-----------------------|--------------|---------|-----------------|
|            | Number | Area | Number | Area |        |                  |
| Kirundo    | 50     | 249.25 | 1189 | - | 429 | 213 |
| Muyinga    | 58     | 224.80 | 1284 | 4 | - | 120 | 71 |
| Ngozi      | 17     | 89.35 | 486  | 28 | 178.45 | 186 | 81 |
| Kayanza    | 26     | 152.15 | 615  | 16 | 43.30 | 226 | 64 |
| Karuzi     | 23     | 142.25 | 273  | 31 | 1192 | 393 | 155 |
| Ruyigi     | 17     | 87.65 | -    | -  | -    | 93  | 17 |
| Cankuzo    | 37     | 190   | -    | -  | -    | -   | -  |
| Cibitoke   | 107    | 270.11 | 7495.22 | 85 | 131.28 | - | - |
| Ruyigi     | 17     | 87.65 | -    | -  | -    | 93  | 17 |
| Bujumbura  | 37     | 182.04 | 644  | 57 | 237.02 | 367 | 262 |
| Bururi     | 16     | 10.74 | 213  | 1  | 0.60  | 60  | 22 |
| Makamba    | 14     | 65    | 778  | 10 | 50    | 211 | 71 |
| Rutana     | 23     | 76.50 | 670  | 8  | 27    | 25  | -  |
| Muramvya   | 15     | 71.76 | 644  | 11 | 68.57 | 125 | 54 |
| Gitega     | 23     | 28.74 | 390  | 14 | 19.86 | 60  | 39 |
| Bujumbura  | 4      | 31.82 | 97   | -  | -     | 2   | -  |
| Mairie     |        |       |      |    |       |     |    |
| Total      | 491    | 1938.12 | 15300.22 | 285 | 2001.01 | 2327 | 1055 |

According to the table, the Republic of Burundi currently has: 491 active ponds with a total area of 19.38 ha; 285 inactive ponds with a total area of 20.01 ha; fish productivity is 15.3 t/year per 100 m².

Taking into account the number of operating ponds engaged in the production of commercial fish in the country, the number of employees involved in the production of 2327 people, the share of women involved - 45.33%, we would expect an increase in the scale of production of aquaculture objects, including promising objects, but this trend is not observed.

| Years | The volume of catch, t |
|-------|------------------------|
| 1977  | 24 964                 |
| 2014  | 16 13                  |

The formation of a strategy for the development of aquaculture is determined by the specific potential of the country's biological resources. Thus, as a result of the monitoring of the state of fisheries, the issue of strategic importance of aquaculture in Burundi is more than relevant, as fish stocks in reservoirs are being depleted (table 3).

Aquaculture in the conditions of stagnant fishing (in the national Gross output, the place of fishing and aquaculture is about 1%) is designed to provide safe food products to the poor population of the country. It should be noted that the consumer basket of fish per person currently does not exceed 3.6
kg of fish per year according to the World Health Organization, when, according to FAO standards, this value should be at least 20 kg per year [1-2].

On the other hand, the depletion of fish stocks is increasing, which is caused by pollution of the coastal zone of Lake Tanganyika, poaching and destruction of natural fish reproduction sites [10-11]. Increasing anthropogenic factors, environmental pollution and the disappearance of spawning grounds have affected the state of fish stocks.

In this regard, there is a need to improve the law on the protection of water bioresources in the country. For example, in 2010, the leadership of the Republic of Burundi adopted measures for the development of the fisheries sector, which is set out in the document "National strategy for the development of aquaculture".

The prospect of fish farming also lies in the fact that the country's population is mainly engaged in agricultural activities, some of which can be reoriented to the development of aquaculture. The available experience shows that in one fish-breeding season it is possible to grow up to 500-1500 kg/ha of tilapia with an average weight of 150-300 grams.

Traditionally, in Burundi, the main objects of artificial cultivation are considered to be fish of the genus Tilapia and Clarias, the Nile tilapia (*Oreochromis niloticus*) and the African clarias catfish (*Clarias gariepinus*). The main objects of aquaculture in Burundi can be fish of the genus carp (*Ciprinus*), Tanganyika sprat (*Stolothrissa*), Tanganyika lake sardine (*Limnothrissa*), lates (*Lates*), which will also be an integral part of the fishery. Other types of fish in the fishery occupy a small share. In particular, most of the fish species in Lake Tanganyika are endemics - *Julidochromis transcriptus*, *Neolamprologus brichardi*, *Julidochromis marlieri* and *Neolamprologus multifasciatus* [12-15].

In Burundi, fish reproduction has been practiced for a long time, but regardless of this, progress in this area has not yet been reflected in the lives of the population. In Burundi, 2 species of fish are grown in artificial conditions: tilapia (*Oreochromis niloticus*) and clarias catfish (*Clarias gariepinus*). These fish are cultivated in small ponds owned by private businesses. These fish species successfully adapt to the artificial conditions of the aquatic environment. Since 2013, the South African fish breeding company “SAMAKI-TAMU” has been growing tilapia from caviar to commercial weight. On this farm there are 40 ponds with an area of 0.5 hectares. At the moment, this enterprise is expanding, in particular, 40 more ponds are being developed (table 4).

| Table 4. Characteristics of «SAMAKI TAMU Company». |
| Province | Ponds number | Area (100 m²) | Capacity (tons) |
|-----------|--------------|---------------|----------------|
| Bujumbura / Mutimbuzi | 20 | 1000 | 100 |
| Total | 20 | 1000 | 100 |

For this enterprise, the total area of the ponds is 10 hectares and it is possible to get 100 tons of fish per year.

| Table 5. State organizations. |
| Province | Ponds number | Area (100 m²) | Capacity (tons) |
|-----------|--------------|---------------|----------------|
| Bujumbura (Mubone Station) | 24 | 150 | 3.75 |
| Bujumbura (Isale Station) | 10 | 70 | 2.3 |
| Cibitoke (Station Maramba) | 20 | 265 | 8.65 |
| Total | 54 | 485 | 14.7 |

There is another fish feed production company in the country. The company "MINOLAC" is engaged in the production of feed. In addition, some private enterprises produce various mixtures for fish feeding. According to a study conducted by the Directorate of Waters, Fisheries and Aquaculture
in 2016, there are currently some public and private fish farming organizations in Burundi (tables 5 and 6).

**Table 6.** Ex-military Association (ADECA).

| Province   | Ponds number | Area (100 m²) | Capacity (tons) | Participants |
|------------|--------------|---------------|-----------------|--------------|
|            |              |               |                 | Men          | Women        | Total        |
|            |              |               |                 |              |              |              |
| Bubanza    | 261          | 638           | 19.1            | 2 057        | 2 461        | 4 518        |
| Bujumbura  | 236          | 593           | 22.3            | 2 023        | 1 207        | 3 230        |
| Bururi     | 5 425        | 15 572        | 467.2           | 33 064       | 48 656       | 81 720       |
| Cankuzo    | 155          | 479           | 14.4            | 2 886        | 2 735        | 5 621        |
| Cibitoke   | 243          | 710           | 21.3            | 371          | 321          | 692          |
| Gitega     | 1 496        | 4 306         | 129.2           | 17 346       | 26 595       | 43 941       |
| Karuzi     | 70           | 497           | 14.9            | 223          | 519          | 688          |
| Kayanza    | 13           | 38            | 1.1             | 545          | 450          | 995          |
| Kirundo    | 139          | 765           | 23.0            | 851          | 1 093        | 1 944        |
| Makamba    | 2 871        | 9 115         | 273.5           | 46 702       | 47 281       | 93 983       |
| Muramvya   | 17           | 96            | 2.9             | 479          | 288          | 767          |
| Mwaro      | 8            | 24            | 0.7             | 100          | 140          | 240          |
| Muyinga    | 45           | 552           | 16.6            | 992          | 1 577        | 2 569        |
| Ngozi      | 36           | 338           | 10.1            | 2 772        | 2 986        | 5 758        |
| Rutana     | 1 304        | 4 610         | 138.3           | 37 050       | 42 509       | 79 559       |
| Ruyigi     | 730          | 1 580         | 47.4            | 2 421        | 1 391        | 3 410        |
| Total      | 13 061       | 40 177        | 1 205.1         | 149 882      | 180 209      | 329 635      |

In terms of volume, Mparambo station is in first place in terms of pond area and productivity. Table 6 shows that at this moment in Burundi there are about 13 thousand ponds with a total area of about 400 hectares. The capacity of these ponds is approximately 1205 tons per year. About 330 thousand people work in this area.

The Republic has a Burundian center for aquaculture development (CBDA) and a network of rural collectives (RECORD) (tables 7 and 8).

**Table 7.** Burundi center for aquaculture development (CBDA).

| Province   | Ponds number | Area (100 m²) | Capacity (tons) |
|------------|--------------|---------------|----------------|
|            |              |               |                |
| Bubanza    | 18           | 150           | 3.75           |
| Total      | 18           | 150           | 3.75           |

The Burundian center for aquaculture development is located in the city of Bubanza. the total number of ponds is 18 with a capacity of up to 3.75 tons per year. The network of rural collectives (RECORD) is located in the capital of the Republic of Burundi. The total number of ponds is 12 with a capacity of up to 1.5 tons per year.

**Table 8.** Network of rural collectives (RECORD).

| Province | Ponds number | Area (100 m²) | Capacity (tons) | Participants |
|----------|--------------|---------------|-----------------|--------------|
|          |              |               |                 | Men          | Women        |
| Gitega   | 12           | 44            | 1.5             | 51           | 67           |
| Total    | 12           | 44            | 1.5             | 51           | 67           |

The Burundian center for aquaculture development is located in the city of Bubanza. the total number of ponds is 18 with a capacity of up to 3.75 tons per year. The network of rural collectives
(RECORD) is located in the capital of the Republic of Burundi. The total number of ponds is 12 with a capacity of up to 1.5 tons per year.

Thus, the Republic of Burundi has sufficient opportunities for the development of pastoral and commercial aquaculture, as there are small enterprises that are engaged in fish farming, there is a significant hydrological potential, optimal climatic conditions, and the country's population is mainly engaged in agricultural activities, some of which can be reoriented to the development of aquaculture.

2. Materials and methods

Studies were conducted to determine humus in the soil of fish ponds. Humus content is the most important indicator of soil fertility, since it contains about 90% of the total nitrogen reserves, part of phosphorus, sulfur, and trace elements. Soils with a high humus content have an agronomically valuable structure, a large absorption capacity, and a large buffering capacity in relation to acid-base factors. Humus substances can also have a direct effect on plants, stimulating their growth and development [2]. The method provides good convergence of parallel analyses, is fast, does not require special equipment (in this connection, it can be used in expedition conditions), and is currently generally accepted, especially when conducting mass analyses.

The determination of soil humus was carried out using the method of I. V. Tyurin - the method is based on the oxidation of soil organic matter with chromic acid to the formation of carbon dioxide. The amount of oxygen consumed for the oxidation of organic carbon is determined by the difference between the amount of chromic acid taken for oxidation and the amount of it remaining unspent after oxidation. As an oxidizer, a solution of $\text{K}_2\text{Cr}_2\text{O}_7$ is used in sulfuric acid, previously diluted with water in a ratio of 1:1.

3. Results

Most of Burundi is composed of folded and slightly transformed clastic rocks, which extends from the Democratic Republic of the Congo to Tanzania and Uganda through Burundi and Rwanda. The country is mainly dominated by light forest-derived soils that form a thin layer of humus over laterite (iron-rich) sub-soils. The best soils are formed by alluvium, but they are limited to the valleys of large rivers [9-10].

Soil samples were taken from several places in Bujumbura: The Perimeter of Maherero, Muramvya (West) and Muramvya (center). For Muramvya, this is data from the Western and Central part of one pond of the SAMAKI TAMU enterprise, located near Bujumbura international airport (approximately 1 km away), about 30 meters to the right of the main road "Bujumbura – Cibitoke, RN 5". The perimeter of Maherero is about 10 km from the airport and 2 km to the right of the RN5 road. In this place, the company "SAMAKI TAMU" has a center for the production of fry, as well as some small ponds.

The results of the analysis of soil samples gave the following results, which are presented in table 9.

| Place               | Nitrogen of nitrates, mg/kg | Acid-soluble forms of phosphate ions, mg/kg | Nitrite nitrogen, mg/kg | Ammonium nitrogen, mg/kg | Organic matter (humus) |
|---------------------|------------------------------|---------------------------------------------|-------------------------|--------------------------|------------------------|
| The Perimeter Of Maherero | 0.99±0.36                   | < 25.0                                      | 0.140±0.060             | < 20 (0)                 | 0.94%                  |
| Muramvya (West)     | 6.62±1.66                    | < 25.0                                      | 0.209±0.080             | < 20 (0.5)               | 1.72%                  |
| Muramvya (center)   | 17.67±4.42                   | < 25.0                                      | 0.089±0.040             | < 20 (0)                 | 2.01%                  |
Based on the data presented in table 9, Muramvya (center) has the largest amount of organic matter (humus) – 2.01 %, in second place Muramvya (West) the indicator was 1.72 % and in the third perimeter Mugerero – 0.94 %, against noma 0.5 %. However, increasing the humus in the soil will help a number of works aimed at hanging it, for example, sowing crops such as cereals or melons. The technology minimizes the load on pond areas, reduces the application of synthetic fertilizers, ensuring the production of safe food aquaculture products. Moreover, increasing the soil fertility of ponds by breeding and sowing agricultural and melon crops will significantly reduce the application of organic fertilizers, allow to increase the feeding capacity of ponds by increasing the biomass of zooplankton and zoobenthos. This, in turn, will make it possible to grow delicious products such as Australian crayfish (*Cherax quadricarinatus*) and freshwater shrimps (*Macrobrachium rosenbergii*) [16, 17].

Moreover, the analysis of the conducted soil studies for the purposes of aquaculture shows that the composition of the soil is mainly clay rocks with a rich amount of humus, which allows you to build fish ponds without significant water filtration.

### 4. Discussion
Taking into account the difficult economic situation in the Republic of Burundi, it is necessary to create conditions for maintaining internal stability, not only for the functioning, but also for the further sustainable development of the agricultural sector. In accordance with SDG (2), the main challenges are to provide the population with the necessary amounts of food that is safe for health. Fish is one of the most important food products, so the economic sector and the production of aquaculture products need to support this promising direction for the Republic of Burundi.

An analysis of the situation of aquaculture development in Burundi shows that there are certain prospects in this direction. First of all, it is favorable climatic conditions, the presence of a significant amount of water bioresources. Is Lake Tanganyika and the Northern lakes: Gweru, Cohoha, Kanzigiri and the river Rusizi, Malagarasi, Rurubu, Ruvyironza, Mubaraza with optimal amounts of water during the year. A special role for the purposes of aquaculture has the composition of the soil (clay rocks) allow you to build fish ponds without significant water filtration.

### 5. Conclusion
In conclusion, it should be noted that fish farming in Burundi is one of the most important areas in the country's economy, as there are all the prerequisites for changing the country's agricultural system. The introduction of new aquaculture facilities will increase the importance of fish farming in the life of the population of this country, which requires the involvement of trained personnel to take operational measures for the sustainable development of aquaculture.

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