FRESH WATER FISH FARMING INTEGRATED SYSTEMS RICE-FISH - CAMEROUN

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INTRODUCTION

1.1 RICE PRODUCTION

Despite great production potential most of rice consumed in Cameroun is imported (Achancho, 2013; Ahidjo, 2017; Goufo, 2008; Horwitz, 2014; INS Cameroun, 2020; Tabi et al., 2013). The country imported over 80% of its rice consumption in 2014 (Horwitz, 2014), in 2019 according to the National Statistics Institute imported 894 486 tons, a 60.9% growth from the previous year (INS Cameroun, 2020), and during the first six months of 2021, it had imported 319 330 tons, up by 59,038 tons (23%) from 2020.[1]

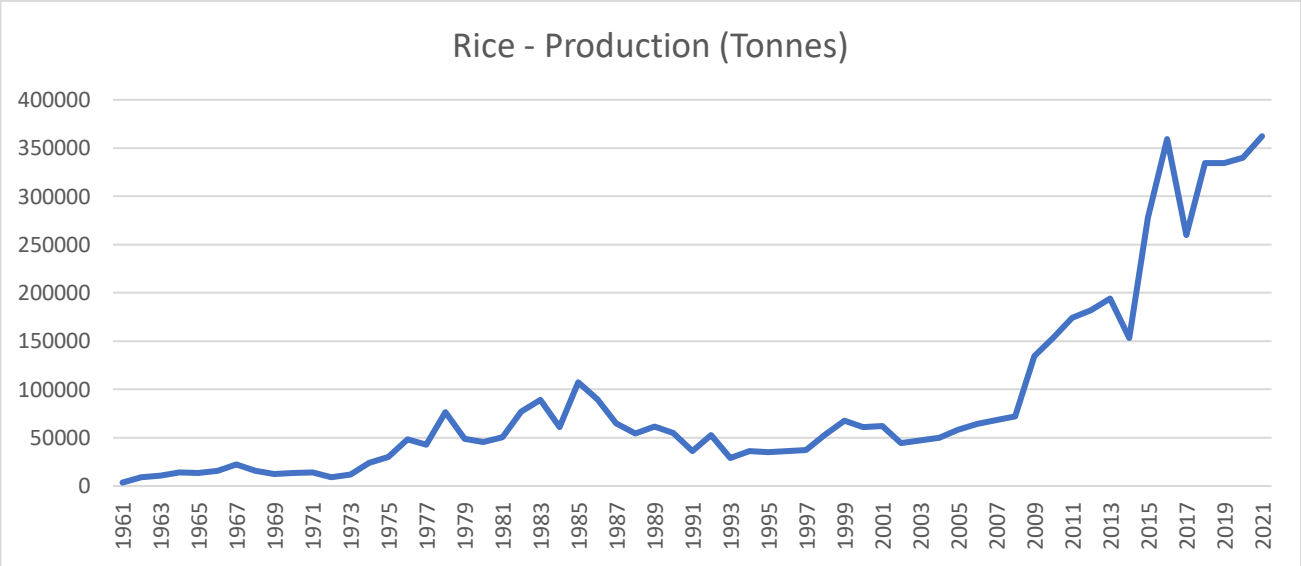

Figure 1 - Rice production in tonnes

According to FAOSTAT data, production grew since 1961 peaking at 107 399 tonnes in 1985. From there it declined to close to a third 35 300 in 1995, with floating values till the beginning of the 21st century, when a new growth cycle can be observed. Production was estimated 362 294 tonnes in 2021, a remarkable growth in 25 years, that nevertheless falls short of closing the production consumption deficit.

[1] Cameroon: Rice imports rose 23% YoY in H1-2021 - Business in Cameroon

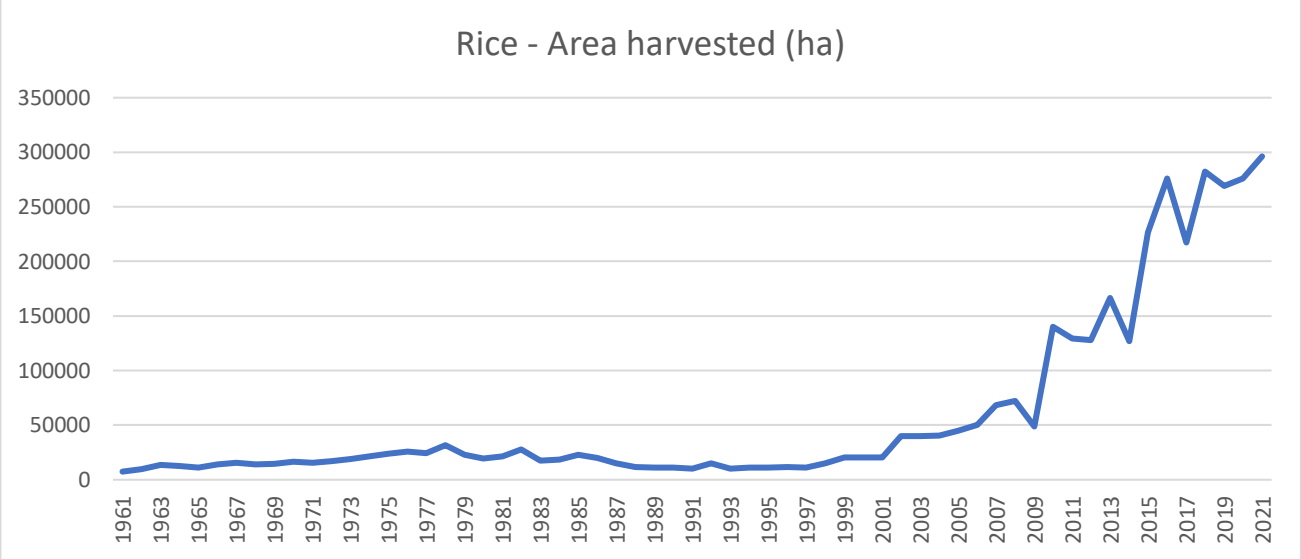

Figure 2 - Area Harvested in ha

Harvested areas follow a similar pattern growing from 1961 and peaking in the late 70's early 80's, when it decreases and floats till around 1999/2000 when a new growth period starts. Apparently, part of the production growth after 1961 was based in productivity gains, eventually related to major irrigation development projects in the 70s, while a more recent pattern shows a steep growth in the harvested areas.

1.2 Rice-Fish Farming Systems

There are social, economic, and environmental benefits of aquaculture in rice farming systems. Rice-fish systems can provide a natural source of plant nutrients and pest control, resulting in lower costs, higher yields, and improved household nutrition. (Timothy G. Reeves et al., 2016)

Rice-fish systems allows for lower pesticides and herbicides usage, and interactions among plant and fish improves soil fertility, and fish feed on vectors of diseases like mosquitoes.

In Lake Victoria basin, a rice-fish integration pilot was found to bring benefits to subsistence farmers, improving and diversifying nutrition and increasing income possibilities (Rasowo et al., 2010). Rice and fish produced concurrently, enhanced productivity, optimizing water, land, and labour resources, and small-scale decentralized hatchery in rice fields was successfully tested.

Still, challenges exist, and rice-fish farming adoption is low outside of China. Integration requires an increase in water usage, there is lack of awareness of its benefits, and low-cost pesticides are generally available, those issues sum to difficult access to credit for most small-holder farmers.

Like with other small-holder and subsistence systems, rice and aquaculture integration interventions must consider both socio-cultural and biophysical factors. The educational status of farmers and

gender division of labour. The paddy field environment - temperatures, oxygen levels or water turbidity, existing rice cultivars and water availability.

2. METHODOLOGY

Rice-fish farming systems suitability assessment targets improving food security, nutrition, and income diversification, and its objective is the identification of appropriate locations for an integrated rice-fish farming system pilot implementation.

The essential location criterion is production:

Where are the rice paddy fields?

This question is answered using available modelled rice production global geospatial data, literature review, web search and satellite imagery visual inspection.

Available data falls short, global datasets - GAEZ (2010) and IFPRI MapSPAM (2017) – have low spatial resolution and show considerable differences, leading to scepticism on quality and reliability. Highly productive areas can be largely identified, but data misses representing smaller and low productivity areas, eventually where the lowest income farmers might be.

Although GAEZ appears to present a better coverage, data is from 2010 and production has more than doubled from 153 078 in 2010 to 328 503 in 2020 (FAOSTAT). On the other hand, IFPRI's MapSPAM shows large areas as no data or no production (production=0).

Considering those limitations, a first preliminary effort is directed at quantifying production at *regional* or *département* level, aggregating the raster/grid data using zonal statistics. This exercise fails areas that should eventually latter be targeted, smallholders in less productive regions.

CSI geospatial analysis team is evaluating existing high resolution rice mapping products and remote sensing crop type classification techniques, eventually a pilot a can be developed during 2023 in the sub-Saharan African region.

Literature review, web search and visual inspection complements the identification of most productive areas targeted for large scale analysis:

- In the Benue subbasin, Niger major river basin - *Nord* region
- Western Logone subbasin, Lake Chad major basin Extrême-Nord region
    - Yaouga, Maga, SEMRY (INTERNATIONAL DEVELOPMENT ASSOCIATION, 1972)-Extrême-Nord (Ahidjo, 2017; Kana & Kana, 2017; M. Fokeng & Tume, 2022)
- Ndop UNVDA Nord-Ouest region

3. MAPPING AT *DÉPARTMENT* AGGREGATED ZONAL STATISTICS

The option to use GAEZ 2010 data is justified as the global dataset presents a more homogeneous coverage than IFPRI's MapSPAM. Zonal statistics are used to aggregate the sum of the raster pixel values by *département*.

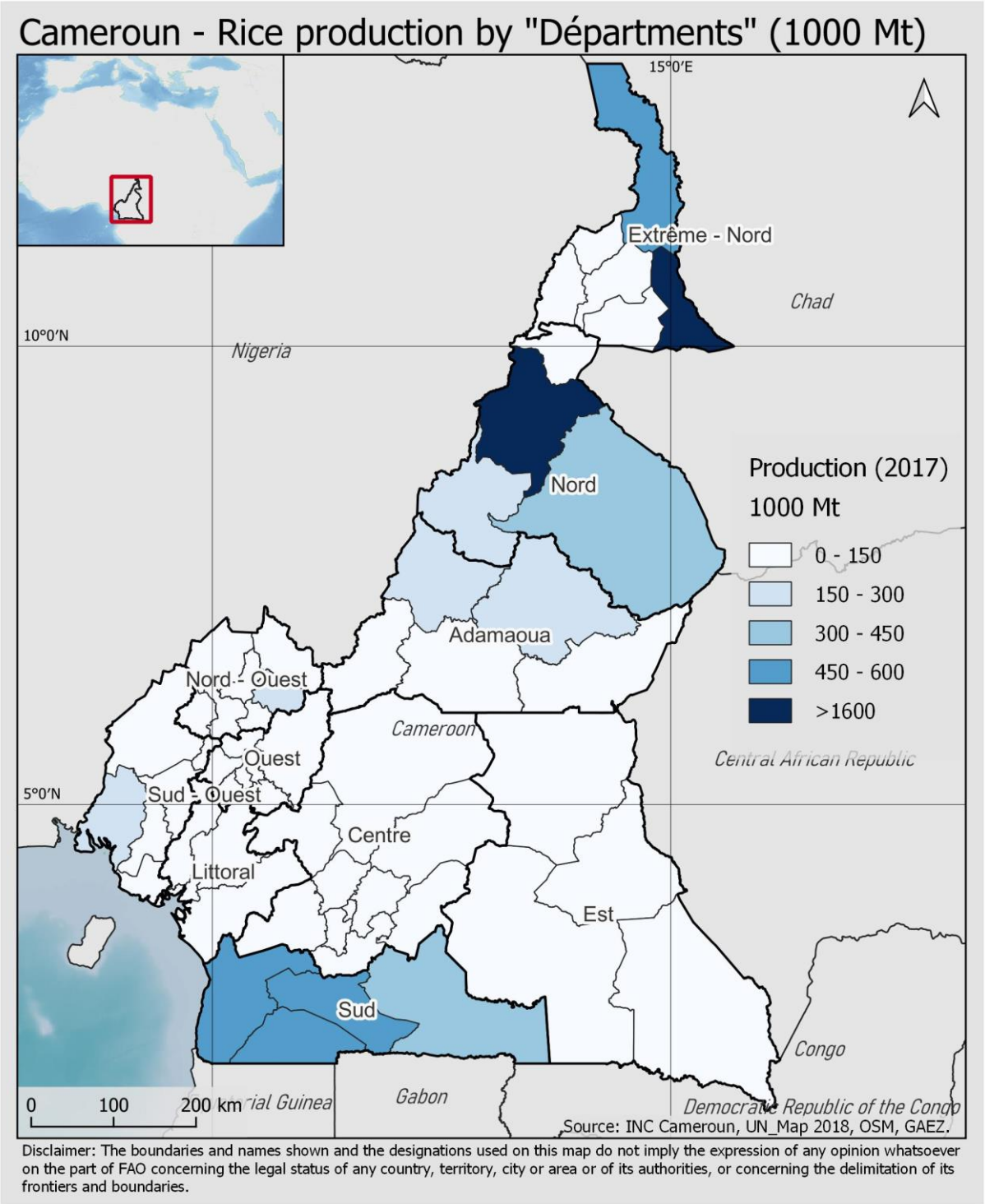

Figure 3 – Map rice production by department

Largest productive areas can be identified in:

- *Extreme-Nord* region - Mayo-Danay and Logone-et-Chari *départments* - Western Logone subbasin, Lake Chad major basin (Yaouga, Maga - SEMRY)
- *Nord* region - in Bénue département - Bénue subbasin, Niger river major basin (Garoua and Lagdo).
- *Sud* region - Western *départments,* Océan*,* Vallée-Du-Ntem and Mvila.

Ouest, Centre, Littoral and Est show the lowest production values.

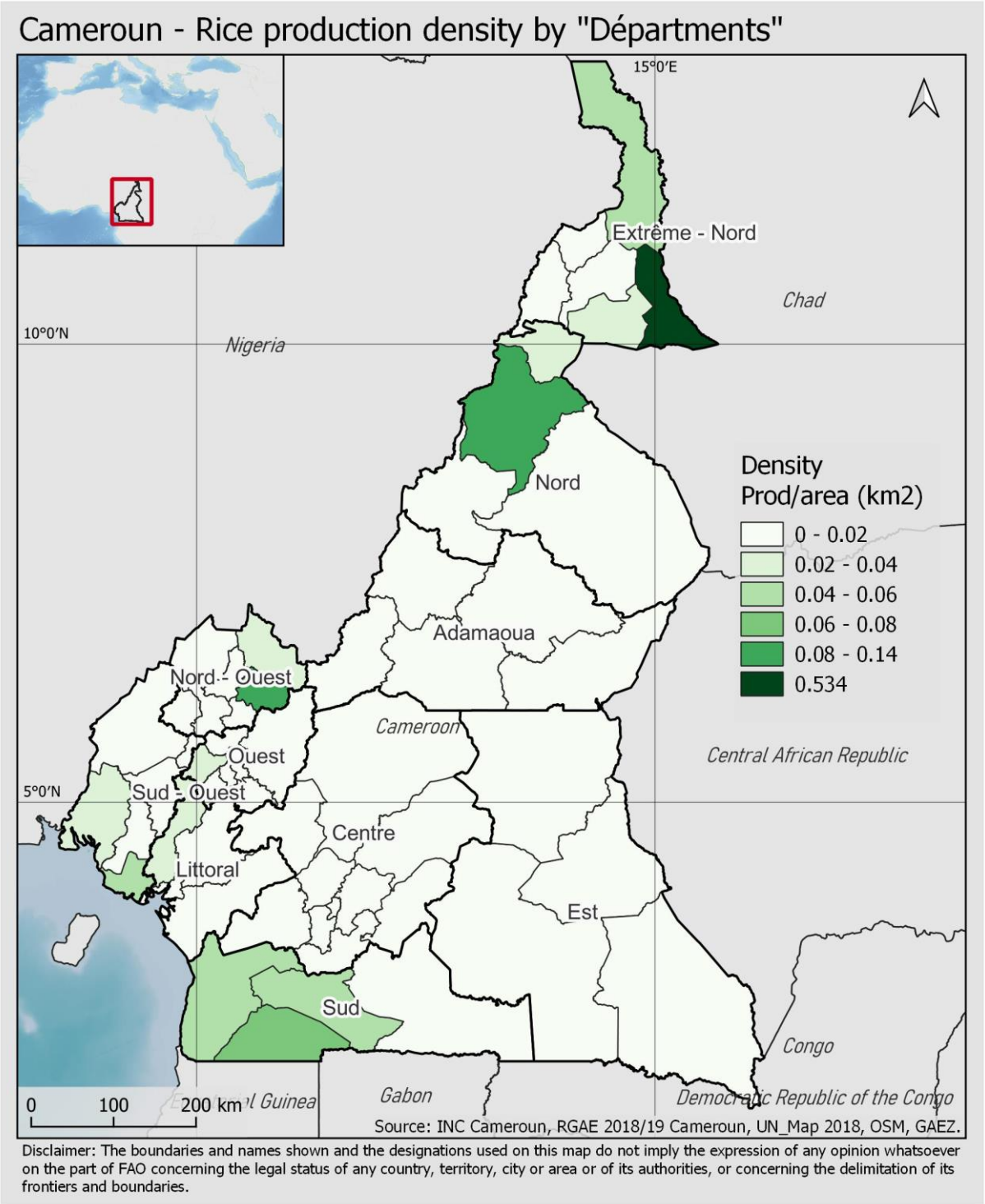

Figure 4 – Map rice production density

"Density" spatial pattern is similar, in the western regions a not so large production hides important dense production areas, like showing in the *Nord-Ouest* Bui *dép*., Ndop, in the Upper Nun Valley Development Authority[2] area. Highest production density is in *Extrême-Nord*, the Mayo-Danay and Logone-et-Chari SEMRY (Yagoua and Maga) area.

[2] Upper Nun Valley Development Authority - UNVDA NDOP

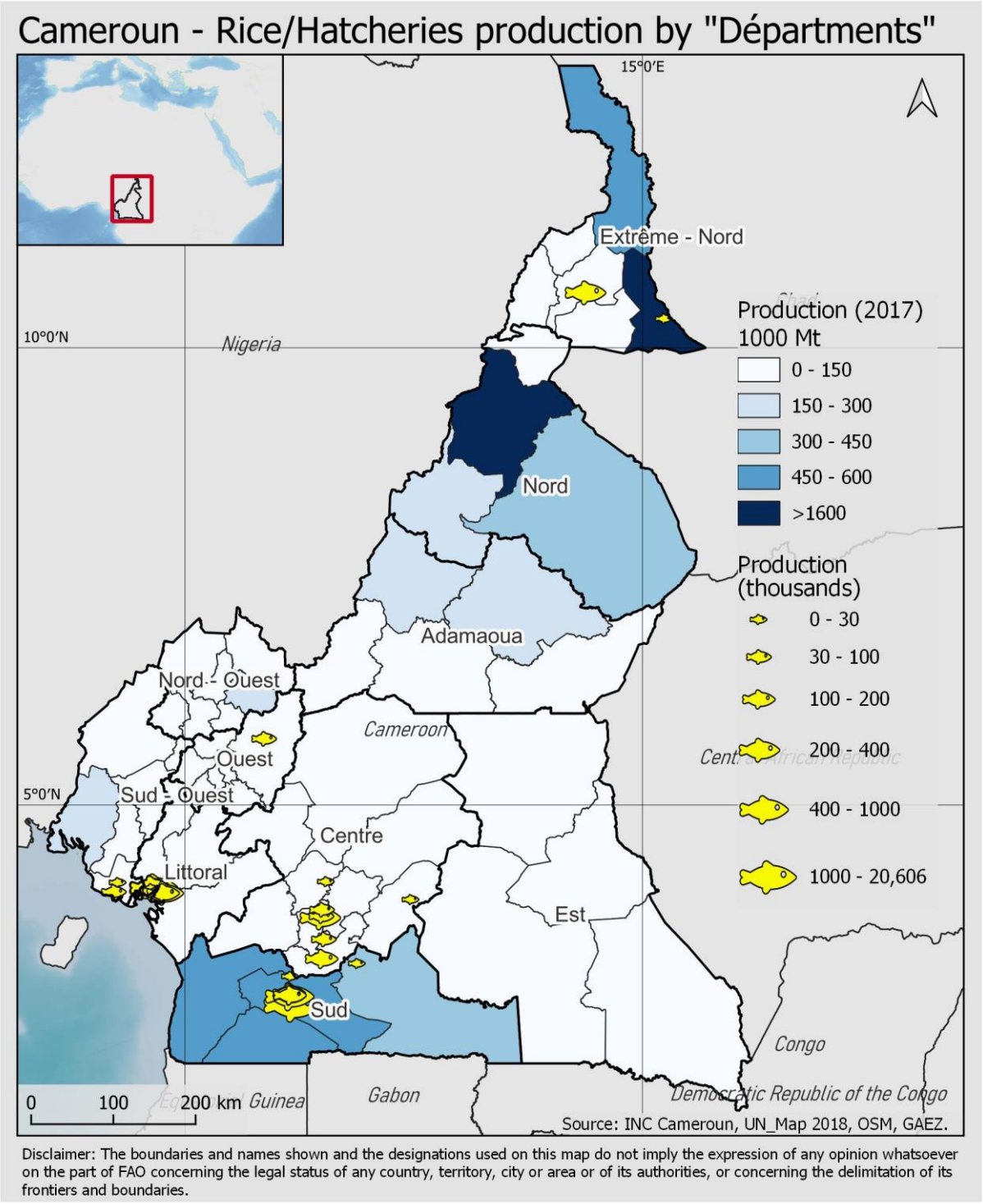

Figure 5 – Map rice/hatcheries production

Not accounting for the *Sud* Region *départments* and Ebolowa, where large productive hatcheries can be found, there is no strong coincidence between rice production areas and production of fish juveniles. In the *Extrême-Nord*, existing small-scale hatchery could eventually be expanded to supply local rice-fish integrated farming systems.

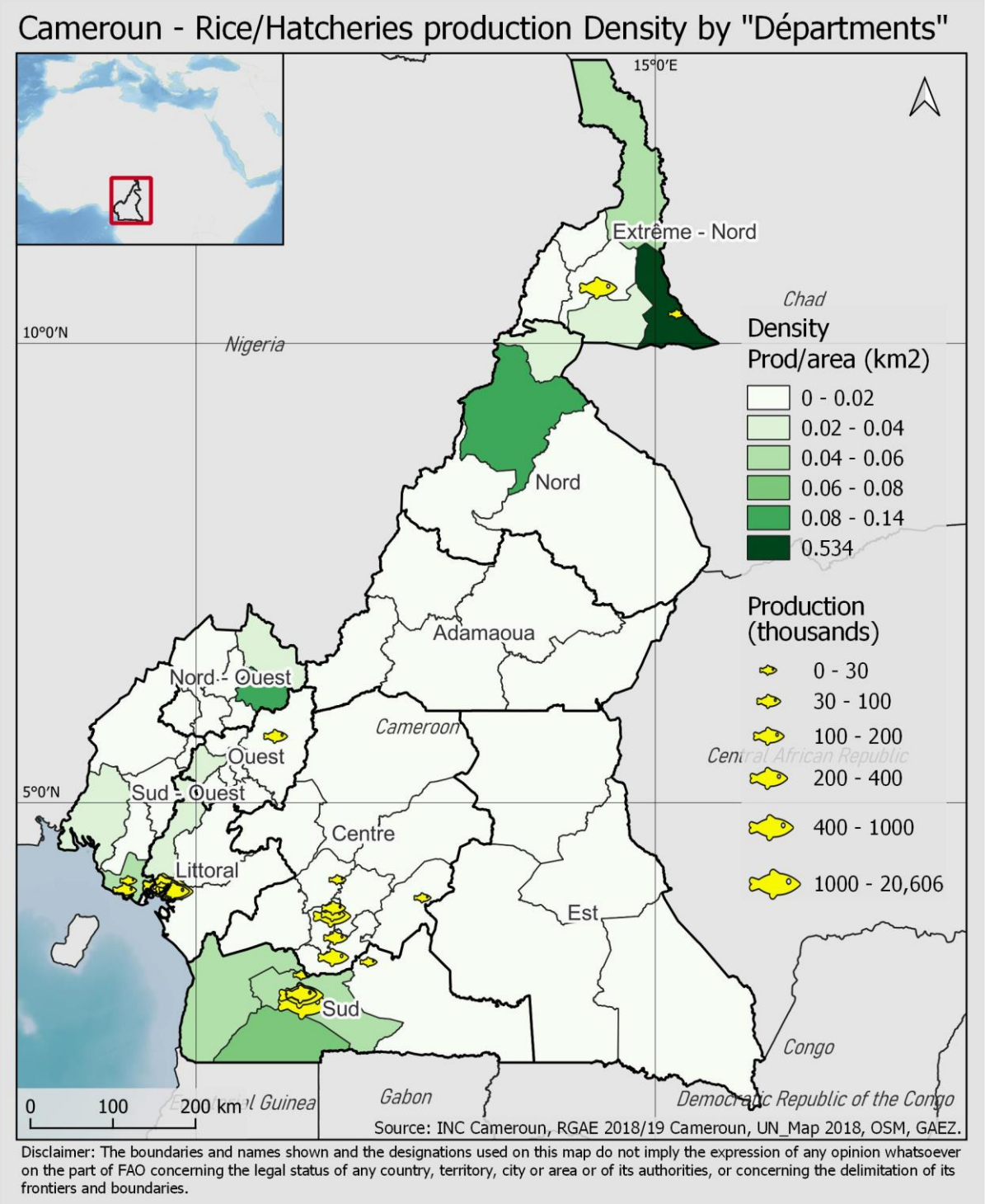

Figure 6 - Map rice/hatcheries density

4. LARGE-SCALE MAPPING

Three areas are selected for large-scale mapping.

- *Nord-Ouest* region Ndop/Kumbo – Ndop, Upper Nun Valley Development Authority area.
- *Nord* region Garoua and Lagdo - in the Benue subbasin, Niger major river basin
- *Extrême-Nord* region, Maroua (Yagoua and Maga), SEMRY - Western Logone subbasin, Lake Chad major basin:

4.1 RICE PRODUCTION *NORD-OUEST* REGION NDOP/KUMBO

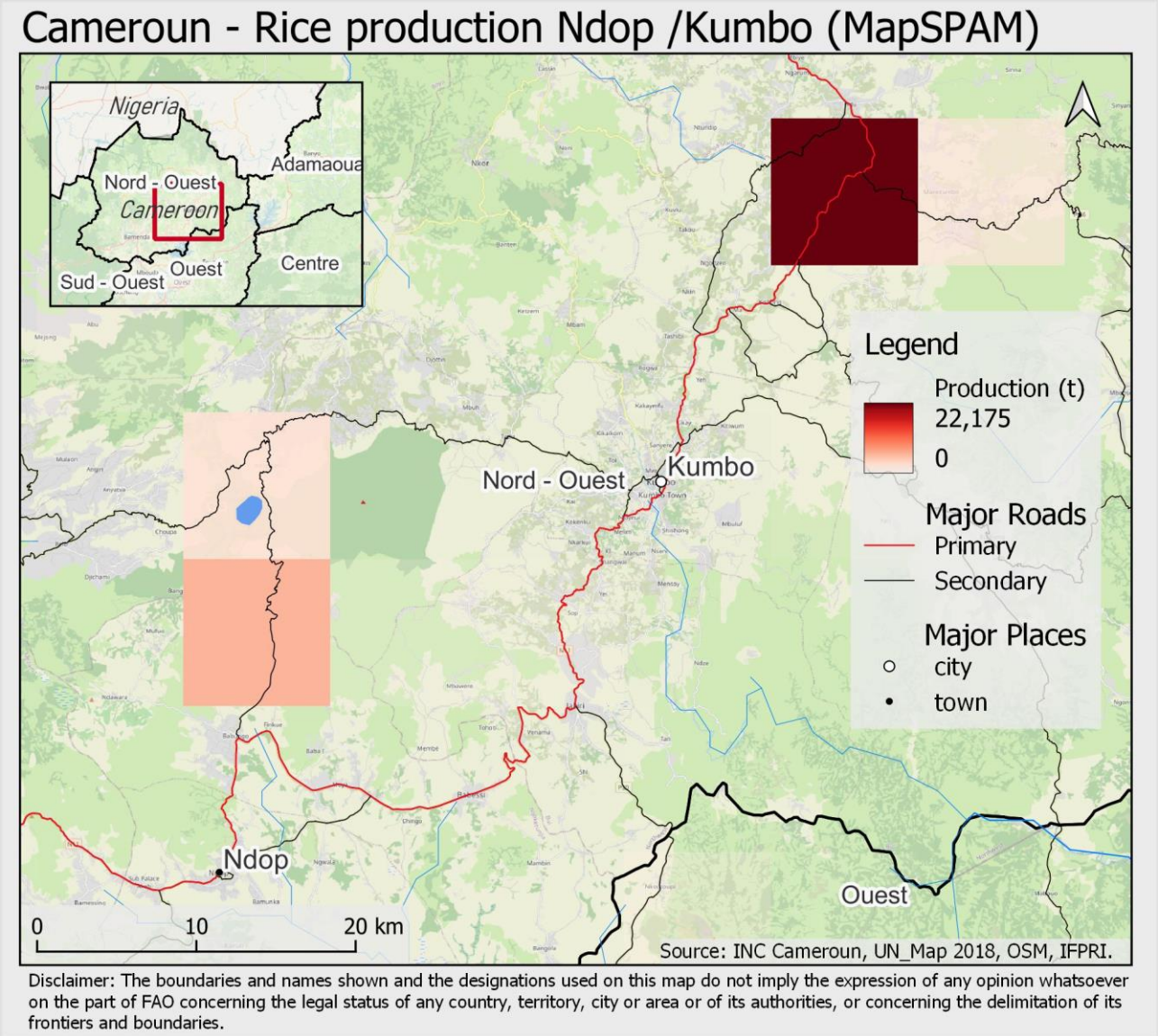

Figure 7 - Map Production Ndop/Kumbo

Nord-Ouest region highly productive areas are north-northwest of Kumbo (Bui *dép*.) and north of Ndop (Ngo-Ketunjia *dép*.) in the Upper Nun Valley Development Authority area (UNVDA).

Created in 1970, the UNVDA mandate is to handle the development of the agricultural sector in the region. The UNDVA has direct intervention in rice production, processing, and marketing, and delivers technical and material support to farmers. The objectives are to provide for all farming activity, from production and transformation to the marketing of products, creating and managing infrastructure and delivering extension services.[3]

[3] http://www.northwest-cameroon.com/home-60-inner-141.html#:~:text=78%2F157%20of%20May%2011%2C%201978%20gives,and%20material%20support%20to%20the%2

The corporation covers around 3 000 ha rice, roads, rice buying and collection centres, rice mill and equipment pool for farmers use.

While there seems to be abundance of water, rice-fish integration might face challenges due to widespread use (misuse) of pesticides, severely impacting wetland biodiversity, where wild fauna population decline has already been observed (Ncheuveu et al., 2021). Farmers increasingly abandon fishing in the paddy fields because of pesticide, signing a drastic population decline of *Clarias gariepinus*, the most harvested specie.

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4.2 RICE PRODUCTION *NORD* REGION GAROUA AND LAGDO

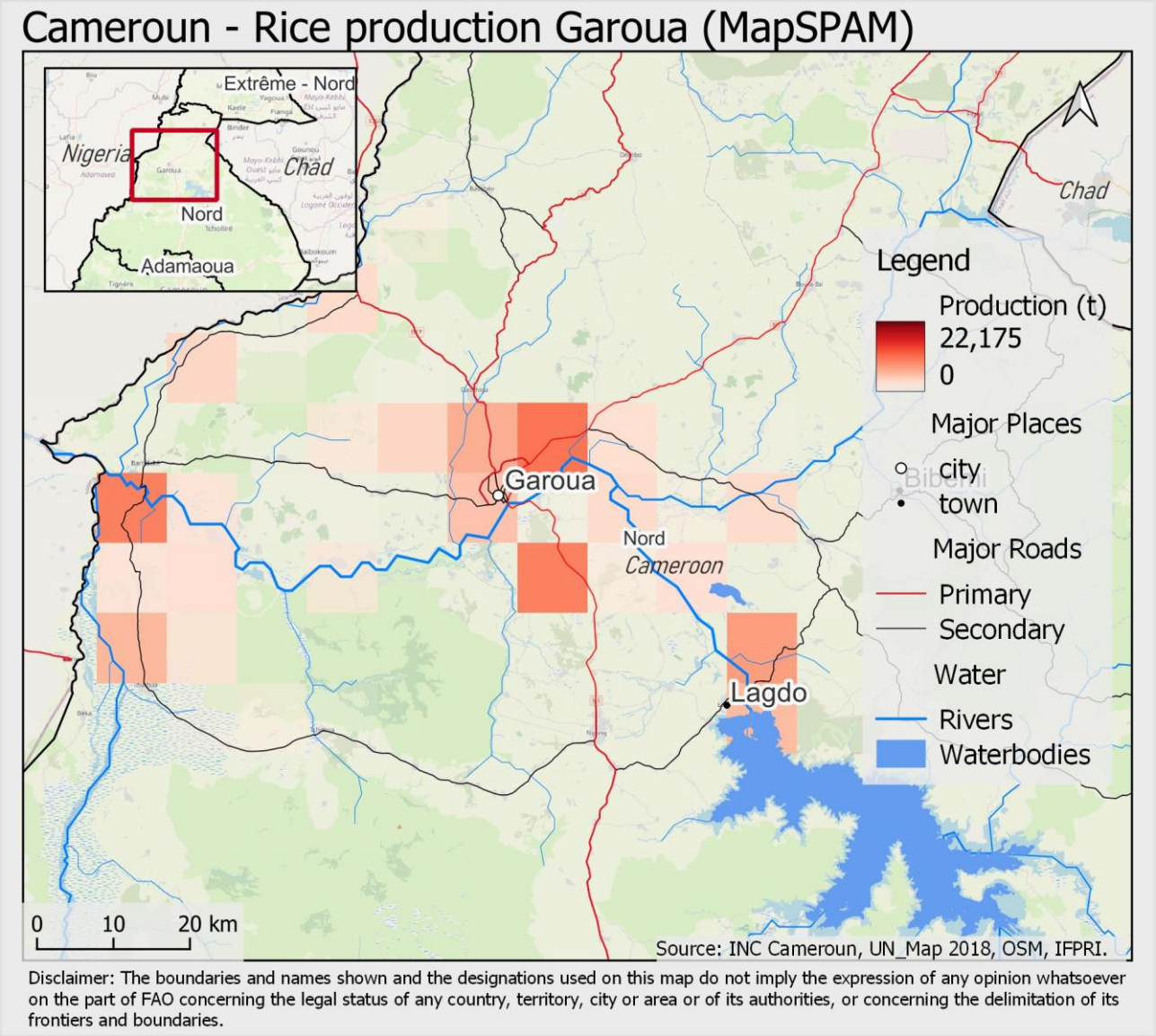

Figure 8 - Map production Garoua

This production area locates in the *Nord* region Bénoue département, Bénoue subbasin of Niger river major basin. Although the Bénoue river and Lagdo dam allow for the irrigation of thousands of hectares of crops downstream, water availability is much lower in the dry season, still, both Lagdo dam and smaller downstream Vurede Douloumi lake have all year water availability.

4.3 RICE PRODUCTION EXTRÊME-NORD REGION, MAROUA (YAGOUA AND MAGA)

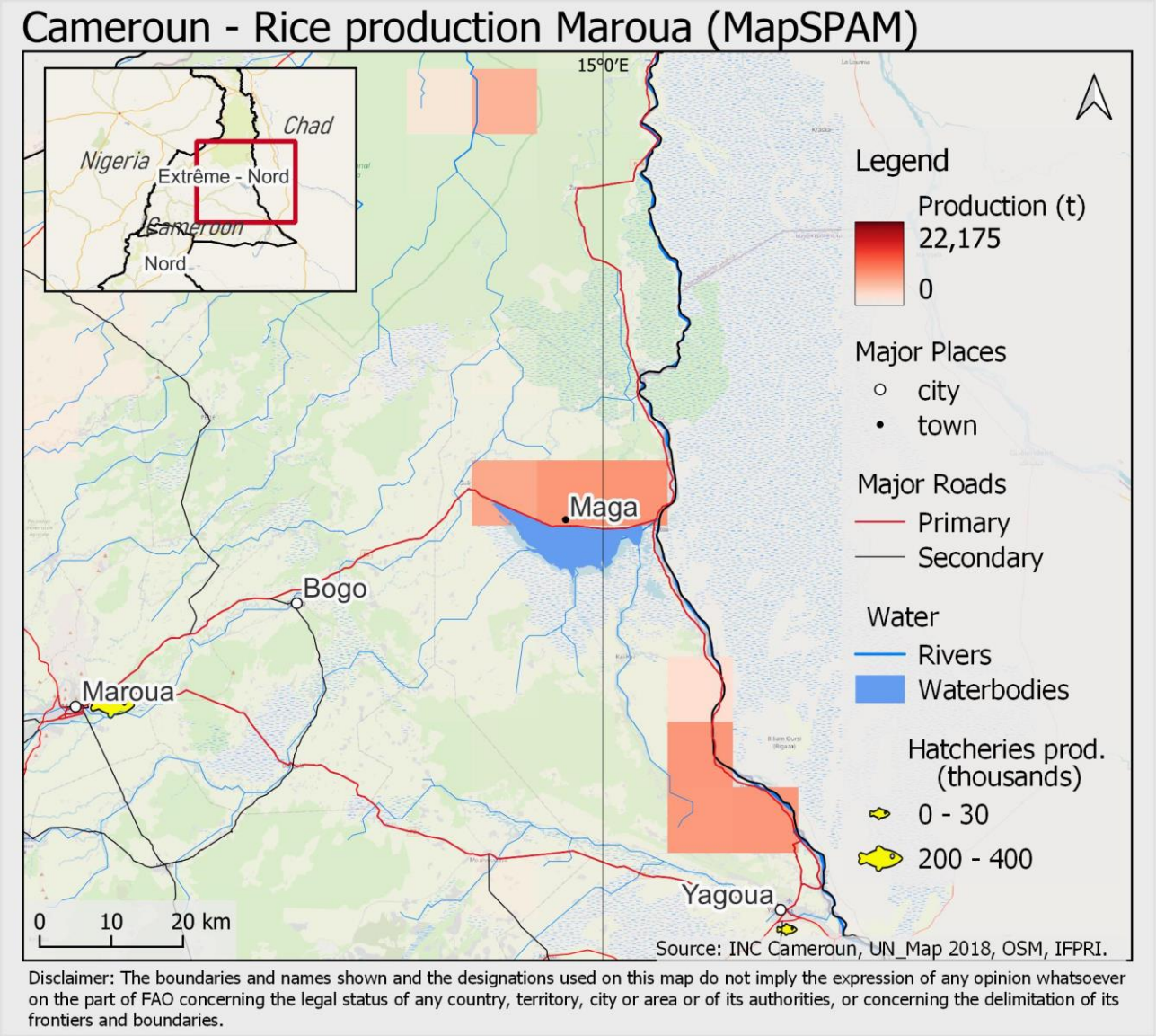

Figure 9 - Production Maroua

Some of the most productive areas in the country are in the *Extrême-Nord* Region, in the Logone river subbasin of the Lake Chad basin, Yagoua and Maga, the area of the *Société d'Expansion et de Modernisation de la Riziculture de Yagoua* (SEMRY) (INTERNATIONAL DEVELOPMENT ASSOCIATION, 1972), and fish hatcheries are also present in the area.

The artificial lake Maga (375km2) dam was constructed during the 1970's targeting the characteristic food insecurity of the Sahelian region. The dam is supplied by the Logone and the Mayo Vrick rivers, and used for rice irrigation (2 seasons), fishing and livestock. The irrigation project in the *départements* of Mayo Danay and Logone-et-Chari serves more than 7 000 ha of SEMRY's area of irrigated rice fields (Ahidjo, 2017; M. Fokeng & Tume, 2022).

The Lake Chad basin is a complex geopolitical space, frontier and important water resource for different countries, that historically has attracted different peoples.

Consequence of natural and human factors the lake is in regression since the precolonial period. Droughts in the 1970s and 80s further reduced water availability, and climate change scenarios are adverse, impacting agricultural production and food security, increasing poverty, famine, and malnutrition, potentially further catalysing conflict and political instability, despite the vast water resources.

Ecological causes for political instability, violence, and conflict, can also be traced to the precolonial period. Demographic pressure and large water infrastructures have amplified tensions, leading to conflicts; Cameroun-Chad over the Longone river unequal exploitation and management; Cameroun-Nigeria over lake Tchad water resources, and the construction of Maga lake/dam.

Large hydro-agricultural projects and policies addressing food security, add to the biophysical and demographic factors, emphasizing water disputes in the Lake Chad basin already a major cause of security and politic instability in the Sahelian region.

CONCLUSION

Despite production potential and remarkable growth in the last 25 years, most of the rice consumed in Cameroun is still imported.

Aquaculture in rice farming systems has clear social, economic, and environmental benefits. Rice-fish systems provide a natural source of plant nutrients and pest control, result in lower costs, higher yields, and improved household nutrition.

Development faces several challenges like:

- Increase in water usage.
- Lack of awareness of benefits.
- Low-cost of pesticides.
- Difficult access to credit.

Interventions must consider other socio-cultural and biophysical factors like:

- Educational status of farmers.
- Gender division of labour.
- The paddy field environment - temperatures, oxygen levels or water turbidity,
- Existing rice cultivars
- Water availability.

Objective

The purpose of rice-fish farming systems suitability assessment mapping is the identification of sites where a pilot can be implemented, targeting small-scale, small-holder, food security and income diversification objectives.

The essential location criterion is production and that's the simple departure question:

Where does rice production take place in Cameroun?

Approach

Global modelled geospatial data on rice production is the starting point in the identification of sites for a pilot intervention.

Since available data, GAEZ 2010 and IFRPI's MapSPAM, has low spatial resolution and quality issues, its use is complemented with literature review, web search and visual inspection of imagery.

The methodology follows 3 steps.

1. Quantifying production at *department* level (administrative level 2) zonal statistics (GAEZ 2010).
2. Improving the identification of most productive areas using Literature review, web search and visual inspection.
3. Large scale mapping and overlaying with existing fish hatcheries.

Quantifying production at département level (administrative level 2) zonal statistics (GAEZ 2010).

Largest rice production *départments*:

- *Extreme-Nord region* Mayo-Danay and Logone-et-Chari *départments* - Western Logone subbasin, Lake Chad major basin (Yaouga, Maga - SEMRY)
- *Nord* region in Bénue *département* - Bénue subbasin, Niger river major basin (Garoua and Lagdo).
- *Sud* region in the most western *départments*, Océan, Vallée-Du-Ntem and Mvila.

Ouest, Centre, Littoral and Est regions *départments* show low or no production values.

A measure of density is obtained dividing production values by area. The spatial pattern is similar revealing:

- Western regions dense production in the *Nord-Ouest* Bui *dép*. in Ndop, the Upper Nun Valley Development Authority area.
- Highest production density in *Extrême-Nord,* in Mayo-Danay and Logone-et-Chari *dép.* SEMRY (Yagoua and Maga) area.

Production mapping is overlayed with hatcheries location. Not accounting for the *Sud* Region *départments* where large productive hatcheries can be found, there is not much coincidence between rice and fish juveniles' production. In the *Extrême-Nord*, existing small-scale hatchery could eventually be expanded.

Although data for the *Sud* region doesn't reveal a large production, a deeper analysis of Ebolowa region should be considered, since there are not only important rice areas (TAMSSAR Nestor et al., 2021) but also strong fish farming activity, including large scale hatcheries.

Large-scale mapping

A. Nord-Ouest region Ndop/Kumbo

Nord-Ouest region Kumbo (Bui *dép*.) and Ndop (Ngo-Ketunjia *dép*.) - Highly productive areas in the under the Upper Nun Valley Development Authority. UNDVA zone appears to have good conditions to pilot rice-fish farming. Nevertheless, no hatcheries can be found and there is pervasive use (misuse) of pesticides. Pesticides impact wetland biodiversity, and a wild fauna population decline is already observed (Ncheuveu et al., 2021), with farmers abandoning fishing in the paddy fields signing a drastic population decline of catfish *Clarias gariepinus* species the most harvested.

B. Nord region Garoua and Lagdo

Nord region Bénoue department - Bénoue subbasin of Niger river major basin. The Bénoue river and Lagdo dam allow for downstream irrigation of large areas. In many river sections water is scarce in the dry season but both Lagdo dam and Vurede Douloumi lake have all year water availability. Hatcheries are also not present in the area.

C. Extrême-Nord region, Maroua (Yagoua and Maga)

Extrême-Nord Region, in Yagoua and Maga - Area of the Société d'Expansion et de Modernisation de la Riziculture de Yagoua (SEMRY) in the Logone river subbasin of the Lake Chad basin. A small-scale fish hatchery is present in the area. Caution is recommended for fish farming projects; water is a conflict factor in the lake Chad basin and a source of insecurity and politic instability in the Sahelian region.

CLOSING REMARKS

Available global data doesn't allow for detailed, high spatial resolution rice field mapping. Smaller or less productive rice areas are missing from the analysis, eventually hiding potential and suitable zones for of small-scale rice-fish integration targeting food security and income diversification.

CSI is evaluating existing remote sensing derived products as well as available methodologies and data to model a high-resolution rice map for the region.

Several challenges exist to the development rice-fish integration. In some of Cameroun rice production areas, water management (Albine et al., 2021) is of great importance and a known cause of conflict. Intensive pesticide uses, and misuses, are also a major concern in some of the analysed areas, including reports of fishing using pesticides in water streams (Kenfack et al., 2019; Ncheuveu et al., 2021).

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