Fish farming in the Congo basin, past, present and future

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Summary

The fish culture has been recently introduced in Africa and begun in 1946 at Lubumbashi, RD Congo (Heenen ponds and Kipopo station) with 2 tilapia species from Moëro lake (*Oreochromis macrochir and Tilapia rendalli*). The good results enjoyed by the colonial administration were quickly extended to the whole country and in the neighboring countries : R Congo, Rwanda, Burundi and finally to all Africa. But the model was to support self food production at community level. After independance, without the public support, the sector crashed totally and the fish culture production gone down totally.

Currently, the fish farming sector in Congo Basin (10 countries) is damaged. Extensive fish production in rural area is insignificanrt due to mismanagement of ponds (no ferilization, degenerate strain of tilapia, no feeding, etc.). Semi-intensive and intensive fish production systems are not yet developed by any fish farmers (only a few exceptions as BTC Fish culture project in Katanga). The main reasons are : inappropriate development policies and lack of strategies and development plans of the sub-sector. Moreover, these multiple and uncoordinated interventions (bilateral, multilateral cooperation, many and various NGOs based on donations) have all followed approaches promoting subsistence aquaculture. These projects, without an exit strategy, have not tried to develop it as a profitable business capable of generating significant revenues and competitive finance themselves and create well-paying jobs. With these constraints are the lack of fish feed industries, difficult access to capital investment and the lack and / or inadequacy of quality seed, lack of qualified staff and lack of control of production technologies.

The future could be better as each country of the Congo Basin has developed, with the help of ACP FISH II, a national policy on fisheries and aquaculture approved by their governments and national assemblies. There is now a strong position, a formal conviction to develop aquaculture in the country with a clear direction to solve the problem of food fish at the technical, social and economic level. On the other hand, each country also made, with the assistance of FAO and ACP FISH II, a National Aquaculture Development Strategy and an Action Plan in order to address this challenge and to try to remove other barriers to this sub-sector development. The Strategy provides policy makers and development agents the fundamental principles that should guide the development and implementation of programs for sustainable development of the sector. In other words, it provides an operational framework within which any development plan for aquaculture will be developed.

In conclusion, at this step, all the instruments are now in place to develop a sustainable and profitable aquaculture in Congo basin, based on two key species of the world aquaculture which are African endemic, but it will take them correctly in application.

Key-words : fish culture, Congo Basin, National Aquaculture Development Strategy and Action Plan, RD Congo, R Congo.

Résumé

La technique de la pisciculture a été introduite en Afrique subsaharienne en 1946 à Lubumbashi (RD Congo) aux étangs Heenen du zoo et à la station de la Kipoko avec 2 espèces de tilapia (*Oreochromis macrochir* Blgr *and Tilapia rendalli* Blgr) du lac Moëro. Les bons résultats constatés par l'administration coloniale furent rapidement étendus à l'ensemble du territoire ainsi qu'aux pays voisins (Congo, Rwanda, Burundi puis finalement à toute l'Afrique). Mais le modèle était basé sur la pisciculture de subsistance visant à nourrir les familles des producteurs sans chercher à la développer comme une activité économique rentable, capable de générer des revenus appréciables. Après l'indépendance, sans appui du secteur public, le secteur s'est totalement effondré et la production piscicole a chuté totalement.

Actuellement, le secteur de la pisciculture est totalement sinistré dans le bassin du Congo. La production extensive en milieu rural est insignifiante vu les mauvaises pratiques (pas de fertilisation des eaux, souche de tilapia dégénérée, pas d'alimentation des poissons, etc.). Les pisciculture semi-intensives et intensives ne sont pas développées à l'exception de quelques initiatives privées. Les raisons principales en sont : politiques de développement inappropriées, absence de stratégie et de plans de développement du sous-secteur. De plus, les multiples projets d'appui (bilatéral, multilatéral, ONG, etc.) se sont toujours basés sur le modèle initial de la subsistance. Ces projets, sans stratégie post projet, n'ont pas cherché à développer d'entité rentable capable de générer des revenus importants et de créer des emplois rémunérés. Enfin, l'absence d'industries d'aliments pour poissons, l'accès difficile au crédit, l'absence et/ou l'insuffisance d'alevins de qualité, le manque de personnel qualifié et le manque de maîtrise des technologies de production n'ont pas permis au secteur de se développer comme dans les autres continents où la révolution bleue fait merveille.

L'avenir pourrait être radieux car chaque pays du bassin du Congo vient d'établir, avec l'aide du Programme ACP FISH II et/ou de la FAO, une politique nationale de la pêche et de l'aquaculture ainsi qu'une stratégie nationale de l'aquaculture avec des plans d'action précis, le tout approuvé par leurs assemblées nationales et leurs gouvernements. Il reste maintenant à relever ce défi et à supprimer les obstacles au développement de l'aquaculture.

En tout cas, la Stratégie fournit aux décideurs et aux agents de développement les principes fondamentaux qui devraient guider l'élaboration et la mise en œuvre de programmes de développement durable du secteur. En d'autres termes, il fournit un cadre opérationnel dans lequel tout plan de développement de l'aquaculture sera élaboré.

En conclusion, à ce stade, tous les éléments sont en place pour développer une aquaculture durable et rentable dans le bassin du Congo mais il faudra les utiliser correctement.

Mots clefs : pisciculture, bassin du Congo, Plan national de développement de l'aquaculture, RD Congo, Congo.

Introduction

The watershed of the Congo, second only to the Amazon covers an area of 3,822,000 km ² (CICOS , 2003) shared by 10 countries : Angola (8%), Burundi (0.2%) , Cameroon (2%) Congo (7%), Gabon (0.04%) , Central African Republic (CAR, 11%) , Democratic Republic of Congo (DRC , 62%) , Rwanda (0.2%) , Tanzania (4%) and Zambia (5%). With a backbone length of 4,700 km, the Congo River in Kinshasa has an average flow of 41,000 m³/sec, supplied by numerous tributaries. The main are Ubangui and Sangha (north equator) and Kasai (southern equator) which have very good water

resources conducive to the development of sustainable fish farming since 1972 although subject to some wave sahelisation and kalaharisation respectively north and south of the basin (CICOS , 2003). The forest cover is still significant (1.6 million km ² = 46%) and mainly located in DR Congo where 10% of the forest is flooded with a relatively small marling range.

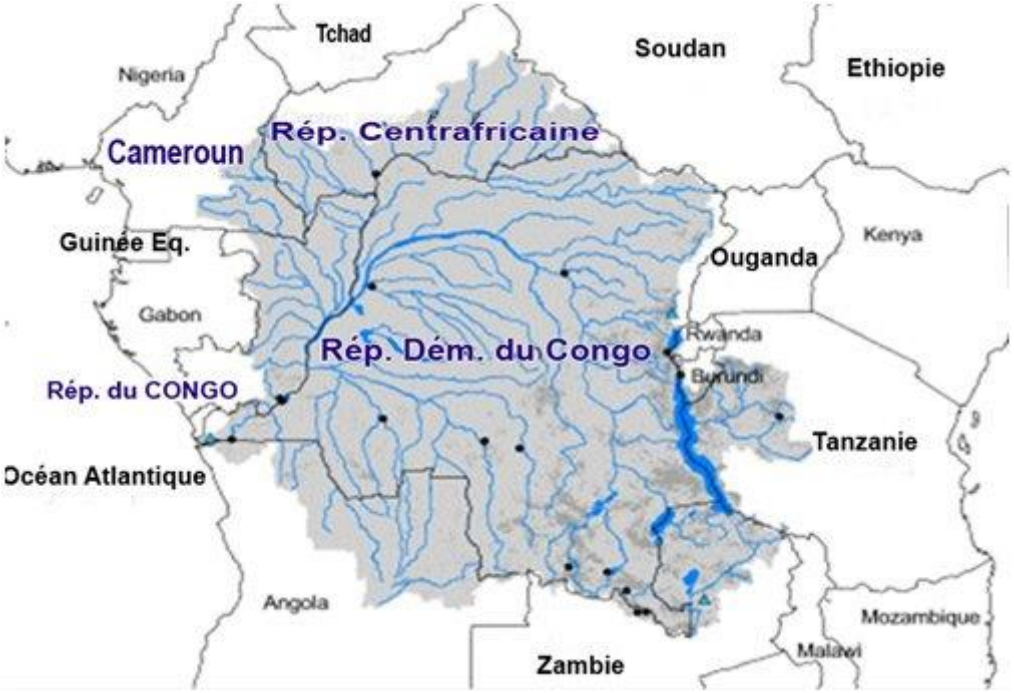

Figure 1: The Congo Basin and its respective areas in its 10 countries of origin (based CICOS, 2003)

Unlike Asia, which saw the birth of this activity in China where farmers have developed it, in a sustainable way for nearly three millennia, fish farming was introduced in sub-Saharan Africa (1930 according to some sources but actually to 1946 around Lubumbashi in DRC) by colonial administrations as subsistence food technique with some success, however, dwindled after periods of independence.

Given the immensity of the Congo River basin shared between ten countries, it would take too long to make the state of the fish in each country, we shall merely indicate past, present and future of this activity in the Democratic Republic of Congo (DRC), which represents the largest area of the watershed (64%). However, we conclude by briefly point on the current state of the fish in the other 9 countries before concluding.

1. Democratic Republic of Congo (DRC, Kinshasa)

In DR Congo, fish culture, although recent introduction, had a rather chaotic evolution

1.1. Past

We can say that the fish culture in sub-Saharan Africa was born in Congo just after the Second World War (1946) and this is the region of Lubumbashi (Heenen ponds and Kipoko station) that the Belgian colonial authorities domesticated two tilapia (*Tilapia* (*Oreochromis*) *macrochir* BLGR) and *Tilapia rendalli* BLGR) whose breeding was popularized and disseminated to the entire country. Spectacular results quickly interested neighboring countries watershed where the technique has been rapidly developed with the main objective to solve the supply of fish indigenous issues. After a short

trial period, follows a rapid expansion of family fish farming model. In 1960, DR Congo totalizes 122.000 ponds covering an area of 4,000 ha belonging to 15,000 farmers (Micha , 1.9 74a) . The main cultured species is *Tilapia* (*Oreochromis*) *nilotica* which gets the best performances. The development is based on the creation of 25 main hatcheries centers (Centre d'Alevinage Principal : CAP) with some secondary centers across the country and an important extension service in each province. After 1960 (post independence period), fish culture declines everywhere decline considered by some authors as a resounding failure. A few years later, the reorganization of the country led the Ministry of Agriculture and Livestock to sign cooperation agreements (MINAGRI, 2008a) with various bilateral and multilateral organizations for projects to boost aquaculture (1970-1990). Thus, for example, the French bilateral cooperation supports the creation of a Centre for Commercialization of vegetable and fruit products (CECOMAF) mainly in the area of Kinshasa, U.S. cooperation (U.S. Agency for International Development , USAID) through the Peace Corps project develops family fish culture throughout the country, the Belgian bilateral cooperation through its General Agency for Development Cooperation (AGCD) is also developing a family fish culture project in areas of Kinshasa, Bandundu and Bas Congo etc. These assistance projects, sometimes competing, have a common goal: to develop family fish farming in rural and suburban areas. All these projects were abandoned in 1990, after the cessation of all cooperation resulting political events (embargo). Calm returned, the Ministry of Agriculture and Livestock (MINAGRI) , through its National Aquaculture Service (SENAQUA) receives in 1,997 support and material of HIPC (Highly Indebted Poor Countries) under the name "Redevelopment Program for aquaculture sector in the DRC ." The strategy of this program (MINAGRI, 2008b) is based on 6 components :

• distribution of materials and installation of various equipment,
• human capacity building through seminars and refresher courses for fish culture,
• rehabilitation of some nursery main centers (CAP: Ngandajika, Kasangulu, etc.),
• support to farmers for the design, construction and / or rehabilitation and management of their farms,
• promotion of the semi-intensive fish farming in peri-urban areas.

During this period, MINAGRI with the support of FAO updates the Master Plan for Aquaculture which was prepared in 1993 and who had obviously been never developed.
The results of all these actions to boost fish farming are disastrous. The finding on the ground shows:
• poorly constructed ponds (bad construction of dikes and plates ponds, improper drainage systems, ponds plates full of stumps and trunks, etc.),
•mismanagement of fish ponds (degenerate strains of cultivated species, improper fish densities and drainage techniques inappropriate, …),
• lack of specialized feed mills for fish,
• unavailability of fry in quantity and quality certified,
• Insufficient and ineffective technical support.

The causes of this disastrous situation (Micha, 1974a, MINAGRI, 2008a) are many:
• bad socio-political situation : unstable, dangerous and/or hostile,
• multiple project initiatives in the field without precise definition of goals and exit strategy,
• perception that aquaculture is an extra speculation for food consumption (subsistence fish farming),
• lack of regulation for the sub- sector aquaculture,
• lack of political stance and therefore political support for the sub-sector,
• lack of strategy and development plan for the sub-sector.

In other words, all these projects were neither prepared nor perceived to develop a profitable business generating significant revenue and creating paying jobs.

1.2. Present

Currently aquaculture is almost abandoned in all provinces and its production is insignificant despite strong demand for fish consumption (import more than 100,000 t/year of horse mackerel). A small exception in the Katanga province (Figure 2), which receives support from the Belgian Technical Cooperation (BTC) for Development Project (training and extension) of the Artisanal Fisheries and Aquaculture (Prodepaak, 2008 - 2013).

Figure 2: Heatmaps of Belgian-Congolese project Development of Artisanal Fisheries and Aquaculture (Prodepaak 2008-2013).

The main results of Prodepaak are :

• partial rehabilitation (Photo 1) of the Kipoko station (47/208 ponds),

• renewal and development of interest in fish farming with 366 private ponds, covering an area of 2,161 ares, restored according to standard technical criteria and producing an average of 4.000 kg/ha/year,

• pond fertilization (manure poultry, pigs, goats, cows) and/ or feed for fish (malt brewery, rice bran, floating pellets from Zambia) reorganized,

• adequate training of technicians in fish culture (> 20 courses of 30 days for 20 to 30 people) , especially in pond construction according to the standards and artificial reproduction of the African catfish (*Clarias gariepinus*),

• training of 16 fish culture managers (public and private sector) during 16 months or more

(construction, water supply, loading fish fry, fertilization and/or feed, agro-fish culture, production and sale of fingerlings of certified quality, harvest and sale consumable fish, organization of the sector : from the water to the mouth),
• facilities for water control with integrated fish farming gardening (vegetables) and small livestock (pigs, poultry , ..).

Photo 1: Aerial view of the hatchery Kipoko, Katanga (photo J.-P. Marquet,2010)

But all this is still little compared to the expectation of coaching more than 20,000 farmers in Katanga . What about the rest of the country ?

Regarding the private sector, entrepreneurs in the region of Kinshasa (about ten), under the leadership of consultants for the Centre for Economic Development CDE EU), have formed a group called Groupement Agro-Piscicole de Kinshasa (GAPK , 2010) to exchange experiences, to improve their practices, to perform their production and to sales fish fry, fingerlings as well as consumable fish..
Also note that a new entrepreneur is preparing the establishment of a farm in Kinshasa and periphery (Kimpoko) to produce, in a near future, in semi- intensive (ponds) and intensive (concrete tanks) systems, 3,000 t/year with implementation of a feed mill plan for extruded floating pellets.
On the public side, the DRC received in 2012, following his request, the assistance of the African Caribbean and Pacific Program of the European Union ACP FISH II (EU) which has supported the Ministry of Agriculture and Livestock (MINAGRI) to prepare a National Policy for Fisheries and Aquaculture. This national policy document in DR Congo (MINAGRI, 2012) was submitted to the Parliament in early 2013 which discussed the document which is awaiting now approval. Meanwhile, the MINAGRI has received the support of FAO to prepare a new law : "Code of fisheries and aquaculture in DR Congo ", adopted by the government in early 2013 and discussed by Parliament in 2013. In addition, FAO has supported the MINAGRI to prepare the strategic sustainable development

of aquaculture in DR Congo. Finally, FAO has always supported the MINAGRI to prepare the Aquaculture Development Plan 2010-2015.

Strategy for Sustainable Development of Aquaculture (MINAGRI, 2008a) is:
• integral part of the National Policy on Fisheries and Aquaculture in DR Congo (favorable context,
• based on three fundamental axes which are:

- improve efficiency of production systems: accessibility to inputs (fingerlings, feed, capital, etc.),
- improve services: extension, training of all stakeholders, research, marketing support (industry),
- improve management : professionalization, application of the new law, aquaculture section (rules applied, ...), etc.

The Action Plan (MINAGRI, 2008b) for Aquaculture (2010-2015) sets specific goals and how to reach them:
• specifying the target species : tilapia (*Oreochromis niloticus*) and catfish (*Clarias gariepinus*),
• fixing the amount of fish to produce 150.000 t for 2015 in:

- Earthen ponds: 3,200 ha,
- Cages : 24,000 m³ to 3,000 m³ for tilapia and catfish,
- Concrete tanks : 15,000 m³ for tilapia and 4,000 m³ for African catfish,
- Number of farmers : 4,000 in tilapia and 600 in catfish,

• improving annual revenues from 316 to 5,580 US$

• specifying requirements: 580 extension agents, 430.000 t of feed,

- setting the consumption of desirable fish to 7.6 instead of 5.8 kg/per capita/year.

To this end, the National Aquaculture Service was reorganized with five divisions: Administration, Extension Division, Monitoring and Evaluation Division, Finance Division, Technical Division and Aquaculture Development Division. Its mandate was clarified, which is increase aquaculture production , diversify production techniques (from extensive to intensive), evaluate and enhance natural resources (valleys, rivers, lakes, ...), promote the development of aquaculture, design and adapt policy aquaculture, promote applied research: domestication of new species, profitability of production systems and supervise farmers to improve their performance. The cost of this action plan for 5 years is estimated at US$ 106 million. It remains to be seen who will put the necessary resources for its implementation.

In conclusion, the new institutional context seems very good but we will have to see the good application of all these aquaculture documents and the actual development of aquaculture on the field in a near future.

1.3. Future

Around the world, aquaculture is a real "big bang" (Micha, 2006): in 2013, almost two fish consumed worldwide comes from culture given the stability or the fall of the global catch since 1990 (FAO, 2012). For the first time the global production of farmed fish has reached and even surpassed that of beef (Figure 3).

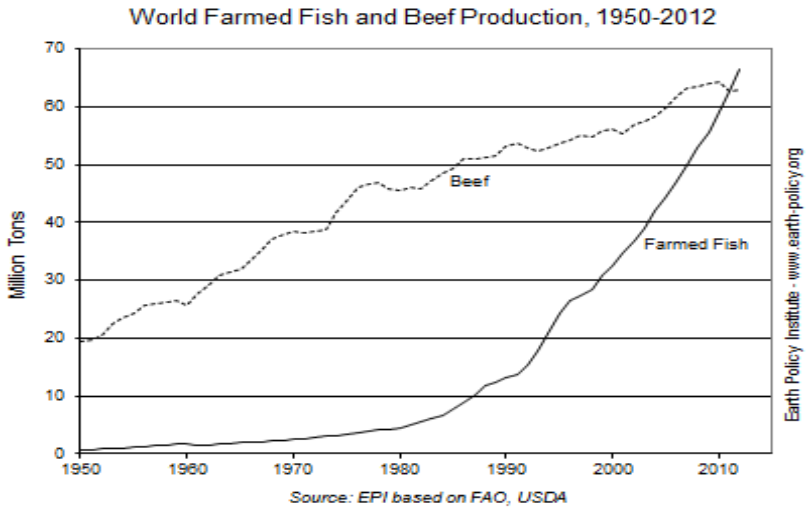

Figure 3: Evolution of world annual global production of beef and farmed fish (1950-2012)

This is partly due to changes in diet to a healthier diet (polyunsaturated fatty acids) and a better welfare of elderly people (average fish consumption: 17.8 kg/person/year globally, 25 kg/person/year in Europe) but also because fish farming to produce animal protein to the man is much more effective and less costly than any other speculation with warm-blooded animals (poultry, sheep, cattle, pigs). Typical reasons for this are well known: the fish poikilotherm does not maintain a constant high temperature, the fish density close to that of water has therefore somewhat skeleton (maximum 4% of the body weight against 20% for some mammals), the fish excreting ammonia better converts protein consumed. It follows that:

• weight gain per gram of food consumed is 0.13 in cattle, 0.48 in broilers and 0.84 in the catfish,
• gain of protein per unit of energy consumed is 6 in beef, chicken at 23 and 47 in the catfish,
• farmed fish is the best compound feed converter (flour, extruded pellets floating) for consumable food by man (1.5 kg feed →1 kg of fresh fish).

Many African countries have been slow to understand the need to develop aquaculture (Percy and Hishamunda, 2001) but in recent years, Nigeria, Egypt, Uganda, Zambia and Ghana have recently substantial productions that only grow. So we have that DR Congo as others countries of the Congo watershed follow suit because there is no other choice given the widespread overexploitation of all natural fish stocks in fresh, brackish and marine waters.

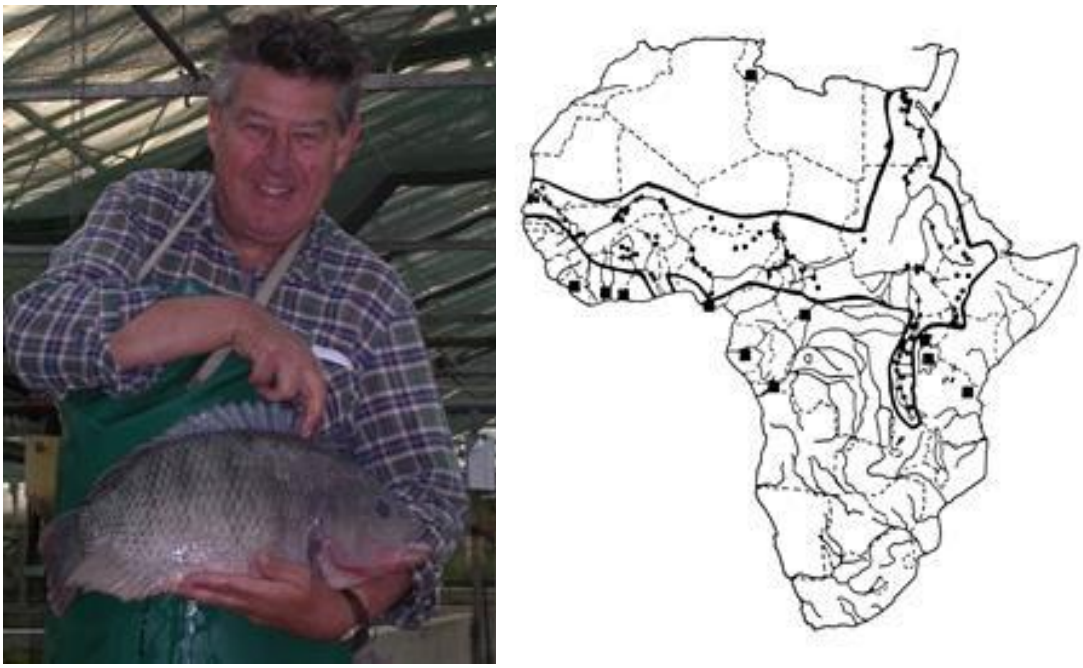

Figure 4: *Oreochromis niloticus* (photo) and its original distribution in Africa (black line)

Immediately and independently of any research, DRC should develop the culture of one of the world best species for aquaculture whose culture is well-known and well controlled since a long time (Micha et al, 1975; Kestemont et al, 1989; Lazard, 2007), namely *Oreochromis niloticus*, an endemic species of Africa (Figure 4), introduced and produced everywhere in the world (World production in 2012: 3.4 million tons in sales prices, output fish culture: 1-2 US$/kg). To do this, the DRC should first develop good strains of *O. niloticus* genetically improved and thus rapid growth. The GIFT strain ("Genetically Improved Farmed Fish") developed around 1987 by World Fish Center in the Philippines and which is used throughout Asia (11 countries) was introduced in Central America (Costa Rica) and Latin America (Brazil) and more recently in Africa (Zimbabwe, Zambia) despite the reluctance of scientists because of the risk of genetic pollution of indigenous African strains. To avoid this problem , however , it would be better to use new selected strain from various local strains such as strain SON ("Source of the Nile") developed in Uganda according to a similar scheme GIFT from three populations : *O. niloticus* from Victoria, Kyoga and Albert lakes and suitable for medium altitudes (~ 1000 m) without marked winter (pers. comm : D. Desprez) . Note that the Rwanda as part of a project ADB has bred two natural strains from Lake Albert and Victoria and distributed fingerlings in rural areas but the "Rwanda Agricultural Board" (RAB) in 2014 plans to begin a breeding program according to GIFT at Kigembe station (1791 m). At high altitudes, the strain niloticus Manzala Stirling could give also good results (pers. Comm. J Magnée), but this requires experimental verification, appropriate equipment and a rigorous broodstock management otherwise you quickly lose the benefit of the selection. For fish culture in plain, it would be better to use a strain of low altitude such as "niloticus Akosombo" strain attempted in Ghana but has unfortunately (pers. comm . J. Magnée) high aggressiveness and growth still relatively low (4 g/d) and limited (curve growth cap: 350 g) indicating that the GIFT protocol does not automatically lead to success. These few non-exhaustive data indicate that it would still be desirable to develop a Regional Network that streamlines research and its application in the Congo watershed. In any case, from a good strain selected, you have to go to the culture of monosex male with fry of the same age and of certified quality from possibly for limited amounts manual sexing or sex reversal with methyltestosterone (feed added of methyltestosterone during the first 4 weeks of life fry, Kestemont et al , 1989). Most of the tilapia production in the world is being done by

this sex reversal but is increasingly contested seen methyltestosterone residues detected, although in very low concentrations, in fish consumed. The future may go to super male/pseudofemale technique. The latter sex control technique (C. Mélard, D. Desprez, pers. comm.) by hormonal manipulation of the system XX/XY includes 4 stages:

- reversal of sex undifferentiated larvae by ethinyl-oestradiol leads to produce 100% phenotypic females 50% 50% XX and XY,
- crossing XY females with males XY leading to 25% females XX, 50% males XY and 25% males YY,

M XY / F XY	X	Y
X	XX	XY
Y	XY	YY

- Crossing males YY with females XY and sex reversal with ethinyl-oestradiol which gives 50% females XY and 50% females YY,

M YY / F XY	X	Y
Y	F XY	F YY
Y	F XY	F YY

- Crossing males YY with females YY which gives 100% males fry without hormone residues for the commercial production.

However, this technique inversion/detection of genotypes based on the sex ratio of offspring is a factor which currently limits the amplification technique on an industrial scale (pers. comm. D. Desprez). Indeed, in practice, we have to find female compatible with the male who will give 100% YY males (pers. comm. J. Magnée). Nevertheless, it should be noted that a Dutch private company Tilaqua, trains technicians to this innovative practice and provides super YY males/pseudofemales strain routinely with some success but high mortalities are sometimes still found.

A second species endemic to Africa, the African catfish, *Clarias gariepinus* Burchell (Figure 5), which reached world records biomass (> 400 kg/m³ of water) in intensive farming system which is mastered since the 1970s (De Kimpe and Micha, 1974, Ducarme and Micha, 2003; Micha, 1974b; Micha,1975) with consequent productions outside Africa (China, Vietnam, Brazil, etc..) should also be quickly produced in DR Congo, seen the strong local demand for this species (5 to 10 $/kg fresh weight). The techniques are relatively simple but you must master the artificial reproduction and rearing ("fingerlings" of 10 g), which is now made on a large scale in Nigeria which knows a strong development of this fish culture in ponds as in concrete tanks (intensive production units of 50 t/year).

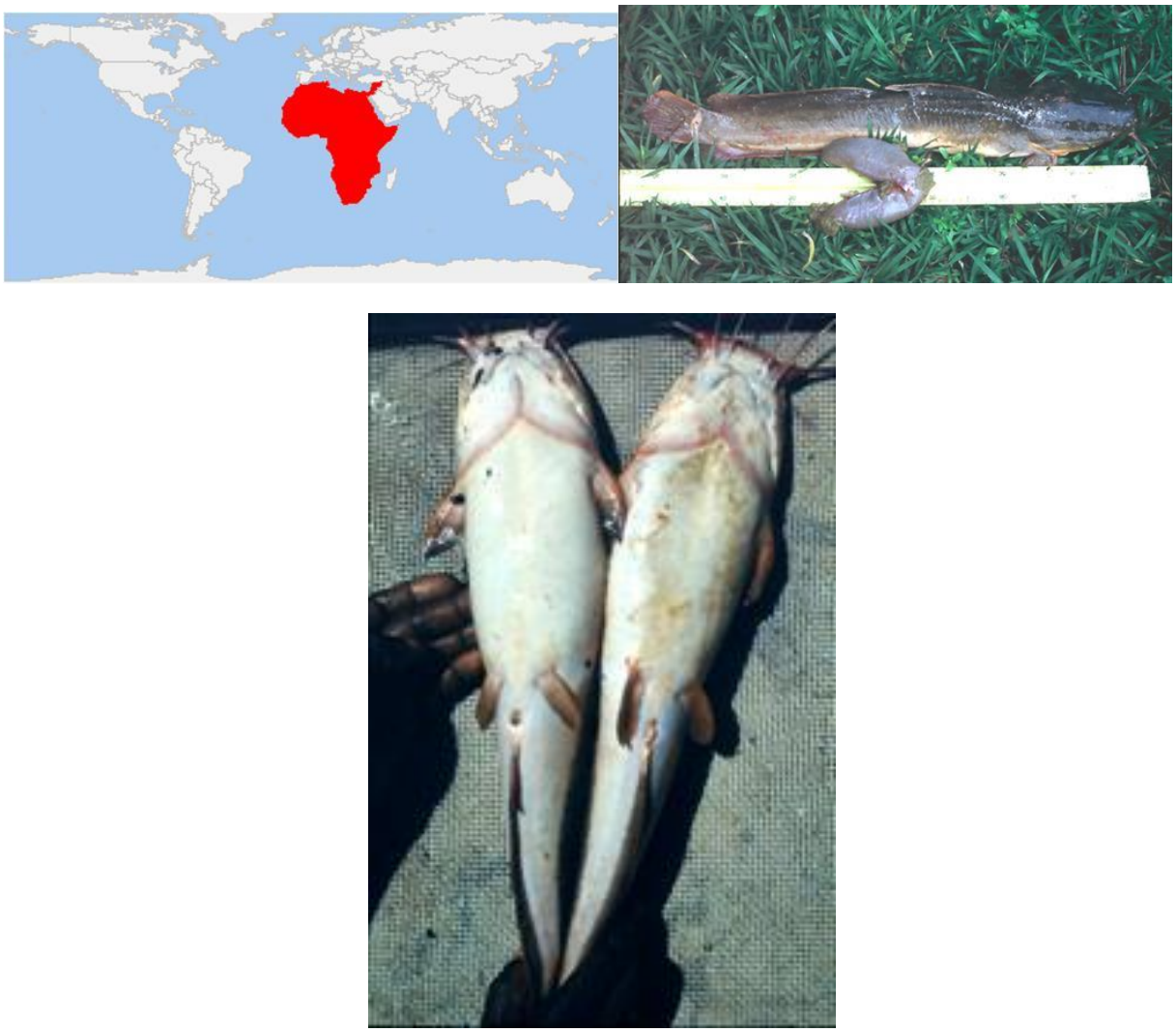

Figure 5: African catfish, *Clarias gariepinus*, original geographical distribution, female with mature ovaries (high fertility: 60,000 eggs/kg), female (left), male (right)

In this regard, efforts for over ten years including with the support of the Association for the Promotion of Education and Training Abroad (APEFE) and the Centre for Economic Development (CDE, UE) in the Kinshasa region to form on private farms technicians able to master the techniques of reproduction and rearing, finally give some success. For example, the small private farm of S. Mutambwe to M'Binza pigeon, Kinshasa with his technician F. Kadima formed at Aquafarm Tihange (Belgium) produce with 5 ♀ (1-2 kg) of *Clarias gariepinus* and10 ♂, an average of 850 g eggs that always give about 500,000 fertilized eggs whose 360,000 living larvae giving 6 weeks later some 180,000 fry (fingerlings 5 g) at a cost of ~0.1 US.$/piece which are sold at a price of ~0.3 US$/unit. This type of production can be renewed every two months if the females are well-fed, but with a rest period in July/August. Well practiced , reproduction and rearing of African catfish are profitable, which also serves to supply continuously producers specialized in the growing out for the market size of this popular fish (selling price 5-10 US$).

Figure 6: Artisanal hatchery for catfish builded by S. Mutambwe at M'Binza Pigeon, Kinshasa and full tank of African catfish fry of about 0.5 g

The choice of fish species to culture in the immediate future is clear, however, remains to be solved sustainably pond fertilization and artificial feeding fish. For fertilization, we refer to the multiple possibilities (Micha, 1985; Micha and Symoens, 1995; Rukera Tabaro et al, 2005, 2012) of agro- fish culture (rice-fish, vegetables-fish, etc.) and with livestock: pigs-fish, poultry-fish, rabbits-fish, etc.) which are already more or less practiced here and there in DR Congo. But for the artificial feeding of fish (Tacon, 2004, Tacon et al, 2009), it is necessary to understand the need to develop the semi-intensive to intensive fish farming. The latter requires feed balanced performance and extruded floating pellets for adequate and profitable results because feed is 50 to 70% of cost production for farmed fish. If the revival program of agriculture in DRC is properly done with processing products, the DR Congo will face a huge potential of by-products to enhance and implementing a good strategy (as appropriate mix of local by-products) could benefit to intensive fish production systems. In this regard, to convince any of the Congolese farmer of the need to feed wisely fish, here's a little basic reminder.

For the constitution of the body, like any living organism, fish needs essential nutrients that are:
• **Proteins** : developed especially from the 10 essential amino acids including lysine and methionine which are often deficient if you are not careful. These proteins are essential for developing muscles and other tissues: enzymes, hormones, eggs and sperm. Common sources of these proteins are

generally fish meal, soybean oil, cottonseed cake, groundnut, palm nuts, malt brewery, etc.,
• **Lipids** (fats, long fatty acids (C18 , C20) essential ϕ3 and ϕ 6) essential for the development and functioning of the brain, nervous system, cell membranes, ovaries, hormones, etc. Common sources of these fats are animal fats (fish) and vegetables (soybean, cotton, peanuts, etc.). Also note that these lipids are essential carriers of fat-soluble vitamins,
• **Vitamins**: two categories: fat-soluble vitamins that regulate the metabolism of structural units (eg, vitamin D and bone metabolism) and water-soluble vitamins that provide energy transfers,
• **Minerals**: essential for the development of the skeleton and various functions. Generally added to compound feed a vitamin and mineral complex that meets the needs of fish,
• **Carbs or carbohydrates** : not required for the constitution of the body but used in diets because they are a source of cheap energy provided to be digestible (eg starch). Indigestible hydrates carbon are simply excreted. However, they are essential to produce floating pellets (starch expansion during extrusion). Common sources include wheat bran, rice bran, corn bran, cassava, etc.

Note that in order to grow and move the fish still needs energy but which can come from proteins, lipids and/or carbohydrates.
To properly feed the fish, the equation to solve is quite simple: you have to go from the nutritional needs to food formulation. For tilapia, *O. niloticus* and African catfish, *C. gariepinus*, nutritional needs are well known and can be met by various combinations of feed by-products. However, be remembered that there is no single food ingredients that contain all the necessary nutrients for a balanced diet. The big challenge will be to :
• make less expensive food meeting the nutritional requirements with the most economical combination of by-products locally available (they are constantly changing),
• make effective programs by checking the quality of by-products available (note the digestibility of each ingredient),
• applied research to develop a quality feed while checking its performance on fish growth and economic profitability of the production,
• promote an interactive approach between farmers, researchers and feed producers.

Among the constraints increasingly raised against the development of fish farming, but mainly against the "bad" fish culture, namely farming predators at the end of the food chain (salmon, tuna, captains, bass, bream, etc.) we must cited the use of wild fish meal to feed the farmed fish, making this unsustainable practice (2.5 kg of wild fish to produce 1 kg of salmon). This is not the case for tilapia and even catfish which are at the bottom of the food chain in the aquatic ecosystems. So, they can be feed with a relatively low protein content (28% for tilapia, 32% for catfish) which may come mainly from plant protein avoiding even the use of fish meal (Table 1). Thus, the future of fish farming is no doubt, but it must grow responsibly and sustainably

Table 1: Composition of extruded floating pellets containing 32% protein for catfish with and without fish meal (modified from Li et al, 2003)

Feed with fish meal		**Feed without fish meal**	
Ingredients	*Pourcentages*	*Ingredients*	*Pourcentages*
Soybean meal	35	Soybean meal	34,6
Cotton meal	10	Cotton meal	12
Fish meal	4	Fish meal	0
Meat scraps, bone, blood	4	Meat scaprs, bone, blood	8,0
Corn	30	Corn	30,3
Wheat bran	15	Wheat bran	15

Fat	1,5	Fat	1,5
Vitamino-mineral complex	Include	Vitamino-mineral complex	Included

In addition, intensive fish farming involves providing fish feed adapted to the size of their mouth which constantly increases from the fry to fingerling and market size. It is therefore technically produce meals and pellets of dimensions adapted to different farmed stages (Figure 7).

Figure 7: Different sizes of powder and pellets to feed the fish at different stages of farming

Given the extraordinary biodiversity of fish in Africa, there is obviously still a lot of research opportunities not only for the domestication of new species for freshwater fish (Schilbeidae, Parachannidae, Mochocidae, Distichodontidae, etc.) as marine water (Haemulidae, Carangidae, Polynemidae, etc.) as well as crustaceans (Palaemonidae) and molluscs. But the question is: why domesticate new species if it is to let them grow on other continents. Clearly there is an urgent need to start with high production in Africa and in the Congo Basin with these two flags species: tilapia and catfish.
Finally, among the concrete immediate prospects the Ministry of Agriculture (MINAGRI) of DR Congo will be able to count on the support of the Belgian Technical Cooperation (BTC) for a new project to boost fish farming in addition to agriculture Bandundu program (2013-2017), districts Kwilu and Kwango as well as that of APEFE (2014-2016) to support extensive fish farming (family) and testing semi-intensive fish farming (tilapia/catfish) in the district of Lower River, Province of Bas-Congo.

2. Others countries in the Congo watershed

See now, very briefly, the state of fish culture in the other 9 countries of this vast basin Congo.

2.1. Angola

The development of aquaculture in Angola (FAO, 2013 FAO, 2.013a) is a strategy adopted by the Government to fight against poverty. The National Institute for Fisheries Research and the Institute of Artisanal Fisheries evaluate potential since 2004 but remains undeveloped and focused on small rural freshwater aquaculture with native species in some provinces although some private commercial enterprises emerge (Kifangondo and Kwanza River) with the support of Brazil. It is possible, with the support of Brazil to the Angolan Directorate of Aquaculture, that this activity will develop shortly.

2.2. Burundi

Introduced in 1950, extensive fish farming based on the distribution of fry (FAO, 2013; FAO, 2.013b) from 2 state stations (Karusi and Isaiah) had an erratic development through different successive projects (Colonial Administration, Belgian AIDR, UNDP, USAID, ADB). Production would have been at its peak, 120 t/year of tilapia (*Oreochromis niloticus*), provided by 2,000 farmers (FAO, 2013b) operating 2,500 ponds of small areas (total 60 ha). Currently, the activity is almost not practiced and production is insignificant although the potential remains high for an integrated agro-pisciculture (rice-fish farming, with livestock: poultry-fish, pigs -fish, rabbits-fish).

2.3. Cameroon

Also introduced after the Second World War by the colonial administration, the fish has been some development up to its peak, more than 40,000 farmers (FAO, 2013; FAO, 2.013c) producing about 5,000 t/year of tilapia (*Oreochroms niloticus*), catfish (*Clarias gariepinus*), carp (*Cyprinus carpio*) and *Heterotis niloticus*. Currently, activity remains very marginal and has difficulies to find a true development. However, the recent strategic framework for sustainable aquaculture development clarifying the respective roles of government, private sector and producers plans to enhance the potential of freshwater aquaculture as brackish water (shrimp at Kribi) and marine, via the development of god production systems, access to inputs, training, research, extension, etc..

2.4. Republic of Congo (Brazza)

Fish farming in Congo (FAO, 2013d) also started in the 1950s with the Centre Technique Forestier Tropical (CTFT) creating 8,400 ponds producing 1-2 t/ha/year of tilapia. From 1968 to 1991, regional projects UNDP/FAO and World Bank (WB) supported the research , training and extension of the fish tilapia (*Oreochromis niloticus*) and catfish (*Clarias gariepinus*) intensifying production to nearly 4 t/ha/year and annually producing 250 t/year. However, lack of monitoring and political unrest (1994.1997 and 1998), the fish culture has completely collapsed and only a few private entrepreneurs on the outskirts of Brazzaville which formed the “Groupe Agro-Piscicole de Brazzaville” (GAPB), supported by the Centre for the Development of Enterprise (CDE) of the European Union (EU), are involved in this trade action. Yet the natural conditions are very favorable for aquaculture in Congo which could be redeveloped quickl, saw the strategic efforts of the current government (the new Code of Fisheries and Aquaculture, National Development Strategy and Action Plan for aquaculture).

2.5. Gabon

Fish farming rural type (units of 2 to 3 ponds of 2 to 5 ares) started under the leadership of the “Centre Technical Forestier Tropical” (CTFT) around 1950 (FAO, 2013e) with tilapia (*Oreochromis niloticus*) in classes of mixed age, sometimes associated with a small predator (*Hemichromis fasciatus*) with an output of 1 to 2 t/ha/year. A company SODEPAL has even developed in the southern region the production of monosex male tilapia (chemical sexing with methyltestosterone) and has an annual production of about one hundred tons. In 2.006, domestic production would have reached 126 t in state stations, whose ancestral Oyem station and 89 private farms, all with a total of 456 ponds. New recent efforts are being made to provide intensive fry production in semi-closed circuit with *Clarias gariepinus* in the Libreville station but the commercial chain does not seem to have been taken into consideration. Nevertheless, the demand

for fish is far exceeding supply and natural conditions are very favorables. On the other hand, as institutional measures and arrangements are very consistent, fish culture should develop into the country though it is still at an administrative level.

2.6. Central African Republic

As in other former French colonies, CTFT promoted, around 1950, rural fish, accompanied by a recovery in the post-independence through regional projects UNDP/FAO and World Bank (WB) from 1968 to 1991, to support research, training and extension aquaculture of tilapia (*Oreochromis niloticus*) and catfish (*Clarias gariepinus*). This has promoted 8,500 small private producers (FAO, 2.013f) intensifying production to nearly 4 t/ha/year and annually producing 360 t/year. Since then, political turmoil reaching their maximum in November 2013 destroyed this activity like any other. Nevertheless, the natural conditions in the south of the country and the interests of farmers are very supportive of this activity inevitably resume magnitude when conditions return to normal life.

2.7. Rwanda

Fish farming has been introduced, as in Congo DRC, by the Belgian colonial administration after the Second World War by creating two large southern state stations Kigembe and Rwasave (SARNISSA, 2013) sourcing tilapia fingerlings hundreds private rural ponds. As elsewhere, also, fish declined after the independence of the country in 1962. Since then several projects (EDF, CRSP, KUL, University of Namur) attempted to revive activity within MINAGRI, University National of Rwanda (UNR) and NGOs like HELPAGE which even created a new fish farm in Ruhengeri to supply quality fry certified (tilapia and catfish) many rural farmers in the periphery. It seems that these efforts are beginning to pay and integrated rural fish farming, whose poultry cum fish culture and rabbit cum fish fish) knows some development.

2.8. Tanzania

In Tanzania, the fish was introduced by the British colonial administration around 1949 with the culture of rainbow trout (*Oncorhynchus mykiss*) and tilapia trials in Korogwe and Malya station (Balarin, 1985; FAO, 1990; FAO, 2.013g, ECA/FAO, 1985) accompanied by the promotion of rural ponds that have achieved in 1968, the number of 8,000 small ponds with tilapia but poor production. Currently, the number of farmers would be a little more than 14,000 private but still low production, the activity remaining marginal. Note that grows on the coast since 1989, the small seaweed species (*Eucheuma spinosum* and *Kappaphycus cottonii*). Finally, aquaculture has great potential but mainly on the sea coast (shrimp, seaweed, marine fish, etc.).

2.9. Zambia

Early 1950s , the first farmed tilapia trials have attracted interest for fish culture that exploded after the successful introduction of carp imported from Eastern Europe (FAO, 2013h, ECA/FAO, 1985, Mwango et alii, 1999). Several farmers from various regions are then invested in this practice which however gone down after independence. But various agencies such as the United Nations Development Program (UNDP), the UN High Commissioner for Refugees (UNHCR), the United States Agency for International Development (USAID), the International Agency cooperation of Japan (JICA), the Norwegian Agency for Development (NORAD) and the United Nations Food and Agriculture Organization (FAO) have tried to promote fish farming (Soma et al., 1999). Thus in recent years, Zambia has revived a commercial fish culture based on compound

feed (floating pellets) for the production of tilapia (*Oreochromis niloticus*) carp (*Cyprinus carpio*), catfish (*Clarias gariepinus*) and introduced crayfish (*Procambarus clarkii*). These productions developed strongly in 2010 reaching 10,000 t/year. In addition, the fisheries legislation was revised by introducing aquaculture and a national aquaculture strategy oriented towards the private sector has been formulated and the Zambian government has set up an appropriate institutional framework. Currently , more than 6,000 small farmers and 15 large private farms produce tilapia, carp and catfish in over 13,000 ponds spread across 9 provinces. Also note that four commercial enterprises whose "Lake Harvest" produce fish in cages of 216 m^3 (6 x 6 m) in Lake Kariba, with a production of 3.5 t/cage. Zambia is well underway to exploit its great potential and is actually on the path of sustainable development of aquaculture.

3. Conclusions and prospect

The 10 countries of the Congo watershed have in a recent past (post World War II) introduced and developed tilapia farming which has known a spectacular boom followed by a general disinterest. The finding is staggering: poor construction, poor management, lack of fertilization and/or feed, poor seed production degenerate, all resulting from a technical support missing or ineffective. The causes of this situation are disastrous socio-political context for the less volatile or hostile and dangerous, the lack of precise definition and objectives for multiple bilateral or multilateral projects and NGO, the absence of regulations for the sub-sector of aquaculture and ultimately no political stance, strategy and real action plan with substantial resources.

Currently, fish in the Congo Basin still stammers. In Angola, Burundi, Central African Republic and Tanzania, it is almost nonexistent. In Cameroon, Congo, Gabon, Rwanda, DR Congo, the fish culture does not go down but activities and productions are very limited although supported by various state projects and bilateral or multilateral cooperation. One country, Zambia, seriously develops this sector whose production becomes significant, creating jobs and interesting incomes, due to the resolution of two classic problems: fingerling production of good strain and certified quality and output extruded floating pellet.

Given the increasing demand for fish as a result of the growth of human populations, food adaptations for better health and overexploitation of wild stocks , the countries of the Congo Basin will have, like other African countries (Egypt, Nigeria, Ghana, Zimbabwe, Zambia, etc.), to develop fish farming such as *Oreochromis niloticus* and *Clarias gariepinus* , two African endemic species among the best ones in the world for fish culture which were introduced on all continents where they are subject to much larger farming than in Africa. The context is now much more favorable since most countries have adapted and modernized their law on Fisheries by adding a part on Aquaculture, developed a National Policy on Fisheries and Aquaculture approved by their parliaments, established a strategy and a concrete action plan for the development of responsible and sustainable aquaculture. However, special attention should be given to the acquisition and management of good strains of fish adapted to different climatic conditions in the watershed of the Congo and to production of fry monosex male of certified quality. In this regard, the sex reversal methyltestosterone still widely practiced currently is increasingly challenged, seen residues of the substance found in very low concentrations in fish consumed. The future may go to the super YY male/pseudofemale technique to produce fry *O. niloticus* all males, providing market fish without hormone residues.

To grow the fry, it remains to solve sustainable pond fertilization and artificial feeding. For fertilization, we refer to the multiple possibilities of agro-fish culture (rice-fish, vegetables-fish , etc.)

and livestock (pigs, poultry, rabbits, etc.) cum fish culture which are already more or less practice here and there : DR Congo, R Congo, Rwanda , etc. But for fish culture in intensive system, it is absolutely necessary to get balanced feed as floating extruded pellets. The programmed stimulus package for agriculture in Congo should lead to a huge production of by-products to enhance through appropriate feed mixtures which could benefit to intensive fish production systems. We must therefore develop a research to produce quality foods that meet the identified needs of tilapia and catfish checking their performance on fish growth and economic profitability.
Obviously, responsible and sustainable aquaculture will have to develop in all countries of the Congo Basin from two African endemic species (*O. niloticus* and *C. gariepinus*) because there is no alternatives to supply African populations in fresh fish (animal protein and polyunsaturated fatty acids of high quality) at a low ecological and energetic cost and at an acceptable price for human populations with a limited purchasing power.

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