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Chapter 7

Aquaculture for Diversification of Small Farms within Forest Buffer Zone Management: an Example from the Uplands of Quirino Province, Philippines

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Abstract

Upland farming systems can have severe negative effects through intensified slash-and-burn activities, erosion-enhancing farm practices on moderate to steep slopes, and further encroachment into forest areas. ICLARM studied, in a 2-year applied research activity, opportunities for the improvement of existing pond management practices in an upland forest buffer zone environment, mainly through integration with other farm enterprises and through the introduction of polyculture. This chapter presents the results of aquaculture integration and production which are discussed in relation to farmer perceptions, other enterprises on the farm, opportunities for nutrient recycling, and in the broader context of sustainable natural resource management.

Introduction

Upland farming systems can have severe negative effects through intensified slash-and-burn activities, erosion-enhancing farm practices on moderate to steep slopes and further encroachment into forest areas. It is important that the farming systems subsequently introduced into these forest buffer zone areas are a sustainable combination of traditional and newly adopted enterprises which suit the nutritional, economic and socio-cultural needs of the farm households. They should further ensure the conservation and simultaneous wise utilisation of the adjacent forest areas. Recent experiences indicate that communities which have been granted long-term stewardship rights over clearly defined areas can sustainably manage these systems through co-management arrangements.

ICLARM conducted a study, from 1996 to 1998, in two communities within a forest buffer zone management scheme in the upland areas of Quirino province, Philippines, which was supported by an ongoing bilateral development assistance programme (DENR-Philippines and BMZ/GTZ-Germany: 'Community Forestry Project Quirino, CFPQ'). A People's Organisation (PO) of approximately 60 farm households in each community implements an agreed-upon management strategy of forested and farmed areas as part of project arrangements. The farmers are migrants displaced from their original homesteads due to the construction of a dam in a neighbouring province. They entered the area 15 to 25 years ago and have established farming enterprises for subsistence (upland rice, irrigated paddy rice terraces, vegetables and livestock) and for cash generation (bananas and ginger). Supported by the CFPQ, the communities through their POs have recently introduced activities geared towards more sustainable resource management and diversification of farm enterprises such as agroforestry plots, forest replanting, citrus varieties, lemon grass, rice-fish and pond aquaculture.

The CFPQ promoted the establishment of small farm reservoirs above terraced ricefields in 1993 which were widely adopted (Fig. 7.1). These reservoirs range in size from 50 to 1,200m^2 and provide opportunities for aquaculture. Subsequently, initial attempts at tilapia culture were made and some households established a reliance on this source of fish for their home consumption, with 'give-aways' to neighbours. Few nutrients were added to ponds, and only in the form of direct feed to the fish such as rice bran, rice hulls, taro leaves and ripe bananas.

Fig. 7.1. Reservoir ponds constructed at the top of a cascade of rice terraces provide an opportunity for aquaculture. Don Mariano Perez community, Quirino province.

Within this context, ICLARM studied opportunities for the improvement of existing pond management practices, mainly through integration with other farm enterprises and through the introduction of polyculture. This chapter presents some of the results in respect to aquaculture integration and production. Further details and results on socio-economics and farm sustainability are presented in Prein *et al.* (1999) and Prein *et al.* (in preparation).

Methods and Activities

Activities were conducted in two communities (*barangays*) in Diffun municipality, Quirino province: Don Mariano Perez (DMP), a community in a remote location between 600 and 1000m elevation without access to roads or electricity; and Baguio Village (BV), an adjacent community at lower elevation, the main settlement (*sitio*) of which is serviced by a road and has electricity.

Farmers normally did not use inorganic fertilisers for their crops (mainly rice), as these were difficult to transport. Only in the third year during the El Niño event did some farmers use small amounts for their rice crops. Most farmers grew azolla in their ricefields.

In the course of the ICLARM activity, farms were visited and their operations and pond management were studied. Furthermore, support was provided to the farmers and to the CFPQ through provision of technical advice in the form of training workshops, regular monthly farm site visits, the facilitation of fingerling supply and further formalised training through government services and facilities, e.g. the Bureau of Fisheries and Aquatic Resources (BFAR) (Fig. 7.2).

Fig. 7.2. Farmers planning for new recycling opportunities, including pond fish culture. Don Mariano Perez community, Quirino province.

All the *barangay* residents were invited to workshops on integrated aquaculture-agriculture conducted in different *sitios*. Those farmers who indicated an interest in aquaculture agreed to have closer interaction in the coming months of the Project and allowed their farm production to be monitored, became farmer-cooperators of the CFPQ-ICLARM collaborative Project. In DMP and BV, 50 and 17% of households had ponds, which was the result of an earlier national campaign in 1989-1993 promoting the establishment of on-farm reservoirs which could also serve for fish rearing. Only one third of all these households in each *barangay* which already had ponds also used them for fish culture. All these registered as cooperators which amounted to the total number of farmer-cooperators per *barangay*. The other two thirds of those with ponds *i.e.* small farm reservoirs but which did not practice fish culture, did not become cooperators.

Results and Discussion

Assessment and Intervention

The average area devoted to fish ponds by farm households in DMP and BV is 300m^2. Generally, the fishpond area accounts for the smallest portion (< 1%) of the land use within a farm. Reasons given by farmers as to why they do not devote more area to fish ponds are: (i) having mainly steep-sloped land; (ii) not having a long hose to tap spring water to divert it into ponds; and (iii) a lack of technical expertise on more productive aquaculture methods.

Only one farmer-cooperator in DMP reported a pond water retention of 8 months while the rest claimed that their ponds do not dry up even in April, the driest and hottest month in the area. However, farmers noted that compared to recent years before the Project, the volume of water from natural springs is now diminished. Water was still abundant in the 1980s but in two recent years (1997 and 1998), the local community noted that there was less rain. Moreover, rainfall did not come regularly in the expected months as it did previously when there was high rainfall in May; lately, rains have started 2 months later. Additionally, the 1997/98 season was an 'El Niño' event with widespread drought which also affected the project sites and caused ponds to dry up early, leading to low production or even total loss of the fish crop.

In the initial site surveys of pond operations in 1996, it was found that farmers in the area maintained constant water levels in their ponds by having a continuous inflow and flow-through of water. This was necessary as the manner of dike construction is according to that of their rice terraces which consist of thin high dikes without a clay core and much compaction, and therefore have high leakage and seepage rates (which is not a problem in the cascading arrangement of rice terraces). This resulted in low water temperatures and clear water in the pond, usually void of phytoplankton. It was also found that few operators added any form of fertilisers to their ponds. The project encouraged the regulation of water inflow towards more stagnant water to elevate temperature and facilitate the establishment of standing phytoplankton stocks *i.e.* green colour of pond water. Additionally, the input of on-farm biomaterials as fertilisers was encouraged, as other inputs were not available in these remote locations.

Fish Culture Management Following Project Intervention

The CFPQ-ICLARM collaboration provided technical advice in fish culture, i.e. appropriate fish species and stocking densities, feeding regimes, pond water management and culture systems. Farmer-researcher discussions used a broader perspective beyond only fish culture towards a view of the entire farming system (Lightfoot *et al.*, 1993a, b). Moreover, the orientation widened further from that of benefits derived from fish culture such as food and income contribution to family welfare, to issues of ecological benefits resulting from good natural resource management. Additionally, whole farm management, production and socio-economics were monitored utilising an ICLARM-developed tool (Lightfoot *et al.,* 1996), the results of which are presented in Prein *et al.* (1999).

Fish stocks

Farmers' usual practice was to have fish stocks in their ponds of mixed ages and sexes with continuous reproduction and partial harvesting of small amounts. Throughout the Project, farmers were given assistance in obtaining new fingerlings, i.e. adequate hatcheries were identified and contacted (notably in the area of Tanay on the northern side of lake Laguna de Bay), species were ordered and plastic bags with oxygen organised, and transport was provided for the 10-hour drive up to Quirino province. These costs were born by the Project, as well as the costs of the fingerlings in the first year. In the second and third years, transport costs *etc.* were still covered by the Project, but the farmers had to pay for the fingerlings themselves. Since 1996, around 25,000 fingerlings were distributed to around 50 farmers in the two *barangays*. Farmers were also introduced to fish nurseries in Quirino province.

Fish species

Tilapias were almost the only cultured fish species in two project sites, Nile tilapia (*Oreochromis niloticus*) were obtained in 1992 from Central Luzon State University (CLSU) in Muñoz, some of which were GMT strain (Graham Mair, personal communication); others were obtained from hatcheries and farms near Santiago and Cauayan and were blue tilapia (*O. aureus*). The farmers called the latter 'native' tilapia and liked their 'sweet' taste and cold tolerance. Some farmers kept 'native carp' in their rice fields. These were identified as *Carassius carassius*, a slender goldfish of silver-white colour which attained 8 to 12cm total length in the ponds and were also consumed by farm households. The project introduced common carp (*Cyprinus carpio*), grass carp (*Ctenopharyngodon idella*) and silver carp (*Hypophthalmichthys molitrix*). Some farmer-cooperators requested catfish (*Clarias gariepinus*) fingerlings.

Farmers were delighted with the newly-introduced species as these displayed rapid growth.

Fish stocking density

Farmers were advised to stock 2 fish m^{-2}. Initially, fish stocking densities followed by the farmers depended on the availability of fish fingerlings. However, with continuous, i.e. year-round fish rearing (without total harvest and complete draining of the pond), farmers were advised that fish densities should be maintained at the recommended level to avoid fish overcrowding and competition for pond nutrients so that potential fish growth could be attained.

Fish species composition

The project also suggested that farmers move from tilapia monoculture to polyculture in which separate natural food niches are exploited by different species, thereby producing more fish from a given pond with the inputs it is receiving. Fish species composition is a concern in polyculture systems and in the first year (1996/97) farmers were advised to use a 60 : 30 : 10 species composition in ponds stocked with tilapia, common carp and catfish (since there was considerable request for the latter), and 60 : 40 species composition for a tilapia and common carp combination. In the second year (1997/98) it was suggested that grass carp and silver carp should be added to the polyculture (Table 7.1).

Fish growth across species

Initial fish sampling showed that tilapia grew slowly at the Project sites (Table 7.1) as the low temperature (ranging from 18 to 32°C, averaging in the low 20s) in the upland area was not conducive for higher tilapia productivity.

The carp showed greater growth potential among stocked species at both Project sites. In the 1 year culture period, carp stocked at an initial weight of approximately 5g obtained an average weight that ranged from 129 to 300g, while the tilapias' average weight ranged from 44 to 95g. Farmers claimed to observe common carp feeding on clams, snails and tadpoles so that they concluded that the population of these aquatic species decreased after stocking this species. Although farmers raised fears of losing some aquatic life with continuous culture of common carp, it is likely that this predation was caused by catfish and not common carp. Farmers observed their own ponds and the aquatic life in them also in comparison to other farmers' ponds. Farmers had a strong feeling for the value of naturally occurring species, also, as these are not perceived to harm the fish and affect production.

Farmers observed that pond water in ponds stocked with common carp became turbid, i.e. milky brown in colour, and expressed fear that the dikes could easily be damaged or collapse as a result of the continuous burrowing activities of the fish. Suspended soil and other particles in turbid pond water inhibited phytoplankton development.

Table 7.1. Average fish size at sampling in farmer-cooperators' ponds, *barangays* Don Mariano Perez and Baguio Village, Diffun Municipality, Quirino Province. 1995/96 to 1997/98.

Species	Culture period (months)	Weight (g)			Length (cm)		
		Min.	Max.	Mean	Min.	Max.	Mean
Don Mariano Perez							
Polyculture Type I							
Tilapia	12	19.6	91.7	44.3	9.3	17.1	13.0
	24	32.9	107.6	66.3	11.3	17.7	14.6
Common carp	12	52.6	348.4	128.6	13.9	26.3	19.6
	24	110.0	517.3	229.8	19.1	32.7	24.3
Catfish	12	133.7	603.8	260.1	25.0	43.3	31.2
	24	500.0	827.0	625.7	31.0	46.5	39.5
Polyculture Type II							
Grass carp	12	167.5	479.1	300.0	21.3	34.2	26.3
Common carp	12	87.5	307.3	167.2	17.3	26.3	21.9
Silver carp	12	144.0	269.3	210.4	22.0	30.9	27.8
Baguio Village							
Polyculture Type I							
Tilapia	12	25.4	212.0	94.8	11.0	21.4	16.4
	24	36.0	136.0	77.9	12.1	20.0	16.3
Common carp	12	62.1	394.4	139.6	15.2	28.1	19.5
	24	104.0	316.0	184.2	19.0	27.8	22.3

Note: Polyculture Type I = tilapia, common carp and catfish stocked in October 1996 in DMP; Polyculture Type II = grass, common and silver carp stocked in September 1997 in DMP; Polyculture Type III = tilapia and common carp stocked in October 1996 in BV.

Another constraint for culturing carp in the area is that the fingerling supply from hatcheries is not always assured. Moreover, farmers may find it very difficult to breed grass carp and silver carp themselves so that appropriate small-scale hatchery technology would have to be introduced once demand increases and stabilises among farmers in the area.

Catfish also displayed good growth. However, the project did not encourage culture of this species because of potential negative effects on biodiversity in natural streams and water bodies. After the first stocking resulted in low recovery rates but very high growth rates, farmers decided not to stock catfish again.

Fish production across species

In 1995/96, tilapia was dominant among stocked fish in farmer-cooperators' ponds in Don Mariano Perez (Fig. 7.3). Tilapia production was estimated at 644kg ha^{-1} (Table 7.2). In the following years, farmers were able to stock some carp and catfish. Common carp gave the highest estimated production at 784kg ha^{-1} in 1996/97. The relatively higher fish production estimates in BV than DMP in 1996/97 were due to the application of commercial feeds by the farmer-cooperators in BV during that year. The drop in fish production for all species at the two project sites in 1997/98 from the 1996/97 culture year was caused by the water shortage due to the 'El Niño' event. While the fish ponds of nine farmer-cooperators completely dried up by April 1998, about half of the farmer-cooperators scaled down their fishpond operations because of limited water supply. Others were able to sustain their fishpond activities by accessing water from other sources, i.e. farmers who had hoses transferred them from other areas.

Table 7.2. Estimated annual fish production in farmer-cooperators' ponds, *barangays* Don Mariano Perez and Baguio Village, Diffun Municipality, Quirino Province. 1995/96 to 1997/98. Note: Figures in parentheses are the number of ponds sampled. Dash (-) signifies no stocking.

	Pond system (number of households)		Pond size (m²)		Production (kg ha⁻¹)					
Barangay	Individual pond	Pond in rice terraces	Average	Range	Tilapia	Common carp	Grass carp	Silver carp	Cat-fish	Total
Don Mariano Perez										
1995/96	5	8	310	47-942	644 (13)	-	-	-	-	644 (13)
1996/97	12	8	228	47-942	296 (20)	784 (11)	-	-	259 (7)	818 (20)
1997/98	12	8	225	37-942	124 (20)	220 (5)	349 (4)	73 (2)	106 (2)	267 (20)
Baguio Village										
1995/96	4	0	238	150-400	440 (4)	-	-	-	-	440 (4)
1996/97	4	0	238	150-400	733 (4)	1200 (4)	-	-	-	1933 (4)
1997/98	3	0	275	150-400	56 (2)	267 (2)	-	-	-	323 (2)

Pond fertilisation and nutrient cycling

Farmers cultured fish for home consumption (Fig. 7.4) and previously only used conventional on-farm resources, e.g. rice bran. The project encouraged the use of other on-farm resources as inputs from other farm activities besides rice cultivation such as spoiled fruit, fruit peelings, leaves, animal manure and kitchen leftovers.

In the pre-project year, i.e. 1995/96, less than half (47%) of the farmer-cooperators recycled bioresource materials into their fish ponds. The initial integrated aquaculture-agriculture workshops conducted with the farmers in mid-1996 convinced them of the merits of recycling although some farmers were already re-using some of their farm by-products, e.g. as livestock fodder. Thus, in 1996/97 all farmer-cooperators increased their recycling. However, seven (23%) farmer-cooperators discontinued their fishpond operations in 1997/98 due to the drought. The total number of bioresource flows combined across all farms reported by the farmer-cooperators at the two Project sites registered an increase from 44 to 136 and to 142 for 1995/96, 1996/97 and 1997/98, respectively (Table 7.3). This was a large increase of 209% in 1996/97 and a modest increase of 4% in 1997/98. Moreover, in this 3 year period, the number of different types of on-farm materials recycled in the farm increased from 8 to 12 and to 18, starting in 1995/96. The most common of these on-farm materials were vegetables (mostly giant taro), cereal by-products (mostly rice bran) and fruits (mostly banana) which represented around 30, 29 and 16%, respectively, of the total bioresource inflows.

In terms of inputs to the fish ponds, the total number of bioresource flows increased from 11 (1995/96), to 53 (1996/97) and to 65 (1997/98) (Table 7.4).

The significant increases in the second and third years indicated farmers' adoption of the integrated aquaculture-agriculture practice and the internalisation of its principles. The majority of the inflows to the fish ponds came from their irrigated rice and upland/fallow natural resource types (NRTs) representing around 48 and 34% of the total number of bioresource inflows, respectively (Table 7.4). The bioresource inflows from the upland/fallow NRT comprised seven material types with bananas accounting for the largest proportion (50%) among the counts of material types within this natural resource type (Table 7.4). On the other hand, there were only three material types used as bioresource inflows to the fish pond emanating from the irrigated rice NRT with rice bran accounting for the largest proportion (90%) among the counts of material types within this NRT.

Fig. 7.3. Harvesting tilapia, common carp and catfish from a pond at 800m elevation. Don Mariano Perez community, Quirino province.

Table 7.3. Bioresource flow types and counts per year on monitored farmer-cooperator farms, *barangays* Don Mariano Perez (DMP) and Baguio Village (BV), Diffun Municipality, Quirino Province 1995/96 to 1997/98. In parenthesis is the total number of IAA-households/respondents in the *barangay*.

	1995/96			1996/97			1997/98		
Species category/ bioresource flow type	DMP (24)	BV (6)	All (30)	DMP (24)	BV (6)	All (30)	DMP (24)	BV (6)	All (30)
Cereals	22	5	27	36	4	40	54	10	64
Corn bran	1	0	1	0	0	0	1	0	1
Corn grain	6	2	8	0	0	0	10	2	12
Rice bran	12	3	15	36	4	40	34	6	40
Rice grain	3	0	3	0	0	0	8	2	10
Rice straw	0	0	0	0	0	0	1	0	1
Fruits	5	0	5	27	7	34	30	3	33
Avocado	0	0	0	0	0	0	4	0	4
Banana	5	0	5	27	7	34	23	1	24
Papaya	0	0	0	0	0	0	3	2	5
Trees	0	0	0	1	0	1	1	0	1
Leucaena	0	0	0	1	0	1	1	0	1
Vegetables	8	3	11	30	6	36	23	6	29
Chayote	0	0	0	1	0	1	1	0	1
Giant taro	7	3	10	25	6	31	19	6	25
String beans	1	0	1	0	0	0	0	0	0
Squash	0	0	0	1	0	1	0	0	0
Sweet potato	0	0	0	1	0	1	2	0	2
Water spinach	0	0	0	2	0	2	1	0	1
Weeds[1]	0	0	0	12	0	12	3	0	3
Animals	1	0	1	7	2	9	8	0	8
Chicken meat	0	0	0	0	0	0	3	0	3
Manure[2]	0	0	0	2	0	2	2	0	2
Termites	1	0	1	5	2	7	3	0	3
Aquatic plants	0	0	0	4	0	4	4	0	4
Azolla	0	0	0	4	0	4	4	0	4
Total flows	36	8	44	117	19	136	123	19	142
Average flows	1.5	1.3	1.5	4.9	3.2	4.5	5.1	3.2	4.7
Material type total (number)									
Cereals	4	2	4	1	1	1	5	3	5
Fruits	1	0	1	1	1	1	3	2	3
Trees	0	0	0	1	0	1	1	0	1
Vegetables	2	1	2	5	1	5	4	1	4
Weeds	0	0	0	1	0	1	1	0	1
Animals	1	0	1	2	1	2	3	0	3
Aquatic plants	0	0	0	1	0	1	1	0	1
Total	8	3	8	12	4	12	18	6	18

[1] Includes tiger grass, itch grass, etc.
[2] Includes chicken, pig and water buffalo (*carabao*).

Non-conventional bioresource materials that were used as inputs to the fishpond included weeds, animal manure and azolla (Table 7.4). Except for animal manure, all on-farm materials thrown into the fishpond are directly utilised by the fish as food. While fish also feed on animal manure, animal manure normally serves for pond fertilisation. However, the practice of using animal manure as a fishpond input is not yet accepted by the majority of farmers in the area because of their apprehension that the quality of the fish may be affected when the fish feed on animal manure. Farmers fear that fish cultured in manured ponds are not safe to eat, especially when they prepare a local special fish dish (*pinapaitan*) for which smaller fish (about 2-5cm) are harvested, washed and cooked ungutted.

Fig. 7.4. A meal of tilapia of various sizes prepared for a group of work-sharing farmers. Don Mariano Perez community, Quirino province.

Conclusions

After the 3-year activity, it can be concluded that farmers have internalised the benefits of bioresource recycling. The total recycling counts of the 30 farmer-cooperators increased from 44 to 142 over the 3-year period. Before the Project, less than half of the farmers-cooperators were practising recycling. Moreover, in the last year farmers utilised as many as 18 types of on-farm materials for recycling compared to only eight types before the project.

The ecological benefit of recycling was also accompanied by cash savings for the purchase of commercial fertilisers particularly in BV. In fish culture, farmers utilised on-farm materials such as rice bran/straw/hull, spoiled fruits/vegetables, chopped leaves instead of formulated fish feeds, and animal manure for pond fertilisation. As farmers used on-farm material inputs in fish culture, the proportion of cash cost to total costs decreased from 81 to 18% (Prein *et al.*, 1999).

Table 7.4. Bioresource inflows to fishponds by natural resource type (NRT) source and species/enterprise category, combined for all 30 farmer-cooperators from both *barangays* Don Mariano Perez and Baguio Village, Diffun Municipality, Quirino Province, 1995/96 to 1997/98.

NRT origin of flow	Species category/Bio-resource flow type	Flows (number) 1995/96	1996/97	1997/98
Forest reserve	Total	1	2	2
	Animals			
	Termites	1	2	2
Upland/fallow	Total	2	26	22
	Animals			
	Termites	0	5	1
	Cereals			
	Corn bran	1	0	1
	Rice bran	0	1	0
	Fruits			
	Avocado	0	0	2
	Banana	1	14	10
	Papaya	0	0	1
	Vegetables			
	Giant taro (leaves/tubers)	0	6	4
	Weeds	0	0	3
Orchard	Total	0	1	4
	Fruits			
	Avocado	0	0	2
	Papaya	0	0	1
	Trees			
	Leucaena	0	1	0
	Vegetables			
	Sweet potato	0	0	1
Homestead	Total	1	2	4
	Animals			
	Chicken meat	0	0	3
	Manure (various)	0	2	1
	Vegetables			
	String beans	1	0	0
Irrigated rice	Total	7	21	27
	Aquatic plants			
	Azolla	0	4	0
	Cereals			
	Corn grain	0	0	1
	Rice bran	7	16	25
	Rice straw	0	0	1
	Vegetables			
	Water spinach	0	1	0
Fishpond	Total	0	1	6
	Aquatic plants			
	Azolla	0	0	4
	Trees			
	Leucaena	0	0	1
	Vegetables			
	Water spinach	0	1	1
Total		11	53	65

Thus, the upland communities in DMP and BV experienced and benefited from some economic, social and ecological services of the practice of integrated aquaculture-agriculture farming systems. Fish culture, although currently a relatively small component of their upland farming systems, generated great interest among the local communities. If farmers put in more resources and time into fish culture, with continued external technical advisory support, integrating fish culture in their existing farming systems may significantly increase the nutritional quality of food and cash income of the farm households. Moreover, on a broader perspective of integrated resources management for sustainable agriculture, there may be an increased appreciation of the communities' role as resource stewards of their forestry resources due to sustainable livelihoods.

The CFPQ-ICLARM project has established farmer desire for improved management of fish culture and has demonstrated its benefits for the farm family and local communities. A modestly and appropriately designed and managed hatchery within one of the *barangays* will ease the difficulty of securing fingerlings of desired species and required numbers from external sources, and reduce the high fingerling mortality rate due to stress during transport. This will enable the community to be almost self-reliant in their fingerling supply. According to previous experience, one or several farmers usually specialise in seed production after mastering pond culture practices. This further transition should be encouraged and supported.

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