Mutual Partnership between Fish Hatchery Operators and Growers for Sustainable Aquaculture Development: A Case in Cambodia

Chin Leakhena

This article is based on the author's research study on the Assessment of Local Seed Production in Takeo and Kampong Speu Provinces of Cambodia, in partial fulfillment of the requirements for her to obtain the Master's of Science degree in Aquaculture and Aquatic Resources Management from the Asian Institute of Technology, Thailand. Conducted from 2012 to 2013, the study was focused on Takeo and Kampong Speu Provinces being the country's center for freshwater fish seed production and grow-out activities, and where the relationship between fish hatchery operators and growers is being assessed to determine its effect on the sustainable development of freshwater aquaculture in Cambodia.

Freshwater aquaculture is an important component of the fisheries sector of Cambodia not only because of its abundant freshwater resources for potential aquaculture development but also considering that freshwater aquaculture could provide the means of increasing peoples' incomes and creating livelihoods in rural communities. During the early part of the country's freshwater aquaculture development, fish growers were confronted with insufficient supply of seed stocks resulting in their complete reliance on seeds from the wild which later became unsustainable or on imported fish seeds that usually commanded exorbitant prices. Later on, the Royal Government of Cambodia promoted the production of locally-produced fish seeds by providing technical support to local freshwater fish hatchery operators. Meanwhile, fish growers were also encouraged to patronize locally-produced fish seeds for their fishpond requirements.

Freshwater aquaculture of Cambodia has exhibited potentials to increase the country's total fisheries production and supply the necessary nutritional requirements of its people as well as increase the country's fisheries export volume. In 2011 for example, the country's total fisheries production was recorded at 631,695 metric tons (MT) of which freshwater aquaculture accounted for about 11% (**Table 1** and **Fig. 1**). It is obvious that if properly managed and sustained, such rate of increase in production could be improved much better than the average annual rate during the past five-year period from 2007 to 2011. Since fish seed producers are instrumental in providing the necessary seed inputs for fish growers, it has become crucial to enhance the mutual relationship between these two major stakeholders in order that positive impacts could be gained from such partnership for the sustainable development of freshwater aquaculture in Cambodia, and eventually, increasing the contribution of freshwater aquaculture to the overall goal of providing adequate food fish and incomes for the country's rural communities.

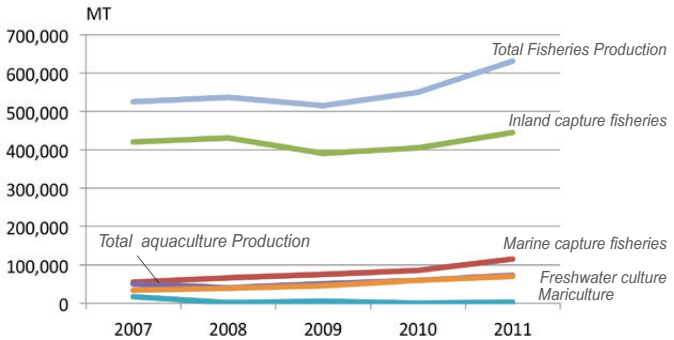

Fig. 1. Fisheries production trend of Cambodia
Note: Production from freshwater culture is almost equal to total aquaculture production

As shown in **Fig. 1**, Cambodia's production from freshwater aquaculture is almost equal to its production

Table 1. Total fisheries production of Cambodia, 2007-2011 (in metric tons (MT))

Categories	2007	2008	2009	2010	2011
Marine capture	54,900	66,000	75,000	85,000	114,695
Inland capture	420,000	430,600	390,000	405,000	445,000
Aquaculture					
Mariculture	16,630	1,370	4,925	--	2,620
Brackishwater	--	--	75	--	--
Freshwater	33,570	38,350	45,000	60,000	69,380
TOTAL	**525,100**	**536,320**	**515,000**	**550,000**	**631,695**

Sources: *Fishery Statistical Bulletin of Southeast Asia: 2007-2011 (SEAFDEC, 2010a, 2010b, 2011, 2012, 2013)*

from aquaculture in general. Thus, boosting the country's aquaculture production to secure incomes and livelihoods in rural areas is synonymous to improving its freshwater aquaculture. In an effort to address the major constraint on insufficiency of quality seeds, the Royal Government of Cambodia has deemed it necessary to develop the local freshwater fish hatcheries in order that future demands for seed stocks of the country's freshwater aquaculture industry could be fulfilled without unnecessarily relying on imported fish seeds or seeds collected from the wild.

Status of Freshwater Aquaculture in Cambodia

Fish cage and pen culture is a historical practice in Cambodia that spans over 1,000 years (Pe and Bun, 2005 cited in FiA, 2010a). Developed since the 10th century, fish fattening in bamboo cages and pens had been carried out especially during the closed fishing season (Nam and Thuok, 1999a). The country's aquaculture therefore started as a fish fattening system using wild caught fingerlings to increase the market price of fish. Recently, such system has evolved into a more advanced fish farming practice using fishponds. Although aquaculture provides a relatively small contribution to the total fisheries production of the country, *i.e.* at 11% in 2011 while capture fisheries accounted for 89%, the constantly increasing production from aquaculture, *i.e.* from 50,200 MT in 2007 to 72,000 MT in 2011, demonstrates the huge potentials for developing this sector into an industry that the country could depend on for improved nutrition of its populace and increased economies in the future. At present, the country's aquaculture development is highly diverse consisting of broad spectrum of systems, practices and operations, ranging from simple backyard-small household pond systems to large-scale, highly intensive, commercially-oriented practices (Nam and Thuok, 1999b; Nam and Buoy, 2005).

While the country's inland fisheries grew rapidly with total production ranging from 420,000 MT in 2007 to 445,000 MT in 2011 after the fisheries sector reform program of Cambodia was adopted in 2000, freshwater aquaculture production also exhibited speedy growth from 33,570 MT in 2007 to 69,380 MT in 2011 (**Table 1** and **Fig. 1**). Just like in most countries of Southeast Asia, aquaculture in Cambodia is also classified into mariculture, brackishwater culture and freshwater culture, where the latter is mostly practiced in cages/pens and ponds (Nam and Buoy, 2005). Freshwater aquaculture facilities are mostly maintained in the Mekong River Basin, *i.e.* in the upper stretch of the Mekong River (19%), lower stretch of Mekong River (14%), Bassac River (7%), Tonle Sap River (17%), and Tonle Sap Great Lake (42%). While the number of fish cages had been more or less stable at 4,492 units during the past 10 years until 2004, this dropped to 2,588 in 2005 due to the country's ban on snakehead fish culture but increased to 3,883 in 2012 (**Table 2**). Nam and Thuok (1999a) reported that 72% of the country's annual freshwater aquaculture production generally comes from cage/pen culture and only about 28% from pond culture.

Although Cambodia has no tradition of culturing fish in earthen ponds in rural areas due to difficulties in keeping water in ponds during the dry season, the number of ponds had rapidly increased from 3,455 in 1997 to 11,509 in 2004, an increase of 43% during an eight-year period (Nam and Buoy, 2005), and in 2012 the number had increased to 53,452 more than one third of which are found in Takeo Province (**Table 2**). This development was brought about by the priority given to aquaculture in the country's national development agenda to improve food security and living standards of its people, as well as balance the declining fish catch from the wild and highly increasing local demand for food fish. As a consequence, it has become necessary to increase the production of fish seeds from hatcheries to fulfill the requirements of the country's rapidly growing aquaculture industry (Viseth, pers. comm. 2012). Thus, in 2012 the number of fish hatcheries totaled 280, of which 266 are operated by private-farmers and 14 are public hatcheries, producing a total of about 130 million fingerlings in 2012 representing a 3.5 times increase over the past four years, *i.e.* from 37.2 million fingerlings in 2008 (FiA, 2012).

In the late 1980s, many NGOs and donor-funded development projects assisted the Royal Government of Cambodia in developing the country's rural freshwater small-scale aquaculture after recognizing the potential role of aquaculture in the country's socio-economic development. The activities then were mostly focused on transferring aquaculture technologies to fish farmers

Typical village fish hatchery in Takeo Province, Cambodia

Table 2. Number of aquaculture facilities in Cambodia (as of 2012)

Province	Culture Ponds	Culture Cages	Hatcheries			Community Refuge Ponds
			Total	Private	Public	
Phnom Penh	201	147	4	3	1	13
Kandal	554	733	12	11	1	25
Prey Veng	9,082	160	22	21	1	69
Takeo	19,146	12	37	36	1	58
Svay Rieng	9418	-	17	16	1	24
Kampong Speu	1,824	-	24	23	1	173
Kampong Cham	-	610	15	15	0	21
Kratie	550	90	10	9	1	10
Stung Treng	380	3	5	5	0	3
Kampong Thom	160	137	6	6	0	27
Kampong Chhnang	501	483	7	7	0	21
Pursat	1,660	755	9	8	1	16
Battambang	1,150	560	25	23	2	23
Banteay Meanchey	-	-	13	12	1	22
Oudarmean Chey	-	-	3	2	1	11
Siem Reap	500	-	11	10	1	92
Ratanakiri	419	-	13	13	0	11
Mondolkiri	389	-	6	6	0	3
Preah Vihear	400	8	7	7	0	14
Kampot	7,000	50	27	26	1	69
Preah Sihanouk	-	-	3	3	0	20
Koh Kong	118	135	4	4	0	13
TOTAL	**53,452**	**3,883**	**280**	**266**	**14**	**738**

Sources: *FiA (2012)*

through training and demonstration activities; establishing provincial stations for fish seed production and extension services; promoting private hatcheries development (*e.g.* small-scale village fish hatcheries); building the capacity of government fisheries officers and staff; and to certain extent, supporting on-farm and on-station research activities. As a result of the collaborative efforts between the Fisheries Administration (FiA) of the Ministry of Agriculture, Forestry and Fishery of Cambodia and the NGOs and donor organizations, small-scale freshwater aquaculture has been promoted throughout the country.

Such development was mainly aimed at generating alternative livelihoods, increasing household incomes and securing the protein source for the country's populace. The major fish species produced from Cambodia's freshwater aquaculture include tilapia (*Oreochromis niloticus*), silver barb (*Barbonymus gonionotus*), common carp (*Cyprinus carpio*), silver carp (*Hypophthalmichthys molitrix*), Indian carp (*Labeo rohita*), Mrigal (*Cirrhinus mrigala*), catfish (*Pangasianodon hypophthalmus*), walking catfish (*Clarias batrachus*), and other species.

A decade later, culture-based fisheries management or community-based management of communal fish refuge ponds was initiated in Cambodia in 1990s for the main purpose of enhancing the natural freshwater fish stocks for integrated rice-fish culture. This involved releasing of broodstock of indigenous fish species into community ponds categorized as public property. Managed by local communities, these ponds are protected mainly for fish spawning. From these community ponds, fish juveniles or fingerlings as well as broodstock are allowed to migrate to inundated rice fields through connecting canals. In 2012, the total number of community fish refuge ponds was 738, including 173 in Kampong Speu (**Table 2**). It has been reported that local households could catch about 349 kg/household/year of fish from this system when management was done by the local communities (Thuok, 2009).

Source of Seeds for Freshwater Aquaculture

The development of freshwater fish hatcheries was initiated in Cambodia during the last two decades when fish fingerlings from the wild had rapidly declined due to various factors such as overfishing, illegal fishing,

deforestation, and changes in the environment. With the increasing importance given to aquaculture and recognizing the role of hatcheries to ensure timely availability of seeds in all areas of the country, the Royal Government of Cambodia embarked on an intensified development of the country's freshwater fish hatcheries. As a result, the number of hatcheries increased to 280 in 2012 and consequently, fish seed production also increased from 7.5 million heads in 2000s to 130.0 million heads in 2012.

The country's first known fish hatchery was built in Phnom Penh Municipality in 1984 (DoF, 2004). In order to supply the increasing demand for fish seeds, another hatchery was established at the Chak Angre vicinity also in Phnom Penh. Aside from seed production, both stations also embarked on fish culture operations to generate sufficient income for operations (DoF, 2004). Furthermore, in 1990s three NGOs, namely: the Partnership for Development in Kampuchea (PADEK), Southeast Asian Outreach (SAO), and Australian People for Health, Education and Development Abroad (APHEDA) also supported the establishment of provincial level fish seed production centers in Prey Veng, Kandal, and Kampot Provinces, respectively. At the start, these centers provided training and fish seeds to fish farmers but due to the increasing number of fish farmers involved and the considerably far distance of grow-out ponds from the hatcheries, sufficient and timely fish seed supply and extension support services became major constraints. These were addressed through the development of decentralized seed production centers and village-based farmer-led extension systems, which later proved to be beneficial because of easy accessibility by fish farmers and increased survival of seeds, resulting in fish farmers' acceptance of locally-produced fish seeds and good relationship between fish seed producers and grow-out operators.

In the mid 1990s, seed production centers were established in the northern provinces of Pursat, Battambang and Banteay Meanchey by a UNDP-funded project on Cambodia's Rehabilitation and Reconstruction (CARERE). However, operations stopped when the project phased out its activities in 1999, except for two stations in Pursat that remain operational until present. Another center was later built in Siem Reap with technical support from the Coopération Internationale Pour le Développement (CIDSE), Adventist Development and Relief Agency (ADRA) and World Food Program (WFP), but when their supports were phased out hatchery operations also ceased. Meanwhile, Japan International Cooperation Agency (JICA) and a micro-finance institution PRASAC supported the development of freshwater fish hatcheries in Takeo and Kampong Speu Provinces but were confronted with frequent environmental problems like floods and administrative problems such as financial and human resources, leading to irregular seed production activities. PRASAC also supported the establishment of another hatchery in Svay Rieng Province in the late 1990s which became operational until 2003 (DoF, 2004).

Private sector hatcheries

Seed production centers established in Cambodia were large-scale, medium-scale and small-scale. While large- and medium-scale private sector hatcheries have wide distribution networks from the far north province of Ratanakiri to the far south province of Preah Sihanouk, the distribution channels for small-scale hatcheries are limited to provincial and district levels, even if many small-scale hatcheries have the capability of producing large quantities of fish seeds, especially those located in Takeo, Prey Veng and Kandal Provinces (Viriyak *et al*., 1999). Nevertheless, most fish hatcheries have been confronted with various constraints such as insufficient water supply which is highly dependent on the monsoon season, inadequate skilled staff and operating budget, inadequate security to prevent theft and poaching, occurrence of predators, as well as unavailability and inaccessibility of hormones for induced spawning of broodstocks, limited nursery areas, ineffective marketing skills, inadequate extension support services, and poor or no access to information. Specifically for the small-scale hatcheries, the key challenges encountered include inadequate knowledge and training, difficulties in purchasing and sourcing hormones for induced spawning, and inefficient transportation systems for the fish seeds (Viriyak *et al*., 1999; Nam and Haing, 2007). Generally, small-scale hatcheries sell their fry to small-scale nurseries but when the hatcheries could no longer supply the increasing demand, nursery operators purchase fry from large- and medium-scale hatcheries. Fish nursery operators play an important role in providing informal credit to grow-out farmers, with the condition that farmers pay the cost of fish seeds at harvest time rather than at the time of purchase.

Public sector hatcheries

Government-controlled large-scale hatcheries were also established but were confronted with insufficient operational budget, as well as predation and poaching as in the case of the hatcheries established in Bati District (Viriyak *et al*., 1999). Other constraints encountered by public sector hatcheries include inadequate skilled human resources, insufficient fund allocation, inaccessibility to information and modern techniques, inaccessibility to transportation, and unclear operation mandates (Nam and Leap, 2007).

Thuok and Viseth (2004) reported that public and NGO-supported hatcheries have also been operating culture activities to generate additional income. When PADEK, SAO and APHEDA phased out their supports to public

hatcheries, fish seed producers had difficulties in seeking government funds to defray their fixed and operational expenditures and continue performing their mandates. As a result, their hatcheries were turned into profit-generating centers from the sale of fish seeds, fish grow-out production and training. Moreover, with sustainable seed production operations, the hatchery centers have also been involved in conducting research to develop and improve the culture technologies intended for small-scale fish farmers (Thuok and Nam, 2004). Although the mandate of most public hatcheries is to produce fish seeds and carry out extension activities, inadequate resources led to the conduct of few or no extension activities while only few public NGO-supported hatcheries include research activities as part of their mandates (DoF, 2004). Insufficient human resource is a major limitation for most hatcheries, as technical and highly-skilled staff preferred to work in high-paying jobs to earn their living and provide the basic needs of their families.

Imported fish seed stocks

Fish farmers in Cambodia had been importing fish seeds from neighboring countries to fulfill their grow-out requirements since locally-produced fish seeds were not sufficient. In 2004, seeds of nine fish species including exotic species were imported, *e.g.* hybrid catfish (*Clarias gariepinus* x *C. batrachus*), tilapia, silver carp, mrigal, common carp, grass carp (*Ctenopharyngodon idella*) and other three indigenous species such as the sutchi catfish (*Pangasianodon hypophthalmus*), giant gourami (*Osphronemus goramy*) and climbing perch (*Anabas testudineus*), where about 60 million fingerlings were bought and brought into the country to supply the demands of pond and cage aquaculture (Nam, 2007). The main exporting country was Vietnam although Thailand, to lesser extent, also exported fish seeds. Of these imported species, the two most important are the hybrid catfish and tilapia contributing about 82% to the total imported fish seeds (63% and 19%, respectively). Such proportion of imported hybrid catfish was expected to increase because the species could replace the giant snakehead in cage culture, which was banned by the Government in the mid 2005 due to its significant dependence on small and wild fish for its diet (Nam *et al*., 2005), notwithstanding the negative impacts brought to the aquatic environment by escapees of the hybrid catfish. The other important imported species are silver carp, sutchi catfish, mrigal, common carp, grass carp, and to certain extent giant gourami and climbing perch (**Table 3**). Inadequate regulations on importation of fish seeds in the country allegedly increased the number of unlicensed traders or small companies that have been illegally importing fish seeds mostly from Vietnam and Thailand reaching as high as 200 million fingerlings per year (Kimleang, 2005). At certain point, Takeo and Kampong Speu encountered problems on the marketing of locally-produced fish seeds due to competitions with imported seeds.

Table 3. Species of fish seeds imported by Cambodia (2004)

Fish species	No. of fingerlings	Percentage (%)
Clarias gariepinus x *C. batrachus*	41,000,000	68.3
Oreochromis niloticus	11,500,000	19.2
Hypophthalmichthys molitrix	3,000,000	5.00
Pangasianodon hypophthalmus	1,500,000	2.50
Cirrhinus cirrhosus	1,200,000	2.00
Cyprinus carpio	900,000	1.50
Ctenopharyngodon idella	600,000	1.00
Osphronemus goramy	150,000	0.25
Anabas testudineus	150,000	0.25
TOTAL	**60,000,000**	**100.00**

Sources: *Nam and Leap (2007)*

Case Study in Takeo and Kampong Speu Provinces, Cambodia

Takeo Province is located in the south-western part of Cambodia (**Fig. 2**) about 78 kilometers from Phnom Penh with a total area of 3,563 km^2 and embraces 97 communes and 1,118 villages (NCDD, 2012). Kampong Speu Province is located west of Phnom Penh with an area of 7,017 km^2. Takeo and Kampong Speu Provinces had been chosen for the study due to various reasons (Chin, 2013), such as the Provinces of Takeo and Kampung Speu support the country's large- and small-scale hatchery industry resulting from the efforts of FiA and NGOs. In addition, most fish seed producers have been operating in these provinces, where majority of the fish grow-out farms are also located. Although aquaculture in these areas is mostly managed by the private sector, it has received strong support from the government and other NGOs.

Fig. 2. Map of Cambodia showing the Provinces of Takeo and Kampong Speu

For the case study, Tram Kak District in Takeo Province and Basedth in Kampong Speu were taken as sample sites. Specifically, 23 fish hatchery operators (Tram Kak: 19; Basedth: 4) and 60 grow-out farmers (Tram Kak: 30; Basedth: 30) were chosen as the study's respondents (Chin, 2013). As shown in **Table 2**, there are 37 hatchery units in Takeo Province and 24 in Kampong Speu while there are 19,146 units of culture ponds, 12 culture cages, and 58 units of community refuge ponds in Takeo; and 1,824 culture ponds and 173 units of community refuge ponds in Kampong Speu.

Fish seed production

Although the country's fish seed production is mostly a small-scale activity considering the availability of water and limited nursing pond size as a result from small land holdings, most hatchery operators use adequate and up-to-date practices and facilities, and are well organized and flexible. However, inadequate skills in broodstock management as well as poor water quality, predation and drought had constrained them from efficiently and effectively operating their facilities. Despite these limitations, local fish seed producers continue to play a significant role in supplying fish seeds to aquaculture operations at local, provincial and even at national levels.

In the beginning, poor survival of fish seeds in ponds had discouraged fish farmers from buying locally-produced seeds. The high demand for fish seeds when many farmers joined the bandwagon of fish culture had prompted some seed producers to sell small-size fish seeds to fish farmers. Also, some farmers coming from distant places agree to buy fish seeds irrespective of size since they did not want to go back to their fishponds without the much needed fish seeds. As brokers for collecting fish seeds from hatchery producers and selling these to fish farmers, some nursery operators do not nurse the seeds for an adequate length of time. At this stage, the hapa nursing technology was adopted in Cambodia while extension support was improved to educate farmers on the need to either stock big size seeds or nurse fish seeds until reaching the appropriate size for stocking (Nam and Haing, 2007).

The socio-economic profile of fish seed producers in Takeo and Kampong Speu Provinces (**Table 4**) showed high proportion of men involved in fish seed production, *i.e.* 17 out of 19 producers in Takeo and three out of four in Kampong Speu, because of the manual labor required in fish hatchery operations (Chin, 2013). The case study also suggested that women provide active participation in the hatchery activities, especially in preparing the hormones and chemicals needed for breeding, taking care of the fish larvae, monitoring the quality of hatchery water, and marketing of the fry/fingerlings. The average age of the respondents at 48 years old, is considered mature enough to manage fish seed production activities. Moreover, their adequate educational background is essential in fish hatchery operations as they are able to absorb and adapt new knowledge and technologies necessary to improve their operations, as well as negotiate fairly with fish farmers during market transactions. Thus, most of the fish hatchery operators had received training on good fish hatchery management provided by FiA, including market sourcing and channeling their produce.

The average family size of hatchery operators at four (4) persons enabled most operators to avail of free labor from family members, cutting on labor costs. However, the average land holding of 0.6-1.0 ha/family limited the farmers' efforts to expand their ventures and continuously supply the demand for fish seeds in view of less number of

nursing and broodstock ponds, and smaller water reservoirs for keeping water used in breeding and hatchery operations. The main occupation of most farmers was producing fish seeds but some were also involved in different activities to earn additional income for their families' needs. Some fish farmers were also engaged in rice farming (50% from Takeo and 100% from Kampong Speu), which is the backbone of Cambodia's agricultural sector as rice is the country's staple food.

Freshwater fish culture

Fish grow-out farmers in Takeo and Kampong Speu Provinces (**Table 4**) were also mostly men, *i.e.* 83% in Takeo and 90% in Kampong Speu, in view of the manual labor required in fish grow-out operations (Chin, 2013), although both men and women contribute significant amounts of time to fish culture activities. While the youngest fish farmer was 26 years old and the oldest 72 years old, age should not be a criterion in fish culture although farmers should start from adult age to be able to carry out the laborious activities in small-scale fish culture operations. Some fish farmers were also engaged in other activities to earn additional income for their families' needs. Thus, most of the fish farmers reported that their sources of income come not only from on-farm but also from off-farm activities such as rice and vegetable farming, among others.

Fish farmers in Takeo and Kampong Speu Provinces started to culture fish in 2000 and most of them culture three species of carps, especially the common carp. Recently however, many fish farmers prefer to culture the silver barb because of the availability of adequate amount of fingerlings to supply their requirements. Since silver barb is an indigenous species in the Mekong River, its culture has been promoted by the FiA and MRC. Moreover, this species is also more suitable in pond culture because of its fast growth rate and high survival rate, and many consumers prefer this species for family consumption.

Generally, the fish farmers have good knowledge and experience in aquaculture operations. With suitable pond areas, fish farmers practice good pond preparation and fertilization, appropriate stocking density, feeding and pond management, and harvesting methods, and thus, get considerable yield. Although aquaculture could offer important long-term potential for Cambodia, the country's current production remains low relying essentially on small-scale pond operations. Nonetheless, in order to maintain the pro-poor focus on growth improvement, interventions are necessary to support small-scale fish farmers which could come in the form of capacity building, such as conducting training courses to enhance their skills and to some extent, providing them some inputs (*e.g.* fingerlings).

Table 4. Basic socio-economic data of respondents (Chin, 2013)

Categories	Takeo	Kampong Speu	Total
Fish seed producers (n)	***19***	***4***	***23***
Gender (% male)	90	75	91
Age (%): ave = 48 years old			
24-40 years old	26	25	26
41-50 years old	26	0	26
51-68 years old	47	75	52
Educational attainment (%)			
Primary school	-	-	30
Secondary school	-	-	65
Family size (%): ave = 4 members			
2-3 members	58	75	61
4-5 members	37	-	30
Land holdings (%): maximum = 2.0 ha			
Small (0.3-0.5 ha)	26	25	26
Medium (0.6-1.0 ha)	38	50	38
Large (1.1-2.0 ha)	26	25	26
Alternative occupations (%)			
Rice farming	59	100	65
Employment with Government	21	0	35
Annual income from seed production (%) (1USD = 4000 KHR)			
1.000-10.000 million KHR	63	75	65
10.001-20.000 million KHR	11	0	9
20.001-80.000 million KHR	26	25	26
Fish consumption (%): ave = 272 kg/family/year			
83-100 kg/family/year	16	25	17
101-300 kg/family/year	63	25	57
301-600 kg/family/year	21	50	26

Table 4. Basic socio-economic data of respondents (Chin, 2013) (Cont'd)

Categories	Takeo	Kampong Speu	Total
Freshwater fish growers/ farmers ***(n)***	***30***	***30***	***60***
Gender (**% male**)	83	90	87
Age (%): ave = 48 years old			
26-45 years old	47	40	43
46-60 years old	50	37	43
61-72 years old	3	23	14
Educational attainment (%)			
Primary school	-	-	53
Secondary school	-	-	30
Alternative occupations (%)			
Rice farming	97	100	98
Teaching	3	0	2
Annual income (%) from fish grow-out activities (1USD = 4000 KHR)			
0.400-6.000 million KHR	71	50	67
6.001-10.000 million KHR	14	50	19
Fish consumption (%): ave = 148 kg/family/year			
100-140 kg/family/year	33	33	50
141-240 kg/family/year	54	67	43
241-360 kg/family/year	13	0	7

Relationship between Fish Seed Producers and Grow-out Farmers

According to many fish farmers from both provinces, their partnership with local seed producers which had substantially improved led to honest transactions in supplying sufficient quantity of good quality fish seeds so that they no longer use imported fish seeds for their fishpond operations. The characteristics of locally-produced fish seeds which farmers consider as indicators for good quality include good shape, bright color, fast growth rate, disease resistance, high survival rate, and easy to feed. In an impact survey conducted in 2009, the results indicated that all fish seeds required by the country's fish farmers had been supplied by local fish seed producers. Meanwhile, some public hatcheries have also been producing other species such as *Pangasius* spp. or walking catfish (Viseth, pers.comm. 2012) as this shift could provide them more income for operations.

While the amount of fish seeds produced locally by village hatcheries had significantly increased in both areas considerably meeting the demand of local fish farmers (FAIEX, 2009), the Government should encourage public hatcheries to consider transferring new technologies and knowledge (*e.g.* breeding of indigenous species) to private or farmers' hatcheries to increase their fish seeds production. Farmers' hatcheries should play the most important role of producing good quality fish seeds to supply the required inputs of local fish farmers in the future, more particularly, supplying locally-produced fish seeds of indigenous species. This would help reduce the negative impacts of exotic fish species on wild fish species due to accidental escape. This necessitates that locally-produced fish seeds should be made more available throughout the country by fish seed producers who have been adequately trained and received support from the FiA. This way, fish farmers would have more confidence to stock locally-produced fish seeds in their ponds.

An average demand of fish seeds is about 1,750 per family per year. Indigenous species (silver barb) is the most popular fish seeds especially for polyculture, of which about 49% is distributed nationwide compared with the other three species such as common carp, silver carp and other species (rohu, tilapia and mrigal). The high proportion of silver barb is influenced by a national regulation that encourages the culture of indigenous aquatic species in Cambodia. As a result of this development, fish farmers now do not utilize imported fish seeds for their pond culture unlike before when many fish farmers were reported to have been importing fish seeds for their ponds. The main reason of fish farmers for avoiding imported fish seeds is poor quality, since many farmers have encountered many problems that came with imported fish seeds, such as slow growth rate and seeds are more adapted to artificial feeds (pellet feeds) which are unavailable and expensive in rural areas.

In addition, the Government's intensified promotion of the use of locally-produced fish seeds gave fish farmers more advantages such as: healthy stocks; uniformity in size and age; fast growth rate; high survival rate and disease resistance. The other advantages are accessibility of local feeds as the stocks could be given such feeds as rice bran, kitchen wastes, vegetables, duckweed, termites, broken rice, and others; good price, and low environmental impacts. More particularly, training on responsible fish culture is also provided by fish seed producers before a fish farmer could start embarking on fish culture operations.

Freshwater fishponds in Kampong Speu, Cambodia

These factors contribute to the fish farmers' choice of locally-produced fish seeds over the imported ones. Such mutual relationship between fish seed producers and grow-out operators is therefore expected to contribute to the sustainable development of freshwater aquaculture in Cambodia.

Recommendations and Way Forward

A major constraint of small-scale aquaculture dovetails to the technical and environmental aspects. Thus, fish seed producers in both provinces consider proper broodstock management as a priority that should be given more focus by the Government. Broodstocks that could give good quality and quantity of seeds should be promoted by the government including those that could withstand poor water quality conditions during the dry season, low water supply and drought, high temperature, limited nursing space, and predation. The market for locally-produced fish seeds could be increased by developing channels to middlemen rather than through growers, NGOs or government.

Furthermore, plans should be developed to support hatchery development in areas where water is abundant all year round, which is a general constraint in fish seed production activities. Considering that the profiles of the fish seed producers and fish grow-out farmers in Takeo and Kampong Speu Provinces are good, particularly in terms of education, production capacity and incomes, their relationship should be enhanced in order that the current one-one cooperation is sustained. Since fish seed producers get higher income and receive higher education than fish grow-out farmers, the former should be trained on the modern techniques of fish culture from hatchery to grow-out, and allowed to continue disseminating the techniques they learn from such training to fish grow-out farmers. Moreover, fish seed producers consume higher amount of fish than fish grow-out farmers, which could be due to the reliance of fish seed producers on fish that they also produce, while fish grow-out farmers who are engaged in rice farming and other activities consume more agriculture staples. Nevertheless, since fish seed producers and grow-out farmers have sufficient resources, both stakeholders should be encouraged to enhance their capability in undertaking fish culture activities, as this could provide them new and better alternative incomes.

There is now an established tradition of fish seed production in the two study areas despite drought and limited water infrastructure. Most producers are successful in producing fish seeds during the seasonal breeding season (end of February to mid of October), depending on the amount of rainfall. The fish seeds produced show good quality in terms of shape, bright color, uniformity of size and age, fast growth rate, disease resistance, healthy, high survival rate, low environmental impacts, and easy to feed especially with locally available feeds. Nonetheless, some barriers such as the lack of water should be addressed by the government. Moreover, the fish producers' capacity in broodstock management should also be enhanced as their knowledge and skills are still limited. The distribution of fish fingerlings from both provinces is already widespread reaching the northwest provinces of Cambodia, which are close to Thailand, up to the northeast provinces, near the border with Vietnam.

Fish grow-out farmers have adequate knowledge in aquaculture practices, after attending fish culture training courses provided by FiA and fish seed producers. With suitable pond areas, good practices in pond preparation, and fertilization, stocking density, feeding, pond management, and harvesting, fish farmers are now getting fair quantity of fish produce. Fish seed production enterprise is also becoming a profitable business in these two provinces. Rural farmers have expressed satisfaction with government and NGOs for their technical supports, and their desires to expand operations in the future. Locally produced fish seeds are available for existing fish farmers, but new farmers who are still starting into fish culture could avail of their required inputs through the provincial fish seed production network. Supply of imported fish seeds had collapsed as the seeds could not compete anymore with the locally-produced fish seeds as it used to enjoy before. Fish seed production in the country could still be increased, *i.e.* by increasing surface area or enhancing the yield from each hatchery.

Considering that land is a constraint as it is quite impossible for poor farmers to acquire more areas of lands, studies should be conducted on improving production efficiency that produces better yields per area and ensures that costs of production would not exceed the value of fish produce, such as improving water quality management, increasing nursery areas and improving the quality of broodstocks. In addition, the market network of locally-produced fish seeds should be expanded while the services of middlemen could also be considered. Nursery management should also be improved to increase the survival of fry after breeding in hatcheries. The combination of these approaches could result in dramatic increase of total production not only in terms of fish seeds but also in marketable-size fish. Furthermore, sustaining the partnership between fish seed producers and fish grow-out farmers which presently exhibits a one-one cooperation and not competition, should be given utmost attention in order to maintain a healthy environment for sustainable aquaculture development in the country.

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About the Author

Ms. Chin Leakhena is Vice Head of Fish Diseases and Genetic Division, Fisheries Administration, Ministry of Agriculture, Forestry and Fishery, Cambodia. She is a member of the 2014 Regional Fisheries Policy Network for Cambodia, based at the SEAFDEC Secretariat in Bangkok, Thailand.