EXTENDING INTEGRATED FISH FARMING TECHNOLOGIES TO MARICULTURE IN CHINA

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Summary

This chapter is to indicate what is integrated fish farming and how it is being extended to mariculture in China i.e. to show new concepts and possible trends of integrated fish farming systems in China in the 2000s with its rationale, intensification, expansion, and how to increase productivity of the aqueous system and strengthening its contribution to ensure food security, to alleviate poverty, to increase jobs and income, and to operate this in harmony with the environment.

1. Introduction

Eco-agriculture rapidly rose in China in the 1980s from eco-household to eco-village, eco-town and further to eco-county. Many ecologists have written a series of articles about eco-agriculture since 1982. Agriculture in China is a macro-agriculture which contains cropping, forestry, animal husbandry, side line occupation and fisheries, and much more. Fisheries include capture and culture fisheries. Capture fishery can be divided into ocean and inland fishing. China limited ocean fishing to zero increase since 2000 because sustainable ocean fishing depends on natural fishery resources in the world. China adopts sanctuaries and closing seasons in rivers, lakes and the Yellow Sea and the East China Sea as well and prohibiting trawling operation. Culture fisheries include freshwater and saltwater aquaculture. Integrated fish farming systems are usually, in a narrow point of view, called pond integrated fish farming by the application of ecological engineering. But pond fish farming can never be a closed ecosystem in a narrow way. It must be connected with other sectors of macro-agriculture in a broad way, including water, fertilizers, energy, health, jobs and food security.

Ecological agriculture was the norm in China for centuries, even millennia. Growing fish in pond is a very old practice. Carp were cultured as long ago as 2698 B.C. in China, where they were grown in ponds on silkworm farms. China has a long history of fish farming not only in fresh water but also in salt water. For example, oyster-farming was recorded as early as in the Han Dynasty (206 BC-220) in China. Mariculture became popular activities during the Song Dynasty (960-1127), culturing purple laver, oyster, clam and pearl mussel and mullet along the coastal areas, mainly in south east provinces, especially in Taiwan Province (Zheng Hongtu; Ye Li Kao, 1600) and in terms of ancient documents such as Qu Dajun, “Song of Harvesting Oyster”; Feng Shike, “Miscellanies when boating in rains” and”Guangdong New Words” in the Ming Dynasty (1368-1644).

Nowadays, someone thinks integrated fish farming is outdated. Yes, if you stick to the point that it is pond integrated fish farming with fish the dominant in the system and your objective is to solely increase the output of feed per unit area per year, following for typical Cartesian approach where one seeks the maximization of one parameter. No, if you take a systemic view of the production methods in which fish farming is just one component in a complex generating multiple outputs that generate a cash flow that is a multiple of what can be achieved if one not only values the fish. Within the context of

sustainable development integrated fish farming systems offer two new trends at least: firstly, integrated fish farming is closely connected with other sectors of the economy with extensive potential links to the preservation of the ecosystems, the provision of fertilizers for agriculture, the generation of bio-fuels for energy, but also, recreation and tourism; secondly, integrated fish farming systems (integrated aquaculture) have extended to mariculture in land based ponds, tidewater and coastal waters working with the cyclicality of natural systems reducing infrastructural costs and increasing productivity.

2. Rationale of Integrated Aquaculture and Mariculture

Lester Brown in his book "B Plan 3.0" wrote "Fish farming advances in China, centered on the use of an ecologically sophisticated carp polyculture, have made this the first country where fish farm output exceeds the oceanic catch." World aquaculture has grown tremendously during the last fifty years from a production of less than a million tons in the early 1950s to 59.4 million tones by 2004.

This level of production had a value of US $70.3 billion. Of the production, 41.3 million tones, or 69.6%, were produced in China.

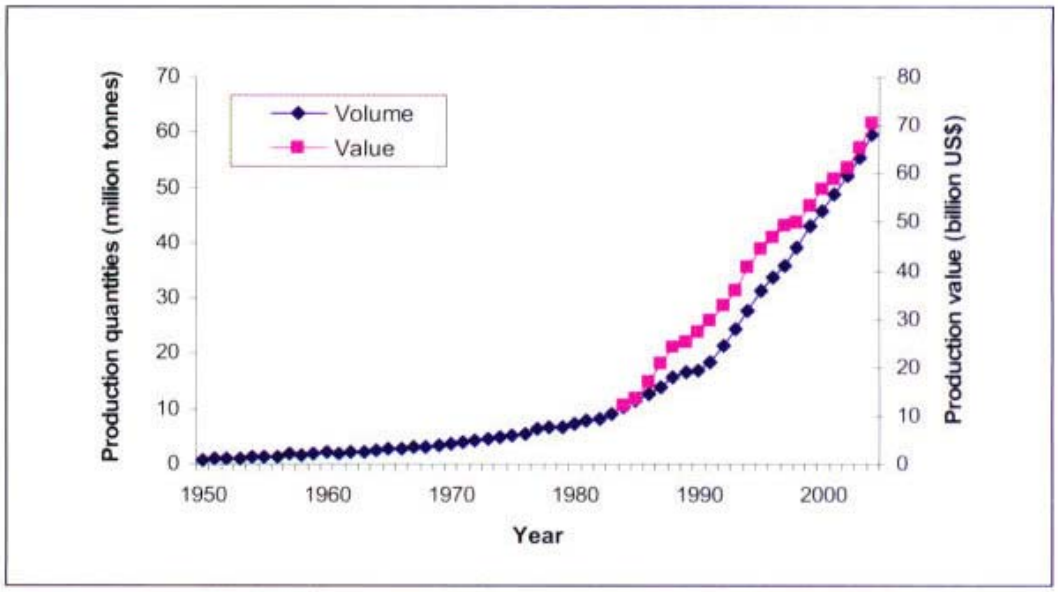

Figure 1: Trend in total world aquaculture production and value (including plants) between 1950 and 2004 [from FAO Fisheries Tech. Paper 500, State of World Aquaculture 2006]

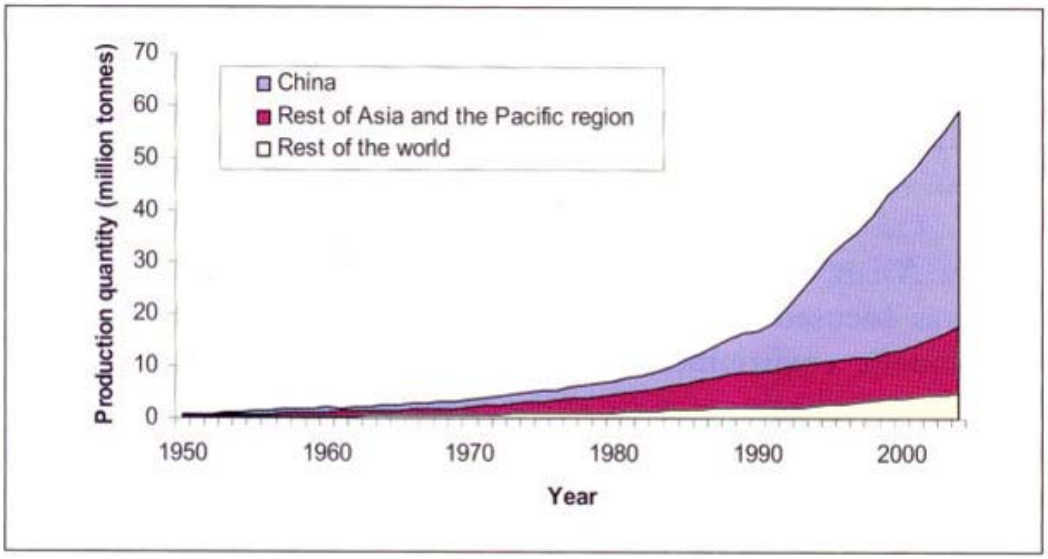

Figure 2: World aquaculture production with China and rest of Asia and the Pacific Region disaggregated from the rest of the world between 1950 and 2004 [from FAO Fisheries Tech Paper

2.1. Chinese Philosophy and ZERI Concept

Ecology, as a branch of sciences, originated in the Western world; however, ecological thinking and practice is more fundamental and broaden than in the west can be found in century-old and profound traditional Chinese culture. The concept of fish polyculture originated in ancient Chinese philosophy. That is to comply with the course of nature in the Book of Changes, which is one of the Five Classics in China. That means to look at the world with a holistic view. "**he shi sheng wu, tong ze bu ji"** in Chinese <guo yu • zheng yu> was one of ecological concepts put forth by Boyangfu in the end of the Western Zhou Dynasty (11th century - 771 BC). It says different things integrated or combined together can reach balance and harmony to some extent and then they will bring about new things. If one sticks to absolute uniform and exclude all others and attempts to make things 100% pure, on the contrary, it can not continue its development due to lack of competition. Chinese culture believes that harmonious coexistence of the opposites (well known in the West as yin and yang) is considered the source and the motive power of sustainable development. As American futurist Erwin Tufler wrote, the significant breakthroughs today do not often come from a single technique whereas from several techniques in parallel or come from integration of several techniques.

Scientific Development Concept we now adhere to is our guidance of modernization. We have two national economic development strategies: Prospering the Nation by Science and Education, and Sustainable Development. The zero emissions concept and ZERI (Zero Emissions Research and Initiatives) program can serve as an action plan if this concept of re-using everything, leaving nothing to waste. Unlike the Cartesian core business approach, that considers waste is a cost, the "natural approach" secures that whatever is a left-over for one is a nutrient or an energy source for the other. If this is accepted, potential resources and new clusters of industries will emerge everywhere that

will have levels of productivity that out perform even the most advanced genetic manipulation of a single species. In the new clusters of industries, various *sectors, which seem to have little in common, will become closely linked.* In this system, *any form of waste must become a value-added input, and a new material input for another production cycle. Sometimes only a re-engineering of the process will be needed, and at other times new technologies will have to be invented.*

This is in conformity with the Chinese philosophy that by-product (waste) from one resource use must, wherever possible, be put into another resource use.

2.2. New Natural Philosophy and the Five Kingdoms

Ilya Prigogine, the Nobel Prize Winner has indicated that "Chinese traditional philosophy emphasizes studying harmony and coordination as well as totality and spontaneity. The development of modern science is more in conformity with Chinese philosophical concept. If the Western science reaches an understanding of totality and harmony with Chinese culture, it will lead to new natural philosophy and concepts." The Austrian born nuclear physicist Fritjof Capra highlighted the need to approach science and development from a different angle in his landmark book "The Tao of Physics".

Biologist**s** under the aegis of Dr. Lynn Margulis argued that on the basis of the specific applications of physics, chemistry and biology all species are classified in five kingdoms of nature - bacteria, algae, fungi, plants and animals - and for billions of years these five kingdoms have worked together to be a highly productive and adaptive system. Along with the five kingdoms, there are five key design principles that each kingdom (except man!) generally adheres to:

(1) Whatever is waste for one is a nutrient or food for another species belonging to another kingdom;
(2) What is a toxin for one organism, is a nutrient or neutral for another belonging to another kingdom;
(3) Whenever highly complex ecosystems operate, viruses to remain inactive and even disappear without causing harm passing through at least 2 other kingdoms;
(4) The more local, the more diverse a system, the more productive, the more resilient; and,
(5) Whenever species of 5 different kingdoms live and interact in an autopoetic system, they can integrate and separate all matter at ambient temperature and pressure.

3. Integrated Fish Farming

3.1. Historical Records of Integrated Fish Farming

The development of integrated fish farming can be divided into three stages: the first developmental stage is from the Han Dynasty to late 1950s; the second yield-pursuing stage is from the late 1950s to the late 1990s; the third sustainable stage is from 2000 up to the future.

3.1.1. Yu Hu Bing

"Yu Hu Bing" is considered to be the earliest record of integrated fish farming, which indicated that "Yu, an official in the Han Dynasty built a fishpond south of Xian Mount in terms of Fan Li's first monograph of pisciculture in the world (473 BC). He planted bamboo and crops on high dykes, flowers in surrounding plots and water caltrop *Trapa* spp. and *Euryale ferox* on water surface. It is a vivid description of comprehensive management of fish farming with economic bamboo and crop planting. Actually polyculture of fish and soft-shell turtle had already appeared in the first monograph of pisciculture in the world.

In the Tang Dynasty (618-907) monoculture of common carp *Cyprinus carpio* had been replaced by polyculture of four cultivated species (black carp *Mylopharyngodon piceus*, grass carp *Ctenopharyngodon idellus*, silver carp *Hypophthalmichthys molitrix* and bighead carp *Aristichthys nobilis*) and this is the first turning point of fish farming in China. It enriched the contents of integrated fish farming to fully utilize different layers of pond water.

"On Pisciculture" written by Huang Shengceng in the Ming Dynasty (1368-1644) indicated the tree of banana *Musa sapientum*, China berry *Melia azedarach*, grape *Vitis vinifora*, and cotton rose *Hibiscus mutabilis* planted on dykes benefited to fish farming. Gao Ming County Chronicle depicted: "Dig lowland deep, put silt onto surrounding plots as dykes, lower center as fishpond, dykes to pond: 6:4, plant mulberry on dykes, stock fish in pond. Mulberry leaves feed silkworms; worm feces feed fish. Both sectors get benefits, ten times crop planting." and it formed a real picture of dyke-pond systems in the Pearl River Delta. Xu Guangqi's "Complete Book of Agriculture" summarized fish farming in Jiangxi Province with the following quotations: "Sheep pen is built on dyke, raise sheep and sweep sheep droppings daily into pond to culture grass carp. The feces of grass carp in turn can feed silver carp…." This is Fish Sheep model. "Transfer adult fish to big pond and dry the bottom to half dry and transplant grass *Nymphoides peltatum* as feed for new fish to grow." This is Fish Grass model in rotation. Sericulture developed in the Pearl River Delta after the 16th Century. Mulberry trees replaced fruit trees on the dykes of fishponds. This is Mulberry tree Dyke Pond system.

3.1.2. The Development of Inland Aquaculture Depended upon Natural Seed Supply in Long Period of Time.

So the seed collection and transportation in the Yangtze River or the Pearl River were flourishing after the Tang Dynasty. However, the seed supply was not sufficient for aquaculture. It seriously retarded the further development of aquaculture until the second turning point, which happened in late 1950s and early 1960s during the second stage. In 1958, China succeeded in the induced breeding of big-head carp, silver carp and white bream *Parabramis pekinensis*. This was the first time in history that a fish was successfully spawned using hormones. The black carp and grass carp were also successfully spawned in 1960 and 1961, respectively although induced breeding and hatching on grass carp were tried in the Pearl River Delta as early as 1921. It solved the bottleneck problem of seed supply and brought to an end of history of collecting fry

from great rivers. China has thrown off the shackle of insufficient supply of seed since then polyculture then has a solid material foundation.

3.1.3. The Third Stage

During the third stage ecological fish farming such as crab macrophytes mollusks fish culture system developed by systems design principles based on the Five Kingdom Theory. It remediates eutrophic pond water by using beneficial microorganisms, aquatic vascular plants and filtering animals. It means sophisticated integrated fish farming systems are developing with each passing day. But the name of "Integrated fish farming" was defined in late 1970s by FAO fisheries officials. Here fish has a meaning of various aquatic products in China.

3.2. Characteristics of Integrated Fish Farming

3.2.1. Integrated Fish Farming Models vary from Different Natural Conditions and Diversified Economy.

For example the Pearl River delta is located south of the Tropic of Cancer with annual average temperature ±22℃ and annual sunshine time 2,000-2,500 hours farmers integrated mulberry planting, silkworm raising and fish farming together to form a mulberry dyke pond system in line with the climate conditions in the Pearl River Delta. This is the most typical integrated fish farming system. [See Figure 3].

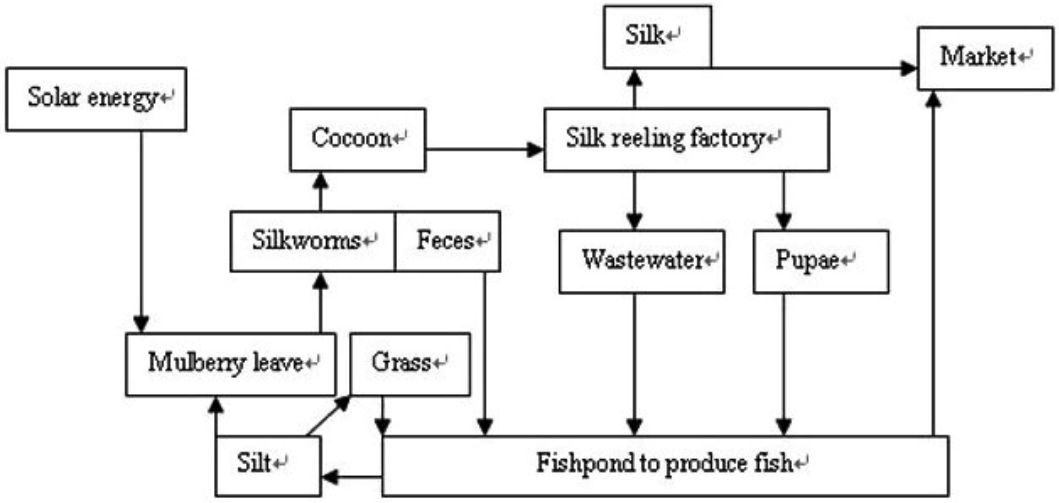

Figure 3. Material Flows in Mulberry Dyke Pond System

Grass Dyke Pond system is practiced in the lower and middle reaches of the Yangtze River with annual average temperature ±15.4℃ and annual sunshine time 2092.6 hours and average precipitation 1,204 mm in Lake Taihu area and similar conditions in Hunan province. In such kind of climate it is suitable for planting crops and raising fowl.

Farmers integrated fish faming with grass planting, pig-raising and anaerobic fermentation for biogas, i.e. planting grass and raising hogs on the dykes, herding duck in part of water surface as duck pen, and culturing fish in water body to form a complicated network structure of comprehensive management of fish, livestock (pig), poultry (duck or geese or chicken), biogas and fruit tree. In 1990 there were 40,000 ha of water body practicing integrated fish farming, which accounted for 54% of intensive pond culture in Hunan Province.

In Northern China with low temperature, less solar radiation energy and scanty water resources green fodder and crop cultivation are different with those in Southern China. But livestock husbandry develops well. Farmers integrated fish farming with cow, sheep, mule or horse and poultry to form Fish cum Cow, Fish cum Chicken models for example in Shandong Province along the Yellow River farmers comprehensively developed integrated fish farming systems about 20,000 ha among which there were 8,000 ha fishponds, 8,333 ha tableland. In integrated fish farming with 46,000 labors employed, they produced 48,000 tons of grain, cotton and oil crops, raised 32,000 pigs, cows and sheep, raised 1.7 million chicken, duck and geese, and planted 1.46 million fruit trees and economic woods in 1990.

There was a village in the outskirts of Yancheng in Northern Jiangsu having 34 ha fishponds adopting integrated fish farming model “one household one fishpond; one pen of pig or sheep or rabbit; one batch of chicken or duck or goose.” In 1990 they raised 1,000 pigs, 26,000 chicken and geese, 400 cow, sheep and rabbit. By recycling 2,500 tons of manures from those animals they produced 13,575 kg fish per ha with annual income for each household over 10,000 Yuan RMB.

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Bibliography

Anon. (2006) from CCTV 7 2006-3-10, several beneficial microorganisms and its improvement to water quality. [Several beneficial microorganisms were used to improve water quality in China]

Anon. (2006) “Status quo and Method of Sea Cucumber Culture in China.” from oceancentury.cn 2006-10-19 [The current situation and culture method of sea cucumber in China]

Chen Jun, Zhang Renshun, (2004). On the Development of Oceanic Ranching in China, Journal of Geography and Geo-Information Science 2000 (1) [The general information of the development of oceanic ranching in China]

CPPCC, (1998) Committee of Education, Science, Culture Health and Sports. Tap the latent power of ocean to enlarge food source. China Science and Technology Forum 1998, (3): 38~40. [See how to enlarge food source].

Edwards, P., (1998). A Systems approach for the promotion of integrated aquaculture, Aquac. Econ. Mang.2,1-12 [About the definition of integrated aquaculture].

Feng Yang; Hou Li; Ping Nie; Ling Tang; Kyo Chung, (2004). Development of mariculture and its impacts in Chinese coastal waters *Reviews in Fish Biology and Fisheries*, Volume 14, Number 1, March 2004, pp. 1-10(10) [See about development of mariculture and its impacts].

Gunter Pauli, (1998) Upsizing, Greenleaf Publishing. Sheffield England [Upsizing: The road to zero emissions, more jobs, more income and no pollution.]

Gunter Pauli (2002) *an idea on how to convert waste streams from shrimp farms into a catalyst for socio-economic development or how three decades of biochemistry research in the Baltic can reverse industrial design errors in the Tropics* 2002 www.zeri.org [about *an idea on how to convert waste streams from shrimp farm*].

Gunter Pauli, (2003). Science Behind ZERI: Five Design Principles www.zeri.org [Five design principles come from five kingdoms of nature.]

Lester Brown (2008). PLAN B 3.0 – Mobilizing to Save Civilization. Earth Policy Institute 1350 Connecticut Ave. NW Suite 403 Washington, DC 20036 [Fish farm output exceeds the oceanic catch.].

Li Chaoxia, Li Jian, Wang Qingyin, He Yuying, Liu Ping, (2006). The Comparison of Morphological Characteristics in Selected New Variety "Huanghai No.1" and the Wild Population of Shrimp *Fenneropenaeus chinensis*, China Fishery Science Vol.13, No.3 2006/85. [About New Variety "Huanghai No.1"]

Li Kangmin, (1991). Developing Ecological Agriculture in 21st Century China. J. Asian Farm Systems Association. I (1991) 191-200. [China is developing eco-agriculture in 21st century]

Li Kangmin & Li Peizhen, (1995), Integration of Agriculture, Livestock and Fish Farming in the Wuxi Region of China In proceedings of the Management of Integrated Freshwater Agro-Pisciculture Ecosystems in Tropical Areas, edited by J.J. Symoens & J.C. Micha, published by Royal Academy of Overseas Science, CTA & FAO 1995. [About the definition of integrated fish farming in China]

Li Kangmin, (1992). Rice-fish Farming Systems in China: Past, Present and Future in Rice-Fish Research and Development in Asia edited by C.R. dela Cruz, C. Lightfoot, B.A. Costa-Pierce, V.R. Carangal, M.P. Bimbao, ICLARM 1992 p17. [The history of rice fish culture in China and various models of rice fish]

Liu Bo, Jiang Guochun, Wang Huiping, and Ye Xiang, (2005)，Crab pond Ecological environment optimization techniques and their effectiveness, J. of Scientific Fish Farming 2005（10）[about crab pond ecological environment optimization technologies].

Luo Yongsheng, Zhang Daobo, Li Zhuojiaz (2006), Prospects for the treatment of intensive aquaculture effluent with probiotics and macro-algae .Transactions of Oceanology and Limnology №2. 2006 [See about how to deal with intensive aquaculture effluent].

Ma Shijun, Li Songhua ed. (1987). Chinese Agricultural Ecological Engineering. Science Publishing House in Beijing 1987.[The book systematically and comprehensively described the applied theory and methods of ecological engineering on agriculture.];

Marilyn Chakroff, (1976). Freshwater Fish Pond Culture & Management, Volunteers in Technical Assistance VITA Publications Manual Series Number 36E September 1976 Revised Edition Dec 1978 USA p2.[The earliest fish farming in the world: Carp were cultured in ponds on silkworm farms in 2698 B.C. in China.]

News (2008) from CCTV.com Feb 13 2008, Abalone integrated with kelp farming. [To show how abalone farming is integrated with kelp farming].

News (2006) from Agriculture Science and Tech Daily 2006-9-28, Shrimp and mud clam polyculture [See shrimp shellfish polyculture}

News (2006) from Agriculture Science and Tech Daily 2006-9-28, How to polyculture razor clam in shrimp ponds. [To show how to polyculture razor clam in shrimp ponds]

News (2006) from China Fishery 2006-6-16, Notes on polyculture of fish and shrimp [Detailed information about shrimp pomfret polyculture]

News (2007) from Jiangsu Agriculture Network 2007/11/12, Loach intensive culture in Ganyu County, [News on intensive loach culture]

News (2007) from CCTV7 2007-8-14 Snakehead intensive culture in Deqing County Zhejiang, [News about intensive snakehead culture]

News (2006) from Dalian Seafood Network 2006-9-20. The kinds of sea cucumbers [See the kinds of sea cucumbers]

News (2007) from CCTV7 2007-7-23 (Getting Rich Program), Top mouth cutler culture,[Detailed information about top mouth culter culture]

News (2005) from The South Daily 2005/12/12, Pearl culture marches on circular economy road, [See this story to deal with effluent from pearl mussel pond and processing industry.]

News (2006).xinhuanet.com/fortune/2006-01/04/content_4008478.htm - 36k Crab Island Circular Economy [See agriculture circular economy is being performed]

News (2007) from CCTV7, 23 Aug 2007, Shrimp Jellyfish, mud clam and globefish polyculture,[About shrimp jellyfish, mud clam and globefish polyculture].

Quoted from Hu Xinghua: The Brief history of Fish Farming in China http://www.fa.gov.tw/tfb5/153/fe153ec.htm [Brief history of fish farming in China.].

Ryther, J.H., (1981) Mariculture, Ocean Ranching, and Other Cultured-Based Fisheries, BioScience Vol. 31 No.3 Living Marine Resources (Mar 1981).[About the basic principles of fish farming in China].

邵培仁(2008)《中国古代的生态平衡和生态循环思想》，《淮海工学院学报》（哲学社会科学版）2008 年第 2 期。Shao Peiren, 2008. "The Thoughts of Ecological Balance and Ecological Recycle in Ancient China" in Journal of Huaihai Institute of Technology (Social Science Edition), in Lianyungang City Jiangsu Province Feb 2008. [See ecological concepts in ancient China]

CCTV7 (2007) Science & Tech Garden Program www.cctv.com, 2007 Aug 23, Notes on polyculture of fish and shrimp [About the notes on polyculture of fish and shrimp].

Shen Yu-chun, Ye Fu-1iang, Liang Guo-pan, Xiang Xian-fen, (2004). Study of Ecological Poly-culture System of Shrimp, Fish, Shellfish and Algae in Water Circular Cluster Ponds, Journal of Zhanjiang Ocean University Vol.24 No.4 Aug 2004 Study of Ecological Poly-culture System of Shrimp, Fish, Shellfish and Algae in Water Circular Cluster Ponds [See about ecological poly-culture system]

Shi Shan, (1986) 石山, 1986.. 湖南省武陵山区农村综合开发治理途径的研究, 农业现代化研究, 英文名称:Research of Agricultural Modernization, 1986 年 06 期 [So called eco-agriculture is clean agriculture without wastes and pollution},

Wang Feng and Zhu Shouwei, (2008) Promoting sustainable development of marine ecological fisheries by scientific progress. J. of "Fishery Environment Protection" 2008 (1) p25. [See the development of marine ecological fisheries in BoHai of China]

Wu Shujing, (2006) "Hard time for shrimp culture", J. of Fishery Environment Protection.2006 No.1 p20.[See about hard time for shrimp culture]

Xiong Bangxi and Liu Zhengwan (1990) Prospects for Integrated fish culture in China's Reservoirs the 4th Asian Fisheries Forum 1995 p20 (Asian Fisheries Society was an official Publishing House) [See about integrated fish farming in reservoirs]

Xu Hongchu and Zhu Shuyuan, (1993). Pond Integrated Fish Farming Technology, Agriculture Publishing House in China. [See the models of Integrated Fish Farming]

Xu Sheng, (2006). Progress on Study on Bioremediation of Water Environment in Shrimp Farming, "MODERN FISHERIES INFORMATION" Vo1.2l No.1l, 20-23 Nov. 2006 [See bio-remediation]

Yang Yufeng and Fei Xiugeng (2003). Prospects for Bioremediation of Cultivation of Large-sized Seaweed in Eutrophic Mariculture Areas. J of Ocean Univ. of Qingtao 33(1):053-057. [See the prospects for bioremediation of cultivation of large-sized seaweed]

Ye Qianji, (1982). "Ecological Agriculture" published by Chongqing Publishing House in Chongqing, 1989. [Eco agriculture is a green revolution in Chinese agriculture]

Ye Qianji, (1988). Eco-agriculture -- Agricultural future in Chinese, Chongqing Publishing House. 叶谦吉 1987 生态农业--农业的未来 《重庆:重庆出版社》[Eco agriculture is "an intensive agriculture system managed and administered according to ecological economics laws."]

Yu YuanAn, (2006) To bring about a revolution in fry breeding; to promote a new surge of mariculture in China, from China Fisheries 2006 No. 5. [See about a revolution in fry breeding].

Zhou Qunlan, Li Kangmin, Xie Jun, Liu Bo, (2008). "Role and functions of beneficial microorganisms in sustainable aquaculture" IOBB 2008 Conference [See the role and functions of beneficial microorganisms in sustainable aquaculture].

Biographical Sketch

Li Kangmin, Male, Nationality: Chinese, Birth: Dec 3, 1934 at Wuxi, Jiangsu Province China. Occupation: Freshwater Fisheries Research Center, Chinese Academy of Fisheries Sciences Senior Researcher; China National Rice Research Institute, visiting researcher; Zero Emissions Research Initiative Resources Personnel (1997-1999) and the Planning committee member of Internet Conference of IBS in 2000.

Graduated from CMC Engineering College in early 1950s, post graduated from Luoyang Foreign Language Institute and engaged in GSH of the PLA. Transferred to the Ministry of Agriculture in 1983. Deputy Director of Asian Pacific Regional Research and Training Center For Integrated Fish Farming NACA/FAO in charge of International Training Course of Integrated Fish Farming for three and half years. Engaged in IFS Deep Water Rice Fish Research, IRRI Deep Water Rice Screening, Eutrophication Control of Lake Taihu, IDRC extracting phycocyanin from blue-green algae *Microcystis aeruginosa* and Surface Aquaponics early or later.

Li Kangmin has been involved in rice fish farming research since 1986, when he published his first paper on rice fish farming and later published in the International Journal of Aquaculture in 1988. He published several papers later on the same topic e.g. Rice fields as Fish Nurseries and Grow-out systems in China.

According to the characteristics of agricultural climate and fishery resources, he has realized that there are three principal paddy areas in China suitable for rice fish farming. China has 20 million ha of paddy fields, 97% of which are under irrigation. In 1988, there were 1 million ha of rice fish fields, which accounted for 5% of the total rice fields. Practices prove that rice fish farming can function to eradicate weeds, to eliminate pests, to loosen the soil, to increase dissolved oxygen and improve the fertility and eventually increase the rice yield by 10%. Each ha of rice field can produce 150 kg of fish on average. In 1998 he and Li Peizhen published the paper of Rice Aquaculture System in China on the Internet Conference, describing that rice fish farming system is now developing to be rice aquaculture system under the transformation process from protein crop to cash crop. By quoting Jiangsu Province as a case, it describes the present status of rice fish farming and crab culture, shrimp culture and special aquatic product culture in rice fields as well. It indicates why rice fish culture can achieve sustainable development in China while rice fish culture is declining in the world. It is due to social, economic and cultural factors in China and all those factors represent the philosophy of the Chinese people.