

A Critical Review on Rizi-Pisciculture

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Abstract

Paddy-cum-fish cultivation a unique economic activity is practiced by the farming communities in all over the world. This is one of the innovative farming techniques for earning livelihood which is known as rizi-pisciculture. It is considered as the most efficient way of utilizing the wet paddy fields for simultaneous paddy cultivation and fish rearing at a time. The common carp is the most commonly cultured fish in the paddy fields out of 51 different species. It is found that the paddy-cum-fish culture is considered as the economically viable and hence sustainable farming practice by the farmers in most parts of the world. However, attempts are being made to critically review the works on paddy-cum-fish culture by the researchers in different fields.

I-Introduction

Cultivation of paddy is the primary economic activity in almost all the societies. It provides the basic livelihood for the sustenance of the human civilization. Similarly collection of fish from seas, rivers, streams and other water bodies is also an important traditional economic activity of most of the rural households in all countries. Though these two are separate occupations for large number of households mostly in rural and coastal areas they primarily depend on production of agricultural crops and collection of fish from various water bodies as a single occupation for earning their livelihood. These households practice both the activities for increasing their household income and better living standard. Many cultivating families not only collect fish from their nearby water bodies but also from their paddy fields. Cultivators harvest the wild fish from their low lying crop fields particularly in rainy season.

In rainy season wild fish migrate to the crop fields from rivers through excess water flow and flood. These fish are trapped in the paddy fields and grow there for some months. After rainy season when water dries up in the paddy fields, farmers use to collect them from their crop

fields. Thus, cultivators earn considerable revenue by collecting these fish from their crop fields and by selling them in market. In the process, farming families not only meet the domestic fish requirement but also earn sizeable income from their crop fields without any investment for fish rearing. With the passage of time farming communities in different areas all over the world try to harvest more fish from their crop fields particularly from their paddy fields which are more conducive for migration of fish in rainy season. Slowly and gradually, farmers started developing their paddy fields by making proper earthen bunds, drains and systems for draining out excess water from their fields before the crop season starts in order to trap more migrated fish in the crop fields during flood and water run-off.

Now a days, in many parts of the World, farmers try to trap wild fish and rear fish seedlings in their low lying crop fields like paddy, jute and other wet crops fields. Thus, rearing of fish along with paddy in the same crop field has become a new and innovative practice followed by many farmers for earning more income from the same paddy fields. This unique farming practice is known as “paddy-cum-fish” cultivation. This concurrent growing of rice and fish is otherwise called as rizi-pisciculture or paddy-cum-fish culture. It is considered as the most efficient way of utilizing the limited wet paddy fields since the same land is being used for both paddy cultivation and fish rearing at a time. This system is known to be originated from China 2000 years ago followed by India 1500 years ago. Presently some farmers in countries like China, Indonesia, Australia, Malaysia, Thailand, Japan, Philippines, Madagascar, Italy, Russia and some countries from Europe, North America and South America are practicing the fish culture in their paddy fields. However, in most of these countries farmers’ rice-fish farming is not deliberate stocking of fish in their paddy fields. The fish stock density in the paddy fields depends on what come with the flood water. Thus, the species cultured usually reflect the stock of fish in the nearby rivers and pond that use to irrigate into the rice fields. While the common carp is the most commonly cultured fish in the paddy fields in all over the world out of 51 different species as reported are being reared in different areas.

II-Review on Paddy-cum-Fish Culture

Paddy-cum-fish cultivation a unique economic activity is practiced by the farming communities in different areas in the world. This is one of the innovative farming techniques for earning livelihood of the farmers. Thus, an attempt is made here to highlight the findings of these studies in following sections.

(a) Paddy-cum-Fish Cultivation

The concurrent growing of rice and fish is known as rizi-pisciculture or paddy-cum-fish culture in the traditional sense. Singh et al. (1980) have defined rice-fish-culture as rearing of fish fingerlings of a given size of varieties of species in rice fields to harvest fish in addition to the main crop of rice. The farmers consider it as an ideal method of land use system since the same land is being utilized for both rice and fish concurrently.

The rice-fish culture has been practiced in Asia for more than 5000 years. The cultivation of fish in rice fields, as per some records, originated about 2000 years ago in China and it started in India nearly 1500 years ago Tamura (1961), Coche, A.G. (1967), Ali (1998). Other countries practicing rice-fish culture are Indonesia, Malaysia, Thailand, Japan, Madagascar, Italy and Russia. In India other than the Ziro valley of Arunachal Pradesh, the practice of the same is existing in north eastern states of India. But in these states farmers collect wild fishes from their rice fields that are trapped by flooded water in rainy season. But the Apatanis in Ziro valley of Arunachal Pradesh have been practicing paddy-cum-fish cultivation in an organized manner since 1960. As per the early review report (FAO, 1957) on “Fish culture in rice fields: a preliminary review & annotated bibliography proceedings in Indo-Pacific Fish Countries” it was practiced in 28 countries from six continents namely-Africa, Asia, Australia, Europe, North America and South America in mid-20th Century. Coche (1967) in his study “Fish culture in rice-fields: A world-wide synthesis” has pointed out that the rice-fish farming in some countries did not involve deliberate or selective stocking of fish in paddy fields. It was simply taking place due to the flood water. Thus, the species cultured usually reflected what was living in the water used to flood or irrigate the rice fields. Kutty (1987) in his paper “Fish culture in rice field” has critically analyzed the paddy-cum-fish culture practiced in different countries of the world and found that the production of fish in rice fields is almost as old as the practice of paddy culture itself. However, the production of fish from the same field is not possible when chemical fertilizers and pesticides are used to increase the production of rice.

A model bankable project on “Fisheries, Paddy cum Fish culture” Lintas (2007) has given an account of the area under which rain fed coastal saline soil is mono cropped in nature. He has also observed that the paddy cum brackish water fish/shrimp culture is practiced during the summer in their coastal saline soil fields without affecting the subsequent kharif paddy crop

in some places of West Bengal, Orissa and Kerala. The project identified that this type of activity provides the farmers a substantial income during the fallow season. A paper on “ Paddy-cum-Fish Culture: Innovative idea for entrepreneurs in rural areas”., Sharma et al. (2011), also gives an account of the paddy cum fish culture that is being practiced in Ziro valley and identified the type of fish species commonly reared in the paddy fields.

(b) Economic Impact of Paddy-cum-Fish Cultivation

The rice-fish integration helps the optimum utilization of available land and water resources and it minimizes the risk element associated with paddy alone cultivation. The rice-fish integrated farming practice yields higher income to the farmers because of the natural compatibility between rice and fish in a managed ecosystem of the agriculture. Further, in rice-fish integration, the fish helps in improving the soil fertility which includes the decomposition of fish excreta, grazing of fish reduces the algal biomass and fish regenerate nutrients such as nitrogen and phosphorus for increased soil fertility. Again, the browsing and movement of fish in rice fields causes high turbidity which prohibits photosynthesis and growth of underwater weeds. So the rice plants above the water get sufficient sun light on the other hand they get adequate soil nutrient. Moreover, the direct benefit of fish rearing in paddy fields is the increased soil nutrient/fertility due to soil perturbation and decomposition of fish excrement.

A research study on “Effect of fish on growth and yield of rice under rice-fish culture” Sinhababu et al. (1983) found that in the wet season the fry of catla-catla, labeo roheta, carrihinus mrigala and cyprinus carpio reared for 105 days in low-laying fields planted with rice cultivars provide higher return. They observed that rice grown with fish yielded 3.8 per cent to 6.3 per cent high over that of rice alone. Torres & Sevilleja (1983) in their paper “Preliminary economic analysis of fresh water fish production under various management systems” found that rice-fish culture offers higher income than rice monoculture. Sevilleja and Lopez (1986) “Rational cropping patterns for rice-fish” demonstrated that rice-fish integrated farming yielded about 40 per cent more income as compared to monoculture of rice. He also identified the need to verify the technology of rice-fish integration through farmer managed trials. Purusshan (1986) in his study on “Recent advances in paddy cum fish culture and its scope in Kerala” observed that the culture of fish and paddy together could potentially increase and stabilize income from rice farms and increases the total annual income. Vyas (1989) in his study on “Fresh water fish

culture in Indonesia” found that the fish grown in this system yielded 1200 kg ha⁻¹ year⁻¹ as an additional product besides rice.

The study of Lightfoot et al. (1990) revealed that the combined effects of these increase rice production by as much as 15 per cent. Earlier studies showed that fish excreta increase the availability of nitrogen, phosphorus, calcium and magnesium in paddy water and hence it increases rice yield. Thus, rice fish culture system is relevant to agriculture programmes of Indonesia in many ways like sustained rice production, increased farmers’ income and improved food quality for rural people.

In early eighties, there was revival in rice-fish culture in Asia especially in some countries like China Li (1992); Indonesia Koesoemadinata & Costa-Pierca (1992) and Thailand Fedoruk & LeelaPatra (1992). Lightfoot et al. (1992), in their study on “Nitrogen models of a wetland rice field ecosystem with and without fish” analyzed rice yield data of 20 rice-fish systems from China, India, Indonesia, Philippines and Thailand and found that the incremental rice yields ranged from 58 per cent to 183 per cent as compared to rice monoculture. The rice yield on an average has also increased by 4.6 per cent to 28.6 per cent. From the studies of Cagaun et al. (1994) on “Impacts of fish & pesticides”, Wu (1995) on “Methods of rice-fish culture and their ecological efficiency” and Cagaun (1999) on “Production, Economics and Ecological effects of Nile tilapia” it is observed that there is considerable improvement on rice yield rates due to fish in in paddy fields.

A book “Development of rice-fish farming in Indonesia: Past, Present and Future” of Koesoemadinata and Costa-Pierce (1992), reveals the history of rice-fish farming that are practiced in Indonesia. It is being in practice for more than a century and it has become instrumental of rural development in Indonesia. The growth of rice-fish culture in Indonesia since 1980 indicates that this system is not only profitable but also adoptable to many areas in Indonesia. The most popular species reared there are common Carp and Java Carp. According to “Fish Supplies and Accessories” (2011) a fish story given by Zoology Department, A.N. College, Patna, the fish species such as certain carps, murrels and tilapia are suitable for rearing in paddy fields and they are beneficial to the paddy plants by performing tillage, destroying weeds and insects that cause damage to the paddy plants. Similarly, a study conducted on fish culture in paddy fields in West Bengal shows the higher survival rate (from 34 per cent to 40 per cent) of labeo, catla and mrigal fish and their growth rate is more in paddy fields as that of in

ponds.

On a paper on “Bright prospects for rice-fish culture” by Ghosh et al. (1995) said that the biological control of aquatic weeds in rice fields could be achieved by culturing certain fish species. The result of an experiment conducted in the farmers’ field shows a 20 per cent to 25 per cent increase in the yield of rice by rearing grass carp. Besides increased rice yield an additional production of 113 kg fish was also achieved. Cagauan et al. (2000) in their studies on “Integrating fish and azolla into rice-duck farming in Asia” reported that in Philippines the fish and the nitrogen fixing aquatic fern azolla and ducks integrated with rice farming can result in nutrient enhancement, pest control, feed supplementation and biological control.

Tiwari (1993) in his research work on “Integrated farming research for sustaining food production” observed that a farming system involving flooded rice, poultry & fish has a high degree of complementarities. Isreal & Sevilleja (1995) in their work on “International cooperation for fisheries and aquaculture development” noticed that the rice-fish culture in Philippines led to higher rice production as compared to rice monoculture. Ghosh & Chakrabarty (1990), in their work on “Rice-fish production system: A viable technology for coastal wetland ecosystem” in India observed that mono crop rice fields under high monsoon area with deep water rice fields are ideal for rice-fish integrated farming. Mukhopadhyay et al. (1992) studied “On-farm research in deep water rice-fish culture in West Bengal, India” and concluded that there is a relative advantage of rice-fish integration in the deep water rice fields in West Bengal. Further, the advantage of this system is that the fish excreta increases soil fertility and also helps to control insect, pests and aquatic weeds. Singh & Swami (1998) in their study on “Record carp production in Punjab ponds new possibilities, Indian Farming” noticed that the integration of aquaculture with agriculture and use of supplementary feed can produce about 10 tons of fish from a hectare of paddy field. Hora and Pillay (1962) on their “Handbook of fish culture in the Indo-Pacific region”, estimated that around 1,36,000 ha or 0.65 per cent of 21 million ha of wet rice fields were used for growing fish in the Indo-Pacific region only.

In a study on “Revisiting underlying ecological principles of rice-fish integrated farming for environmental, economic and social benefits” Gurung and Wagle (2005) suggest some pertinent patterns that can help in understanding the interactions of abiotic and biotic factors in the rice fields for productivity enhancement. They say that the rice-fish system has a competitive advantage over the only paddy crop cultivation system because of control of rice plants over

weeds, micro algae, rice pest, etc. in one hand and increased nutrient supply due to top down, perturbation and nutrient regeneration by fish on the other. They further noticed that rice yield is less where rice alone was cultivated.

In a paper on “Integrated rice-fish farming in Nigeria: Its feasibility and economic viability” Okoye (2005) has highlighted on rice-fish culture, various experimental exercises and their effects. In a research work on “Breeding Biology and Artificial Propagation of *Channa Punctatus* (Bloch) with an emphasis on its rearing in rice field ecosystem”- Saikia (2010), analyzed certain aspects of the ecology and breeding details of *channa punctatus* and growth of *channa punctatus* in rice-fields in Assam.

A book called “Paddy-cum-Fish Culture in Ziro Valley, Arunachal Pradesh” by Kacha, D. (2017) critically analysed the impacts of fish culture in paddy fields in Ziro valley. An analytical study is also made on development of fish farms, area under paddy-cum-fish culture, production of fish and fish nurseries in Ziro valley in particular and Arunachal Pradesh in general. Moreover, the cost-benefit analysis of various indigenous economic activities including paddy-cum-fish culture of the farmers are done for ascertaining the economic viability and sustainability of the long practiced paddy-cum-fish cultivation by the Apatanis in Ziro valley.

A paper on “Indigenous irrigation system, farming method and economic condition of Apatani tribe of Arunachal Pradesh”, Nayak and Nayak (2004) have made an elaborate analysis on the farming methods and indigenous irrigation systems adopted by the Apatani farmers in Ziro valley. They found that the fish-cum-paddy cultivation and their irrigation systems are economically viable and hence sustainable.

In the thesis ‘A study of Technological change in Arunachal Agriculture’, Saikia (2004), highlights the significance of paddy-cum-fish culture of Apatani tribe of Ziro valley. The finding of his research work is the paddy-cum-fish culture has boosted the economic condition of Apatani farmers in a big way. “Apatanis paddy-cum-fish cultivation: An indigenous hill farming system of North East India” Rai (2005) identified that the fish culture in paddy fields and growth of millet on bunds are highly beneficial for the sustainable economic growth of farmers with a high degree of ecological efficiency in Ziro valley. Similarly, a paper “A sustainable mountain paddy fish farming of the Apatani Tribe of Arunachal Pradesh, India” of Nimacho et al. (2010) highlights the effects and trend of paddy cum fish culture which is being practiced in Apatani valley since 1964-65. It has also identified the varieties of fish available and the various crops

grown in the paddy fields. The practice of pisciculture in Apatani valley designed by National Informatics Centre, Lower Subansiri Unit, also highlights the way of practicing paddy crops with fish culture in Apatani valley.

On a research work on “Indigenous agricultural systems of north east India” Lalsiemlien (2008) analyzed the inherent characteristics of the sustainability of rice based farming system of the Apatanis, Zabo based terrace wet rice cum fish culture of the Chakhesangs and Bamboo drip irrigation system of Jaintia and Khasi Hills in Meghalaya and tried to explore the ways to replicate them in other parts of the region. In a work on “Influence of different levels of supplementary feeding on the growth performance of major carps” Muhammad, et al.(2003), conducted an experiment in some ponds to observe the effect of varying levels of supplementary feed on the growth performance of Indian major carps and to evaluate the optimum feeding level for these species and found a highly positive correlation between feed added and weight gain in all treatments.

Debasis and Debasis (2011), in their paper on “Prospect of paddy cum fish culture” of Lohit district”, analyzed the nature of the practice of paddy-cum-fish culture and its important role in generation of employment opportunities for both skilled and unskilled youths. They highlighted on production methodologies and suggested that the varieties of fish could be cultured in paddy fields along with other crops as well in rainy season. Kanwar (2010) in his thesis “Nutrient uptake of indigenous rice cultivars for enhanced productivity from rice-fish system of Apatani valley, Arunachal Pradesh, India”- made a comparative study on an experimental site located at Apatani valley in managed rice-fish plots and the other farm managed at R.G.U. by the researcher. He observed the pattern of nutrient uptake and level of rice production of paddy in two different locations during kharif sessions of 2006-2008. He found that the soil and water condition are highly favourable for fish culture in the rice field of Ziro valley.

(c) Negative Impacts of Fish Culture in Paddy Fields

There are also good numbers of studies which show the negative impact of fish-cum-paddy cultivation. Li et al. (1995) found in their report that the rice yields in fields with fish to be 4.3 per cent lower as compared to fields without fish. Similarly, Dam (1990) observed that the stocking of Nile tilapia negatively affected rice yield in the Philippines. A controlled experiment

in Vietnam showed that paddy yields were not significantly different for plots with and without fish. The studies on “Effect of fish on the yield & yield components of rice in integrated concurrent rice-fish system” by Vromant et al. (2002), “Rice with fish culture in the semi-deep waters of the Mekong Delta” by Rothuis et al. (1998) and “Rice-fish farming system research in China” by Xu & Guo (1992) shows that fish rearing in paddy fields has no significant effect on rice production. Ardiwinata (1957) in his study on “Fish culture in rice fields in Indonesia” reported that out of five trials, three cases showed no effect of fish on rice yield and two gave lower rice yields in presence of fish.

Fernando (1993) in his study on “Rice-field ecology and fish culture” found that the rice-fish culture has had both positive and negative effects history during the last 150 years. Further, he noticed that fish rearing in rice fields could create many problems in establishing economically viable farm operations. Fernando (1993) in his book title “Rice field ecology & fish culture- an overview” noticed that in industrialized countries like Japan, Italy, Hungary etc, fish culture in rice fields is rarely practiced mainly due to the fact that it is no longer economically attractive and that the cultivation of rice has been mechanized to such an extent that the rice fields in those countries are becoming unsuitable for fish culture. In recent years, various authors have studied the effect of fish-cum-rice culture in various parts of the world. Their purpose was to examine the advantages and disadvantages of it and also to suggest some concrete solutions in order to stimulate its development.

Lipton (1983), in his extensive research work on “Prospects of paddy-cum-fish culture in the north eastern region of India”, examined the practice of paddy-cum-fish culture and found that there is more scope for fish production in paddy fields in north eastern states. Through his paper “Watershed management in Hills” Satapathy (1997), analyzed the ill-effects of the continuous non-scientific use of agricultural land and suggested some models based on watershed. His model of farming system could be a remedial measure for controlling the degradation of land and for efficient water management in the hills of North East India. In a research paper on “Alternate wet/dry irrigation in rice cultivation: A Practical way to save water and control Malaria and Japanese Encephalitis” Wim et al. (2001), observed that the intermittent drying of the rice field instead of keeping them continuously flooded help the human health by controlling the diseases especially Malaria and Japanese Encephalitis as it usually breeds from rice fields.

Conclusion

It is concluded that the rice-fish farming in some countries did not involve deliberate or selective stocking of fish in paddy fields. In many parts of the world it is found that the production of fish in rice fields is almost as old as the practice of paddy culture itself. However, the production of fish from the same field is not possible when chemical fertilizers and pesticides are used to increase the production of rice. The rice-fish integration helps the optimum utilization of available land and water resources which minimizes the risk element associated with paddy alone cultivation. The rice-fish integrated farming practice yields higher income to the farmers because of the natural compatibility between rice and fish in a managed ecosystem of the agriculture. “Rice-field ecology and fish culture” found that the rice-fish culture has had both positive and negative effects history during the last 150 years. Moreover, it is noticed that in industrialized countries like Japan, Italy, Hungary etc, fish culture in rice fields is rarely practiced mainly due to the fact that it is no longer economically attractive and that the cultivation of rice has been mechanized to such an extent that the rice fields in those countries are becoming unsuitable for fish culture.

REFERENCES:

1. Ali, M.R., 2003 : “Influence of Different Levels of Supplementary Feeding on the Growth Performance of Major Carps”. *Pakistan Journal of Biological Sciences* 6(9): 849-853, ISSN 1028-8880.pp-849-853.
2. Ardiwinata, R.O. 1957 : “Fish-culture in rice fields in Indonesia”- Proceedings Indo-Pacific Fisheries Council 7:pp.119-162.
3. Ali, A.B. 1998 : “Rice agro ecosystem and the maintenance of biodiversity” Agriculture Publishing House, Beijing. P.25
4. Coche, A.G 1967 : “Fish-Culture in Rice-field”. *A world wide synthesis*, Hydrobiol; 30(1):pp.1-44.
5. Cagauan, A.G. Dela C., 1994 : “Impacts of fish and pesticides: Role of fish in Enhancing Rice field Ecology and in Integrated pest management” (Eds C.R.dela Cruz). ICLARM Conference Proceedings 43, Manila: pp.22-23.
6. Cagaun, A.G. 1999 : “Production, Economics and Ecological effects of Nil tilapia (*oreochromis niloticus* L.): A hybrid aquatic fern azolla (*Azolla microphylla* kaulf. *Azolla filiculoides* Lam) and mallard duck (*Anas platyrhynchos* L.) in integrated low land irrigated rice-based farming system in the philippines”. Ph.D. thesis, University Catholique de

- Louvain.
7. Cagauan, A.G. et al. 2000 : “Integrating fish and azolla into rice-duck farming in Asia”. *Naga*, the ICLARM Quarterly vol.23. no.1.
 8. Fernando, C.H. 1993 : “Rice-field ecology & fish culture- an overview”. Proceedings Indo-Pacific Fisheries Council, Hydrobiol, 259: pp.91-113.
 9. Fedoruk, A. & Leelapatra, W. 1992 : “Rice field fisheries in Thailand”. Rice-Fish Research and Development in Asia. (Eds. by C.R. Dela Cruz; C. Lightfoot, B.A., Costa-Pierce, V.R. Carangal & M.P. Bimbao) ICLARM Conference proceedings, 24: pp.91-104.
 10. FAO 1957 : “Fish culture in rice fields”. A preliminary review & annotated bibliography proceedings Indo-Pacific Fish Countries 7 (2/3): pp.193-206.
 11. Gurung, T.B. and Wagle, S.K. 2005 : “Revising Underlying Ecological Principles of Rice-Fish Integrated Farming for Environmental, Economical and Social benefits”. Nepal Agriculture Research Council (NARC), Fisheries Research Station, Pokhara Lake, Baidam, Nepal. Published by Our Nature (2005) 3:pp.1-12.
 12. Ghosh, B. et al. 1995 : “Bright Prospects for rice-fish Culture”. *Yojana*, 39(9): pp.47-48.
 13. Ghosh, A. & Chakrabarte, P.K. 1990 : “Rice-fish production system: A viable technology for coastal wetland management in West Bengal”. Rice in wet land ecosystem (Eds)- R.R.Nair & C.A. Joseph, Kerala Agricultural University,1: pp.261-267.
 14. Hora, S.L. & Pillay, T.V.R. 1962 : “Handbook of fish culture in the Indo-Pacific region”. FAO Fish. Tech. Paper, (14). P.204.
 15. Hofstode, A.E. & Ardiwinata, R.O. 1950 : “Compiling Statistical Data on Fish Culture in Irrigated Rice field in West Java”. *Landbouw*, 22: pp.469-492.
 16. Israel, D.C. & Sevillega, R.C. 1995 : “International Cooperation for Fisheries & Aquaculture Development”. Proceedings of the 7th Biennial Conference of the International Institute of Fisheries, Vol. 2. pp.273-283.
 17. Kacha, D. 2017 : Paddy-cum-Fish Culture in Ziro Valley, Arunachal Pradesh Patridge, Penguin Random House Company, Bloomington in Indiana, USA.
 18. Kutty, M.N. 1987 : “Fish Culture in Rice Fields”. African Regional Acquaculture Centre, Port Harcourt, Nigeria.
 19. Kanwar, A. 2010 : “Nutrient Uptake of Inigenous Rice Cultivars for Enhanced Productivity from Rice-Fish System of Apatani valley, Arunachal Pradesh, India. An Unpublished thesis, RGU, Rono-Hills, Itanagar, Arunachal Pradesh.
 20. Koesoemadinata, S.D. 1992 : “Development of Rice-Fish Farming in Indonesia: Past, Present and

- Future. Research Institute Water Fisher Agency for Agriculture Research and Development. 1- Jala Sampur Bogor, Indonesia.
21. Koesoemandinata, S. & Costa-Pierce, B.A. 1992 : “Development of rice-fish farming in Indonesia: Past, Present & Future”. pp.45-62. In C.R. dela Cruz, C.Lightfoot, B.A. Costa-Pierce, V.R. Carangen & M.P. Bimbao (Eds):Rice-fish Research & Development in Asia. ICLARM conference proceedings, 24: P.457.
 22. Khoo, K.H. & Tan, E.S.P. 1980 : “Review of rice-fish culture in southeast Asia”. PP. 1-14. In R.V.S. Pullin & Z.H. Shehadeh (Eds) Proc. of the ICLARM SEARCA conf. on Integrated Agriculture-Aquaculture farming system 6-9 August 1979, Manila, Philipines, P.258.
 23. Li, K. 1992 : “Rice-fish farming in China: past, present & future”. pp.17-26. In: C.R.Dala Cruz, C.Lightfoot; B.A.Costa-Pierce, V.R. Carangal & M.P.Bimbao (Eds); Rice-fish research & development in Asia ICLARM conference Proceeding, 24: p.457.
 24. Li, K. 1988 : “Rice-fish culture in China: A Review”. Aqusculture 712, pp.172-186.
 25. Lipton, A. P. 1983 : “Prospects of Paddy-cum-Fish Culture in the North Eastern Region of India”. *‘Sea food Export Journal’*, 15(1) pp.25-30.
 26. Lightfoot, C., Roger, P.A., Cagauan, A.G. & Delia, C.R. 1992 : “Preliminary Steady-State nitrogen models of a wetland rice field ecosystem with & without Fish”. V. Christensen & D. Pauly (Eds) Trophic models of Aquatic ecosystems ICLARM, conference proceedings no.26.
 27. Mukhopadhyay, P.K., Das, D.N & Roy, B. 1992 : “On-farm research in deep water rice-fish culture in West Benge, India”, pp. 255-272. In C R data Cruz, C. Lightfoot, B.A. Costa-Pierce, V.R. Carangal & M.P. Bimbao (Eds) Rice-fish Research and Development in Asia, ICLARM conference proceedings 24: P.457.
 28. Nayak, B.D. and Nayak, S.S. 2004 : “Indigenous Irrigation System Farming Method and Economic Condition of Apatani Tribe of Arunachal Pradesh”. In an edited book ‘Watershed Management: Social and Institutional Issues in North East India’ Published by ICAR, Research Complex for NEH Region, Shillong.
 29. Nimachow, G., Rawat, J.S., Dai, O. and Loder, T. 2010 : “A Sustainability of Paddy-Fish Farming of the Apatani Tribes of Aruanchal Pradesh, India”. *‘Acqua culture Asia Magazine’*, volume XV NO.2, April-June-2010.
 30. Purushan, K.S. 1986 : “Recent Advances in Paddy-cum-fish culture & its scope in Kerala”. *‘Sea Food Export Journal’*. Vol.8. (5): pp.1-4.
 31. Ramakrishnan, P.S. 1997 : “Scientific Basis of Traditional wet rice cultivation by North-East Indian Hill Tribes”. Trends in Agrarian structure in the hills of North-

East India, Ajay Verma Common Wealth Publishers, New Delhi.

32. Rai, S.C. 2005 : “Apatani paddy-cum-fish cultivation: An Indigenous hill farming system of North east India”. *‘India Journal of traditional knowledge’* vol. 4(1), January 2005, pp.65-71.
33. Rothuis, A.J., Nuan, D.K., Richter, C.J.J., & F. Ollevier, 1998 : “Rice with fish Culture in the semi-deep waters of the Mekong in Delta, Vietnam”: A Socio-Economic survey. *Aquaculture Research Journal* 29; pp.47-57.
34. Satapathy, K. K. 1997 : “Watershed Management of Hills”. Trends in Agrarian structure in the hills of North-East India, Common Wealth Publishers. New Delhi. pp.248-263.
35. Saikia, B. 2004 : “A study of technological change in Arunachal Agriculture”. Trends in Agrarian Structure in the Hills of North East India. Ajay Verma Common Wealth Publishers New Delhi. pp.120-130.
36. Sahrawat, K.L. 2006 : “Fresh water shortages and strategy for wetland rice cultivation Management”. *More Expressions*, A quarterly publication, Vol. (1) Inaugural Issue (January, 2007).
37. Sing, H. & Swami, S.K. 1998 : “Record Carp Production in Punjab ponds new Possibilities”. *Indian Farming*, 48(b) P.21.
38. Sevilleja, R.C. & Lopez, E.A. 1986 : “Rotational Cropping Patterns for Rice & Fish”. FAC Progress Report, Fresh-Water Aquaculture Center, Central Luzon State University, Nueva Ecija Philippines.
39. Sinhababu, D.P., Ghosh, B.C., Panda, M.M. & Reddy, B.B. 1983 : “Effect of fish on growth & yield of rice under rice-fish culture”. *Journal Oryza* 20: pp.144-150.
40. Sharma, A., Arpita, S. and Saxena, A. 2011 : “Paddy-cum-Fish Culture: Innovative idea for entrepreneurs in Rural Areas”. Deptt. Of Agricultural Communication, College of Fisheries, G.P. Pant University of Agriculture and Technology, Pantnagar (Uttarakhand).
41. Singh, V.P., Early, A.C., Wickham, T.H. 1980 : “Rice agronomy in relation to rice-fish-culture”. In ICLARM Conference Proceedings 4, Manila.
42. Tiwari, P.N. 1993 : “Integrated farming research for sustaining food production”. In *Journal of the Research Department* Vol.XI.No1. Shillong Director of Research, Government of Arunachal Pradesh. pp.223-245.
43. Torres, M.C., & Sevilleja, R.C. 1983 : “Preliminary economic analysis of fresh water fish production under various management systems”. Tech. Report No.13. Freshwater

- Aquaculture Centre, Central Luzon State University, Nueva Ecija Philippines.
44. Tamura, T. 1961 : “Carp cultivation in Japan. In: Fish as a food”. (ed. G. Borgstrom), Academic Press, New York, pp.103-120.
 45. Vinke, M.M.J. 1996 : “La rizipisciculture et less elevages associes in Afrique”. Symposium on Aquaculture in Africa, Accra, Ghana, CIFA Tech. Paper (4) supl.1:pp.659-707.
 46. Vinke, M. 1976 : “La rizipisciculture etles elevages associes in Afrique”. CIFA, tech.pap. (4) Suppl. 1:pp.659-707.
 47. Vromant, N., Duong, L.T., & Ollevier, F. 2002 : “Effect of fish on the yield & yield components of rice in integrated concurrent rice-fish system”. ‘Journal of Agriculture Science’ 138: pp.63-70.
 48. Wim, V.D.H., Sakthivadivel, R., Melanie, R., Jhon, B.S., Martin, H., Birley and Fleming, K. 2001 : “Alternate wet/dry irrigation in rice cultivation: a Practical way to save water and control Malaria and Japanese Encephalitis”. Research paper Published by ‘Plant Research International’. pp.145-189.
 49. Wu, L. 1995 : “Methods of rice-fish culture and their ecological efficiency”. K.T. Mackay (Eds) Rice-fish culture in China. International Development Research Centre (IDRC), Ottawa, Canada 276.pp.91-96.
 50. Xu, Y. & Guo, Y. 1992 : “Rice-Fish Farming System Research in China. In: Rice-Fish research & development in Asia”. (Eds. C.R. De, La Cruz., Lightfoot, B.A. Costa Pierce, V.R. Caranga & M.P. Bimbao) ICLARM conference proceedings 24: pp.315-324.