

Agriculture–aquaculture mix boosts productivity

RIU

Validated RNRRS Output.

Growing crops and fish together raises productivity and helps relieve pressure on land and water resources. This could help many developing countries where land and water are under extreme pressure. Simple forms of community management make good use of water and nutrients and boost harvests of fish from rice fields, ponds and traps. Community groups successfully manage integrated systems in Central Bangladesh, southeast Cambodia and northeast Thailand. Integrating water use in aquaculture and agriculture is now spreading throughout South and Southeast Asia. In northwest Bangladesh around 30,000 households already produce fry and fingerlings in rice fields. These integrated systems have great potential for improving livelihoods and nutrition for millions of the rural poor.

Project Ref: **AFGP04:**

Topic: **3. Improving Fishers Livelihoods: Better Fishing Management & Aquaculture**

Lead Organisation: **University of Stirling, UK**

Source: **Aquaculture & Fish Genetics Research Programme**

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Description

Research into Use

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[Bangladesh](#), [Cambodia](#),
[India](#), [Sri Lanka](#),
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Target Audiences for this content:

[Fishers](#),

AFGP04**A. Description of the research output(s)****1. Working title of output or cluster of outputs.**

In addition, you are free to suggest a shorter more imaginative working title/acronym of 20 words or less.

Integrated Aquatic Production for Rural Livelihoods

Development of diverse and productive agro-aquaculture systems to enhance food production and livelihoods opportunities for poorer households and communities

2. Name of relevant RNRRS Programme(s) commissioning supporting research and also indicate other funding sources, if applicable.

Aquaculture and Fish Genetics Research Programme (AFGRP)

AFGRP support also led to award of linked work in the EU INCODEV programmes

Improved resource use efficiency in Asian integrated pond-dike systems (POND LIVE), and Managing Agrochemicals in Multi-use Aquatic Systems (MAMAS)

3. Provide relevant R numbers (and/or programme development/dissemination reference numbers covering supporting research) along with the institutional partners (with individual contact persons (if appropriate)) involved in the project activities. As with the question above, this is primarily to allow for the legacy of the RNRRS to be acknowledged during the RIUP activities.

R7052: Fish Seed Quality in Asia (Improving freshwater fish seed supply and performance in smallholder aquaculture systems) – Partners: Bangladesh Fisheries Research Forum (BFRF); Bangladesh Agricultural University (BAU); CARE Bangladesh

R8286: Impact of Production and Marketing of Freshwater Aquatic Products on Rural Livelihoods – Partners: Regional; Worldfish Center, Bangladesh: Bangladesh Agricultural University (BAU), UK; Hambrey Consulting

R7917: Self Recruiting Species in Aquaculture, Their Role in Rural Livelihoods – Partners: *Regional: Worldfish Center, Network of Aquaculture Centers in Asia, Bangladesh; Bangladesh Fisheries Research Forum (BFRF); Bangladesh Agricultural University (BAU), Vietnam: Research Institute for Aquaculture 1; Ministry of Fisheries, Thailand – Asian Institute for Technology*

A07: Evaluation of Issues in Aquaculture Production (Aquaculture Strategy Studies)

A09: Documentation of Aquatic Resource Use in West Bengal (Aquaculture Strategy Studies) **A10:** Climate Change Impacts- Aquaculture (Aquaculture Strategy Studies)

D10: Communication for Aquaculture Development (Dissemination Programmes).

4. Describe the RNRRS output or cluster of outputs being proposed and when was it produced? (max. 400 words).

This requires a clear and concise description of the output(s) and the problem the output(s) aimed to address. Please incorporate and highlight (in bold) key words that would/could be used to select your output when held in a database.

In many areas of the developing world **land** and **water resources** are being placed under extreme pressure. While Green Revolution technologies have ensured that expansion of food production has exceeded population growth, abandonment of traditional land and water management systems and increased use of agrochemicals have had profound effects on the structure and function of **agro-aquatic ecosystems**. In many locations further intensification and expansion of conventional agriculture will be either unfeasible or be unable to bring about further increases in productivity, particularly due to constraints on water availability. Solutions which extract greater productive value from finite land and water resources whilst minimizing negative impacts are therefore required.

Integrated farming systems in which nutrients and water inputs are reused locally and **efficiency** of use is improved have been widely promoted. Although they can be effective on a small semi-subsistence and larger commercial scales and offer a broad range of social and ecological benefits, performance is context specific may be constrained by weak integration resulting from factors including nutrient deficits, excessive use of agrochemicals, and insufficient information and management capacity.

It has therefore been necessary to adopt a new adaptive and holistic strategy which recognises that integration can take many forms and generate a variety of benefits to multiple users. AFGRP projects and associated research have comprehensively addressed issues of integrated water use in **aquaculture** and agriculture. This has included: farmer participatory research trials to boost fish production in **pond-dike systems**, analysis of interactions at the production/market interface for **aquatic products**, participatory action research to optimise agro-aquatic production, enhanced species diversity management; strategies for **agrochemical** application and management; use of **rice fields** for **fish seed** production; and understanding the roles of integrated agriculture as a social safety net in urbanising areas.

This can now provide a comprehensive basis, from policy framework to community participation and production services, to develop effective strategies for improved and sustainable **agro-aquatic production**, taking into account regional and local specificities, and the commercial and social context, and delivering significant, positive and widely shared benefits to producer communities and consumers alike.

5. *What is the type of output(s) being described here?*

Please tick one or more of the following options.

Product	Technology	Service	Process or Methodology	Policy	Other Please specify
X	X	X	X	X	

Approaches to integrated agro-aquatic production and its promotion will vary according to need and context. It is a very broad theme and could therefore potentially incorporate all of options listed above

6. *What is the main commodity (ies) upon which the output(s) focussed? Could this output be applied to other*

commodities, if so, please comment

Because the output is broad in scope it can be applied to a vast range of agricultural commodities. Principle among these are fish, rice, vegetables and fruit

7. What production system(s) does/could the output(s) focus upon?

Please tick one or more of the following options. Leave blank if not applicable

Semi-Arid	High potential	Hillsides	Forest-Agriculture	Peri-urban	Land water	Tropical moist forest	Cross-cutting
X	X	X	X	X	X	X	X

As noted in question five, this is a very broad theme and could therefore potentially incorporate all of options listed above. It is likely to have the greatest impacts with regards land water, peri-urban, semi arid, tropical moist forest and high potential systems, but could well have applications elsewhere

8. What farming system(s) does the output(s) focus upon?

Please tick one or more of the following options (see Annex B for definitions).

Leave blank if not applicable

Smallholder rainfed humid	Irrigated	Wetland rice based	Smallholder rainfed highland	Smallholder rainfed dry/cold	Dualistic	Coastal artisanal fishing
X	X	X	X	X	X	

All of the above farming systems have the potential to incorporate elements of integration

9. How could value be added to the output or additional constraints faced by poor people addressed by clustering this output with research outputs from other sources (RNRRS and non RNRRS)? (**max. 300 words**).

Please specify what other outputs your output(s) could be clustered. At this point you should make reference to the circulated list of RNRRS outputs for which proformas are currently being prepared.

Two AFGRP projects, 'Self Recruiting Species in Aquaculture, Their Role in Rural Livelihoods' and 'Fish Seed Quality in Asia (Improving freshwater fish seed supply and performance in smallholder aquaculture systems)' are concerned largely with integration in the context of rice fields and the ecosystems they support. Fish produced in these systems, whether wild or stocked, play an important role in pest management and weed control. Pesticide and herbicide use is minimised or eliminated by farmers producing fish in this manner since the aquatic components of these systems are highly sensitive to agrochemical application. The fish provide perform additional beneficial functions including fertilization and soil aeration.

This output (Integrating water use in aquaculture and agriculture) therefore complements the following outputs from other programmes;

- Crop Protection Programme – ‘Weed management in irrigated rice’; ‘Cost effective weed management packages for lowland rice in Bangladesh’; ‘IPM promotion through improved training manuals’; ‘Managing rice pests in Bangladesh by improving extension service information management for policy and planning’;
- Livestock Production Programme - Cultivation of African dhaincha and fodder khesari as animal feed in rice fields, ‘ “Soil and water conservation’
- Crop Post Harvest Programme; - ‘Pest management tools and strategies’ ‘Food safety in peri-urban horticultural products’; (From the
- Fisheries Management Science Programme - ‘Floodplain fisheries management’
- Natural Resources Systems Programme) - ‘Bangladesh: Integrated Floodplain Management’.

Validation

B. Validation of the research output(s)

10. **How** were the output(s) validated and **who** validated them?

Please provide brief description of method(s) used and consider application, replication, adaptation and/or adoption in the context of any partner organisation and user groups involved. In addressing the “who” component detail which group(s) did the validation e.g. end users, intermediary organisation, government department, aid organisation, private company etc... This section should also be used to detail, if applicable, to which social group, gender, income category the validation was applied and any increases in productivity observed during validation (max. 500 words).

Benefits of integrating water use in aquaculture and agriculture were demonstrated and validated in the AFGRP and associated research detailed above. Farmer trials in Bangladesh indicated that moderate increases in nutrient inputs to carp polycultures in pond-dike systems could nearly double production whilst retaining former levels of vegetable production. Work on enhancing production of self recruiting species occurring naturally in farmers’ systems showed that simple steps taken by farmers in Bangladesh led to substantial increases in production of small indigenous fish in carp polycultures and other small water bodies. In Cambodia and NE Thailand catches of fish in rice fields, household ponds and traps were enhanced by simple forms of community management, with increased household consumption.

Participatory action research, stakeholder involvement throughout the planning and implementation process, and support from fisheries departments and local academic institutions were the key to the successful application of these interventions and allowed for continued adaptation.

Research in Central Thailand and Sri Lanka established a baseline understanding of the behaviour of pesticides in tropical ecosystems, and their accumulation in fish, water and vegetables in integrated systems. This showed the importance of tradeoffs between intensifying terrestrial elements of integrated fruit/horticulture/fish systems and the quality and value of aquatic output available to the poorest community members. Ecotoxicology testing and modelling, and participatory appraisal techniques were used to validate results. Management strategies to

reduce human exposure to pesticides resulting from this technical platform were investigated and practically applied in the field. In NE Thailand research indicated that integrated farming systems had evolved in the presence of off-farm employment opportunities, improved marketing and increased commercialisation. Whilst highly integrated systems were poorly suited to contract farming they performed an important role in the livelihoods of family units from whom members had migrated to urban areas to take up off farm employment.

In Bangladesh, as in Thailand, access to markets was found to have been of critical importance to the development of integrated agriculture/aquaculture and, in the former, had stimulated major wage increases and generated employment opportunities among labourers in both farming and marketing. Also in Bangladesh, production of tilapia and common carp seed in rice fields massively increased the productivity derived from rice fields and the fish ponds of adopting farmers, and was replicated by its rapid spread to new adopters, stimulating substantial increases in tilapia production. These results were variously validated by participatory research methods, studies by supporting institutions, stakeholder workshops, production of dissemination materials and academic research including six PhD theses and numerous peer reviewed publications and grey literature.

Taken together they suggest that farming systems that integrate water usage with other activities to produce more than one crop are viable in a range of forms, providing context specific benefits extending to numerous actors downstream from the site of production. A distinct option to monoculture commercialisation, these have major potential for diversified and poverty-targeted production

11. *Where and when have the output(s) been validated?*

Please indicate the places(s) and country(ies), any particular social group targeted and also indicate in which production system and farming system, using the options provided in questions 7 and 8 respectively, above (max 300 words).

The research listed in section A took place, and has been validated, between 1999 and the present. Promotion and uptake of decentralised common carp and tilapia seed production has been validated across NW Bangladesh. Households in the lowest income group are found to attain the greatest seed production efficiencies under this system, and incomes nutrition gained are particularly important as they are proven to reduce vulnerability during the 'lean season'. Farmer trials that substantially increased yields of small indigenous fish in carp ponds were carried out in the Central and NW regions. Also in Central Bangladesh, benefits of active farmer approaches to integration, where irrigation of associated crops with pond water occurred over more passive management were demonstrated by detailed community appraisal. In a pilot study relatively minor increases in pond inputs dramatically increased fish yields. An in depth marketing study revealed the range and importance of employment opportunities, demand for labour and, elevated wage levels generated by several forms of integrated aquaculture/aquaculture (IAA) throughout Bangladesh. Comparative studies in Vietnam, Thailand and West Bengal also established the extent to which improved access to markets, particularly urban ones, stimulates production of and trade in fish from integrated systems and makes fish more accessible to the poor. The Red River Delta, NE Thailand, and Cambodia were the location of interventions in which local resource user groups were established. These organisations decided communal management strategies to increase the biodiversity of rice based farming systems linked to perennial water bodies, thereby sustainably increasing fish harvests, both in terms of volume and the duration over which they could be captured. This particularly favoured the poorest community members who consume disproportionately large quantities of wild aquatic animals. These outputs

were applied to a broad range of production systems; semi-arid, high potential, peri-urban and land water and farming systems; smallholder rainfed humid, irrigated, wetland rice based, smallholder rainfed highland

Current Situation

C. Current situation

12. **How and by whom** are the outputs currently being used? Please give a brief description (**max. 250 words**).

Integration of water use in aquaculture and agriculture can occur in a multiplicity of ways. However, whilst there are islands of good practice, particularly those linked to AFGRP research sites, much more to be achieved by the scaling up these successful approaches. Adopters of decentralised seed production techniques in Bangladesh stock tilapia brood fish and common carp eggs harvested from ponds into rice fields. The resultant fry may be removed for sale to traders, restocked in owners' ponds for growout, or over-wintered until they reach a larger size and are sold, restocked, or consumed as food.

Members of local resource user groups in SE Cambodia and NE Thailand collectively manage interconnected water resources (rice fields, homestead and trap ponds, and perennial water bodies) to enhance recruitment of wild and stocked fish species. Actions taken include habitat improvement, the conservation of broodstock and fry and their translocation between different components of the system.

Farmers proactively managing integrated systems in Central Bangladesh gain from improved income and more frequent fish and vegetable consumption which is particularly valuable during food deficit months. Information generated by all the projects identified in this proforma has been widely disseminated to institutional users (NGOs, governmental fisheries and extension departments, academics) through workshops, publications and materials such as films, web resources, posters and leaflets. This knowledge is being applied in the field where it is shaping policy decisions and directions, contributing to changing institutional attitudes, and informing other research and development efforts.

13. **Where** are the outputs currently being used? As with Question 11 please indicate place(s) and countries where the outputs are being used (**max. 250 words**).

Outputs are being used throughout S and SE Asia, as detailed in Question 12, additionally, other research outputs from Thailand and Sri Lanka relating to how pesticides can be effectively and sustainably used in commercial agro-aquatic farming systems have wide reaching significance in terms of food safety, food security, occupational health and resource utilisation, all of which contribute greatly to rural livelihoods. Similarly, findings relating to changes in the structure, functions and social role of IAA systems in NE Thailand, and the role of markets and urbanisation in determining demand for aquatic produce in Central Thailand carry major policy implications for other countries in the region where development is following similar trajectories. Dissemination of these findings to policy makers and other players shaping development throughout the region is an ongoing process that has been enacted in all the countries where projects have been located, and internationally through

numerous publications.

14. What is the scale of current use? Indicating how quickly use was established and whether usage is still spreading (max 250 words).

Integrated water use for aquaculture and agriculture occurs in a variety of forms throughout Asia, and strategies to extend or enhance related activities therefore carry great potential. It should be noted that much of the work detailed in this proforma was of a basic or strategic nature. Much application of the work took the form of small-scale pilot studies and in most cases resources were not available for further promotion that would have secured far ranging impacts. However these trials have been indicative of the great potential for future application. The greatest end user adoption resulting from projects detailed here has occurred in NW Bangladesh where an estimated 30,000 households now produce fry and fingerlings in rice fields.

In Cambodia formation of local resource user groups to improve management of self recruiting aquatic animal populations has spread from the six communities where the intervention to place to twelve other neighbouring villages. Approximately 20 peer reviewed publications and 100 other publications have resulted from AFGRP projects and associated research dealing with integration. These will impact research and policy formation, and the understandings developed hold much promise for future application on a much wider scale. For example, the significant role played by self recruiting species in the livelihoods of rural poor throughout Asia had been very largely overlooked until now. If effectively taken up this new knowledge could have a major impact on policy formation and extension practice

15. In your experience what programmes, platforms, policy, institutional structures exist that have assisted with the promotion and/or adoption of the output(s) proposed here and in terms of capacity strengthening what do you see as the key facts of success? (max 350 words).

Development support from a range of bilateral development agencies has assisted the promotion and adoption of outputs relating to integrated water use. Use of programme funds to provide add-ons to existing development projects operated by other such institutions adds value by broadening scope and impact, exploiting complementarities and the reciprocal utilisation of expertise. This was the case for the EU INCODEV funded POND LIVE project.

Partnership with intergovernmental development agencies (e.g. WorldFish Centre), NGOs (e.g. CARE Bangladesh) and local academic institutions (e.g. the AIT in Thailand, RIA1 in Vietnam and BAU in Bangladesh) has repeatedly proven essential to project implementation and dissemination. These partnerships, particularly when maintained over the long term, play an extremely important role in capacity strengthening in target countries, and this outcome is one of the most important benefits derived from collaborative projects. The local expertise of these institutions also ensures that field research and interventions are appropriately targeted in terms of location and user group, and those actors whose participation and endorsement may be critical to project success (e.g. government agencies) are fully engaged.

Where public infrastructure is very weak NGOs, particularly those at the grass roots, may offer the best vehicle for promotion of extension messages, particularly since they have the advantage of freedom from fixed civil service rules and standard operating procedures. However, in some instance these organisations may lack the

technical expertise to disseminate information relating to agriculture effectively, or may focus primarily on other functions such as micro-credit provision, suggesting that collaboration between NGOs and GOs could play a significant role for transforming communication about improved technologies to farmers. The role of neighbours and relatives in transferring information on agricultural technology is equally critical and should not be overlooked as it may be stronger than that of formal information providers.

Current Promotion

D. Current promotion/uptake pathways

16. *Where is promotion currently taking place? Please indicate for each country specified detail what promotion is taking place, by whom and indicate the scale of current promotion (max 200 words).*

Little formal promotion of various programme pilots currently occurs as key research phases are completed. Promotion of local resource user groups for management of self recruiting species by the aquaculture division of the Cambodian department of fisheries, and adoption of the LRUG model for community management of other natural resources by the NGO Catholic Relief Services is an exception.

Farmer to farmer transmission of decentralised tilapia and common carp seed production techniques is taking place in NW Bangladesh and has also been recorded in relation to improved management techniques for integrated pond-dike systems in the country's Central region.

Policy briefs, project reports, research results and peer reviewed publications are in circulation and for each of the projects detailed information has been provided to key stakeholders (fisheries departments, NGOs etc) in each of the countries concerned, particularly through the medium of workshops.

17. *What are the current barriers preventing or slowing the adoption of the output(s)? Cover here institutional issues, those relating to policy, marketing, infrastructure, social exclusion etc. (max 200 words).*

A number of factors hinder further uptake and adoption of farming practices that use water resources in an integrated manner. Insufficient knowledge is perhaps the critical limiting factor, particularly for more complex types of integration since more components in a system require more skills to manage them effectively. Fish seed is one of the most essential inputs for aquaculture. Poor quality, high price and low availability act as constraints in many areas.

Integrated systems cultivating several complementary crops in staggered seasonal cycles are well suited to subsistence needs, but if only small quantities are produced may make marketing problematic. This is particularly so in rural areas with poor transport infrastructure.

Attempts to intensify and commercialise agro-aquatic systems may lead to reduced total gains, lower diversity and poorer system function. In the absence of simple alternatives, poor understanding of human health and other negative implications of heavy pesticide application encourages their overuse, and secondary beneficiaries are

excluded.

18. What changes are needed to remove/reduce these barriers to adoption? This section could be used to identify perceived capacity related issues (max 200 words).

Broader development objectives need to be reflected in the policy and technical support environments to rebalance aims for short-term agricultural output towards more diversification with greater and more equitable benefits, and more resilient agro-aquatic ecosystems

Information services are a key priority for wider adoption. Introducing homestead-based seed production and nursing, via simple systems like those pioneered in NW Bangladesh would reduce input costs to aquaculture substantially. Where integrated systems are being intensified retaining diversity in production reduces vulnerability to price fluctuations and pests, as well as generating cash flows and turnover that supplement that of the major crop. The aquatic components of these systems, which are generally the most sensitive to pesticide application, are also the most important to the poorest users. Policy and provision of extension services should therefore promote more sustainable application of pesticides by demonstrating economic benefits derived from reduced crop protection costs (which can account for 30-40% of operational costs for these systems), and associated increases in biodiversity and the harvest of self recruiting animals. Policy should also support the development of improved marketing infrastructure for as this can substantially increase the opportunities available to semi-commercial operators.

19. What lessons have you learnt about the best ways to get the outputs used by the largest number of poor people? (max 300 words).

In order to impact the poor, technologies, processes or action plans must be highly appropriate to their livelihoods. These must be simple to implement, relevant, low cost, build on pre-existing assets, and show tangible financial or other benefits. Ideally outputs should be skills-based as they can be easily acquired and transferred to others. Interventions will often be most effective when devolved or decentralised as far as possible to the local level (e.g. to grassroots NGOs) since administration costs are reduced and familiarity with conditions on the ground is ensured.

The NGO sector will often have the best capacity to perform extension activities due to its diffuse nature and the weakness of state institutions in many locations, and private sector agents can have a key role. Public institutions should not be overlooked however and their participation in project design and subsequent endorsement can be valuable. Currently the majority of tropical agricultural research is being conducted on a regional level, with African and Asian case studies being disseminated, where appropriate, to their respective region. However, little effort has been made to share knowledge across regions and for example use many of the lessons learned within the Asian context to inform the development process in Africa

Impacts on Poverty

E. Impacts on poverty to date

20. *Where have impact studies on poverty in relation to this output or cluster of outputs taken place? This should include any formal poverty impact studies (and it is appreciated that these will not be commonplace) and any less formal studies including any poverty mapping-type or monitoring work which allow for some analysis on impact on poverty to be made. Details of any cost-benefit analyses may also be detailed at this point. Please list studies here.*

Studies on the impact of decentralised seed production have been carried out by CARE Bangladesh and DFID Integrated; Rice Fish II Qualitative Project Impact Assessment (2001) and a PhD Thesis “Decentralised seed production strategies in Bangladesh: A new approach to developing quality seed supply for sustainable rural aquaculture and livelihoods”, expected publication date 2007. A second thesis, “The livelihood impacts of fishponds integrated within farming systems in Mymensingh District, Bangladesh” (2006), includes assessment of a farmer trial which dramatically increased fish production in ditch-dike systems. Two theses evaluated the impacts of interventions to promote self recruiting species in Bangladesh and Southeast Asia respectively; “Self-recruiting species (SRS) in aquaculture: their role in rural livelihoods in two areas of Bangladesh” (2006) and “Self-recruiting species in farmer managed aquatic systems (FMAS): it's importance to the livelihoods of the rural poor in Southeast Asia (expected 2007). Another doctoral thesis “Impact of pond dike system on livelihoods in Northeast Thailand” addresses the poverty impacts of integrated farming systems in NE Thailand (expected 2007).

21. *Based on the evidence in the studies listed above, for each country detail how the poor have benefited from the application and/or adoption of the output(s) (max. 500 words):*

- *What positive impacts on livelihoods have been recorded and over what time period have these impacts been observed? These impacts should be recorded against the capital assets (human, social, natural, physical and, financial) of the livelihoods framework;*

Positive livelihoods impacts are numerous. They include improved human capital - through the acquisition of knowledge and skills relating to management of stocked and self recruiting fish; social capital – by communal resource management, participation in farmer led research and problem solving, status accorded to adopters who transmit knowledge to others, social cohesion facilitated by gifting of harvested fish, support for family members employed off-farm (e.g. child care), stakeholder participation in marketing networks; Natural capital - more sustainable use of the natural resource base, increased biodiversity in integrated systems; Physical capital – diversified or improved on farm infrastructure (e.g. deepened trap ponds), increased ownership of fish; financial capital - elevated incomes, particularly during ‘lean season’, extended window over which crops can be harvested and sold, improved returns to investment.

- *For whom i.e. which type of person (gender, poverty group (see glossary for definitions) has there been a positive impact;*

Different integrated farming systems return positive impacts to a range of people, particularly extreme vulnerable and moderate poor from farming households and engaged in ancillary activities. These include landless wage labourers (e.g. Burmese and NE Thai wage labourers in Central Thailand) and fishers (for whom employment in integrated fish and giant freshwater prawn culture and participation in marketing and fry trading in Bangladesh has provided alternative, elevated income sources). Participation according to gender is mediated by cultural

norms that vary from country to country. However, even in the most restrictive societies the location of integrated small-holdings close to the homestead allows for female involvement in or responsibility for activities such as weeding and preparing fish feed. Increased household intake of fish protein has been shown in the studies listed above to enhance the nutrition of women and dependents in particular.

- *Indicate the number of people who have realised a positive impact on their livelihood;*

Globally, very large numbers of realise positive livelihoods impacts from integrated agro-aquatic ecosystems. Much of the work detailed in this proforma has focussed on research concepts piloted on a small scale. Uptake and adoption has therefore also often occurred on a similarly limited scale. This should not detract from the far wider potential application of these findings which have been proven as effective means to reduce poverty. So far, the largest group of beneficiaries have been an estimated 30,000-60,000 primary and secondary adopters of rice field fish seed production in NW Bangladesh. Research aimed at increasing SRS production, raising fish and vegetable yields from pond-dike systems, and reducing pesticide application in intensive ditch-dike systems have been trialled with 20, six and one communities respectively. It should be recognised that in each of these instances there is a great deal of scope for wider uptake, given appropriate dissemination.

- *Using whatever appropriate indicator was used detail what was the average percentage increase recorded*

Decentralised seed production produced annual income gains of US\$23, US\$46 and US\$55 to poor, middle income and better off households respectively. Among households restocking fingerlings in their own ponds, the contribution of fish production to household income was 12%. This is double that of households raising fish in ponds who purchased fingerlings from outside sources. In Bangladesh yields of small self recruiting indigenous fish from carp polycultures doubled, and in SE Asia, around 80% of local resource user group members reported increased yields of SRS. The productivity of carp polycultures more than doubled following increased nutrient application in Central Bangladesh. In Central Thailand design of a low drift pesticide nozzle reduced application by 10% with no reduction in efficacy.

Environmental Impact

H. *Environmental impact*

24. *What are the direct and indirect environmental benefits related to the output(s) and their outcome(s)? (max 300 words)*

This could include direct benefits from the application of the technology or policy action with local governments or multinational agencies to create environmentally sound policies or programmes. Any supporting and appropriate evidence can be provided in the form of an annex.

There are numerous environmental benefits associated with integration. In broad terms, more sustainable use of the natural resource base is achieved because system inputs are cycled between the different components in an efficient manner. Outputs generated by one component (e.g. manure from livestock, vegetable trimmings) which

would otherwise become wastes requiring disposal are become valuable resources (e.g. fertilizer, feed). Productivity per unit area land and water is increased (e.g. by stocking fish in a pond that would otherwise be used only for irrigation). The interdependence of system components can act to discourage unsustainable practices. For instance, farmers reduce pesticide applications which would otherwise be toxic to fish seed produced in rice fields. This often dramatically increases the biodiversity of these systems.

25. Are there any adverse environmental impacts related to the output(s) and their outcome(s)? (max 100 words)

Any form of agriculture results in some degree of adverse environmental impact. However, the greater the degree of integration inherent in a system the less pressure it will place on ecosystem functioning.

26. Do the outputs increase the capacity of poor people to cope with the effects of climate change, reduce the risks of natural disasters and increase their resilience? (max 200 words)

Integration diversifies crop production and expands the productivity of finite land and water resources. This reduces vulnerability to climate change and some natural disasters. Destruction caused by floods, hurricanes etc will impact farmers whose livelihoods are dependent on a single crop more severely than those who spread risk by producing a variety of crops since although one or more system components may be lost others may survive. The cultivation of crops on raised dikes, which is a feature of many integrated systems, can offer protection from flooding. Likewise, inclusion of a pond on farms conserves water and is particularly important in rainfed and drought prone areas.
