ISSUES BRIEF | 1894

Recommendation Domains for Pond Aquaculture

KEY MESSAGES

Aquaculture, the world's most dynamic food source, can now be made more economically, environmentally and socially sustainable.

Recommendation Domains for Pond Aquaculture is a suite of decision-support tools that use integrated mapping of the factors that affect aquaculture to help policymakers, planners, managers, researchers and extension workers

- identify the specific strengths and constraints that determine locations' suitability;
- concentrate the promotion of aquaculture in the most ideal locations;
- match appropriate aquaculture systems and technologies to locations according to their prevailing conditions;
- identify interventions that would improve locations' suitability and evaluate potential suitability assuming those interventions occur; and
- explore how changes in conditions — such as new roads that improve access to markets, or climate change that alters water availability — will affect locations' future suitability.

FISHERIES IN TRANSITION

Healthy, nutritious fish provides 200 million Africans with 22-70% of their dietary animal protein. In Asia, the average figure is 30%, climbing to 51% in Bangladesh, 58% in Indonesia and 75% in Cambodia. As a source of protein, essential fatty acids and micronutrients, fish is most prominent — often critically so — in the diets of the poor. As growing economies allow more people to escape poverty, they tend to eat more fish, not less, as they adopt a richer diet. Fish production must rise to keep pace with demand that grows along with spending power as well as with population.

As demand for fish rises, three quarters of wild-caught fish come from fisheries that are depleted, overfished or fully exploited. While aquaculture cannot fully replace capture fisheries, it can relieve pressure on them. Relief is urgently needed. In some coastal areas of Asia, overfishing has driven fish stocks down by as much as 70% over the past quarter century. Faltering capture fisheries and growing populations have made Africa the only region where per capita fish consumption has declined. It fell from 9 kilograms per year in 1973 to 6.6 kilograms in 1997, less than half the world average, and remains at this low level today. In Malawi, per capita fish consumption plunged from 14 kilograms in the 1970s to 4 kilograms in 2005.

Aquaculture has grown steadily and is expected to be the dominant contributor to meeting continuing growth in global demand for fish. The decision-support tools use integrated mapping of the factors that affect aquaculture to evaluate and rate locations in terms of their aquaculture potential.

BENEFITS OF AQUACULTURE

Aquaculture has developed and expanded rapidly in recent decades and now provides almost half of all fish consumed globally. Developing countries dominate aquaculture, contributing 90% of total world production, but they vary greatly in their state of aquaculture development. Depending upon how it is done, aquaculture can sustainably improve food security by making fish more readily available and affordable, or it can damage the environment, to the detriment of all, by depleting aquatic commons such as fisheries and wetlands to satisfy its demand for wild seed and feed and by polluting these commons with runoff. The focus of WorldFish's aquaculture research is to maximize the benefits and minimize the environmental costs to ensure that this development objective is both pro-poor and sustainable.

Low-input freshwater aquaculture is particularly effective at alleviating poverty and malnutrition. When farmed extensively, many fish species need no commercial feeds and produce good harvests relying solely on manure, kitchen waste, leaves and crop residues, converting them into nutritious protein. A survey in Malawi in 2006 found that the rate of malnutrition among children under 5 dropped by two thirds, from 45% to 15%, among smallholder farm families that practiced integrated aquaculture-agriculture for 3 years.

In recent decades, research has bolstered the productivity of small-scale aquaculture without demanding excessive additional inputs or capital. It has achieved this by improving genetic stocks, refining aquaculture practices oriented toward smallholders and fine-tuning them to local conditions. Heightened production of low-cost freshwater fish makes this "rich food for poor people" more plentiful in rural areas and more affordable in urban markets, improving maternal health and child development.

Many countries look beyond the contributions of subsistence ponds to food security and public health. They see aquaculture as potentially providing broader economic benefits by diversifying into market-oriented small and medium-scale production systems that are able to provide significant quantities of fish to local and urban consumers. This progression is necessary and inevitable if aquaculture is to develop into a sustainable and productive subsector that can make meaningful contributions to the rural economy by diversifying household incomes, enhancing entrepreneurial skills and making disadvantaged groups such as women and youth less vulnerable by creating employment and business opportunities. In Bangladesh, evidence shows that on-farm pond aquaculture promotes gender equality by increasing women's access to, and control over, productive resources.

REALIZING THE POTENTIAL

A number of countries have developed national frameworks for aquaculture development that include strategies and policies to guide it along a sustainable path, taking into consideration the range of technology options that can be operated over a spectrum of intensities and corresponding levels of investment. The number of farmers who potentially can benefit from aquaculture research and extension is very large, yet the adoption of improved aquaculture has been

patchy. In Africa, where aquaculture supplies less than 2% of fish production, huge potential lies unrealized. Developing just 5% of the area in Africa suitable for aquaculture would produce enough additional fish to meet the minimum needs of the continent's growing population until 2020. In many Asian countries, ill-conceived placement or mismanagement of fishponds has sometimes degraded the environment and so disenfranchised the poorest of the rural poor, who live by harvesting natural aquatic resources.

Small and medium-scale aquaculture is still largely informal, heterogeneous and widely scattered. Expanding and developing the subsector demands more infrastructure, inputs, services and market support to meet needs that are often specific to locations and contexts. As resources are limited, public policies and investments to promote aquaculture growth should be specifically and appropriately targeted for maximum impact. An informed basis for identifying the targets and priorities constitutes an important bridge between formulating national strategic frameworks and implementing well-targeted projects that improve the chances of successful and sustained adoption. Central to this recommendation is the ability to

1. identify where and under what conditions various types of aquaculture would be feasible and

2. recognize what constraints need to be overcome.

RECOMMENDATION DOMAINS FOR POND AQUACULTURE

A 3-year research project led by WorldFish is poised to give agricultural policymakers, planners, managers and extension workers the decision-support tools they need to help farmers and fishers adopt aquaculture where appropriate and practice the methods optimal for their locations. Scientists piloted the project in four African and Asian countries to test the applicability and utility of the tools at different levels of aquaculture development (Figure 1). These range from the early integration of homestead

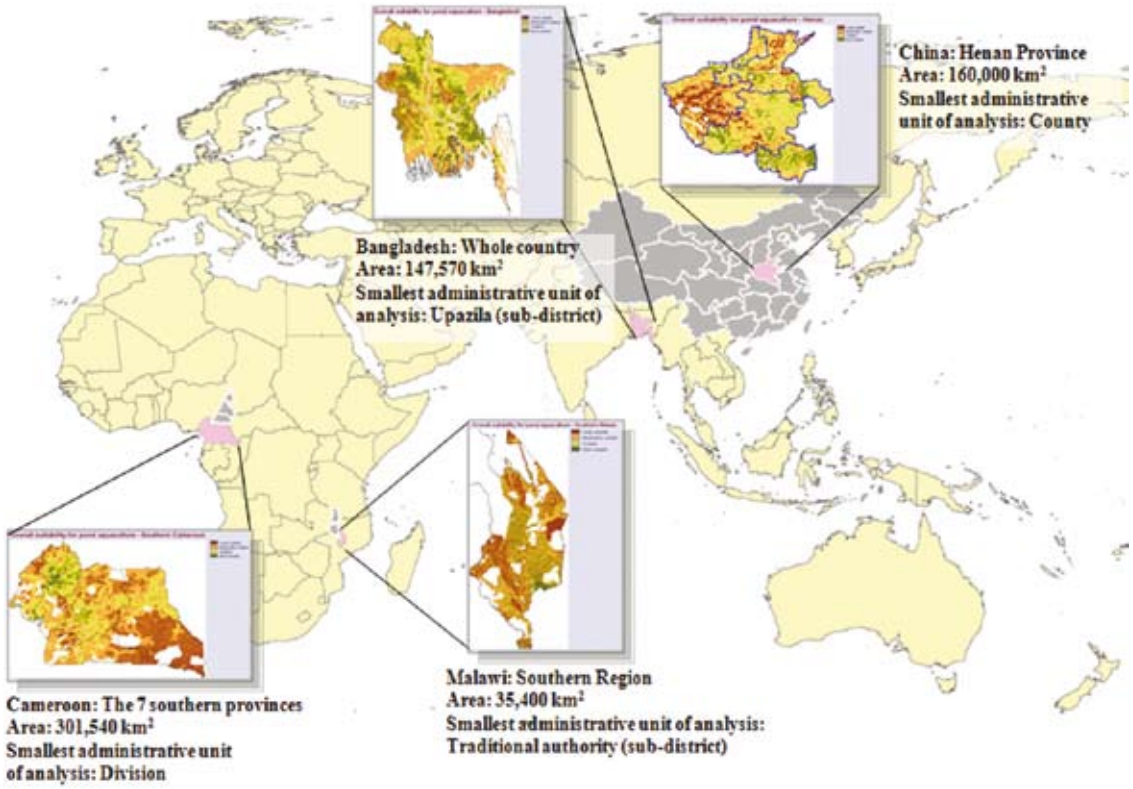


Figure 1. Recommendation Domains for Pond Aquaculture pilot sites in Bangladesh, Cameroon, China and Malawi

fishponds in Malawi and Cameroon to intensive commercial production in China. Bangladesh represents an intermediate stage (Figure 2).

The project systematically identified the factors that influence the likelihood that aquaculture will prove successful. Readily quantifiable factors that can be mapped — such as temperature, the availability of water and other inputs such as seed and feed, terrain and soil conditions, market access, and labor resources — were mapped using geographic information system (GIS) technology. These maps were used as input layers in an integrative GIS model that matches aquaculture requirements with available resources to determine both the potential and the limitations of target areas.

Figure 3 shows assessment results for the Southern Region of Malawi. Suitability for freshwater pond culture was assessed for current subsistence production and a future scenario of semi-intensive production for the domestic market. In the future scenario, greater emphasis was placed on access to markets and water. The resulting model (Figure 3b) shows higher suitability ratings for locations close to roads and urban areas (and therefore enjoying easy market access) and rivers (which provide water) than for locations distant from these features.

The same rating at two locations may reflect different limitations. For aquaculture planning and management, it is important to know the nature of the constraints in less-suited

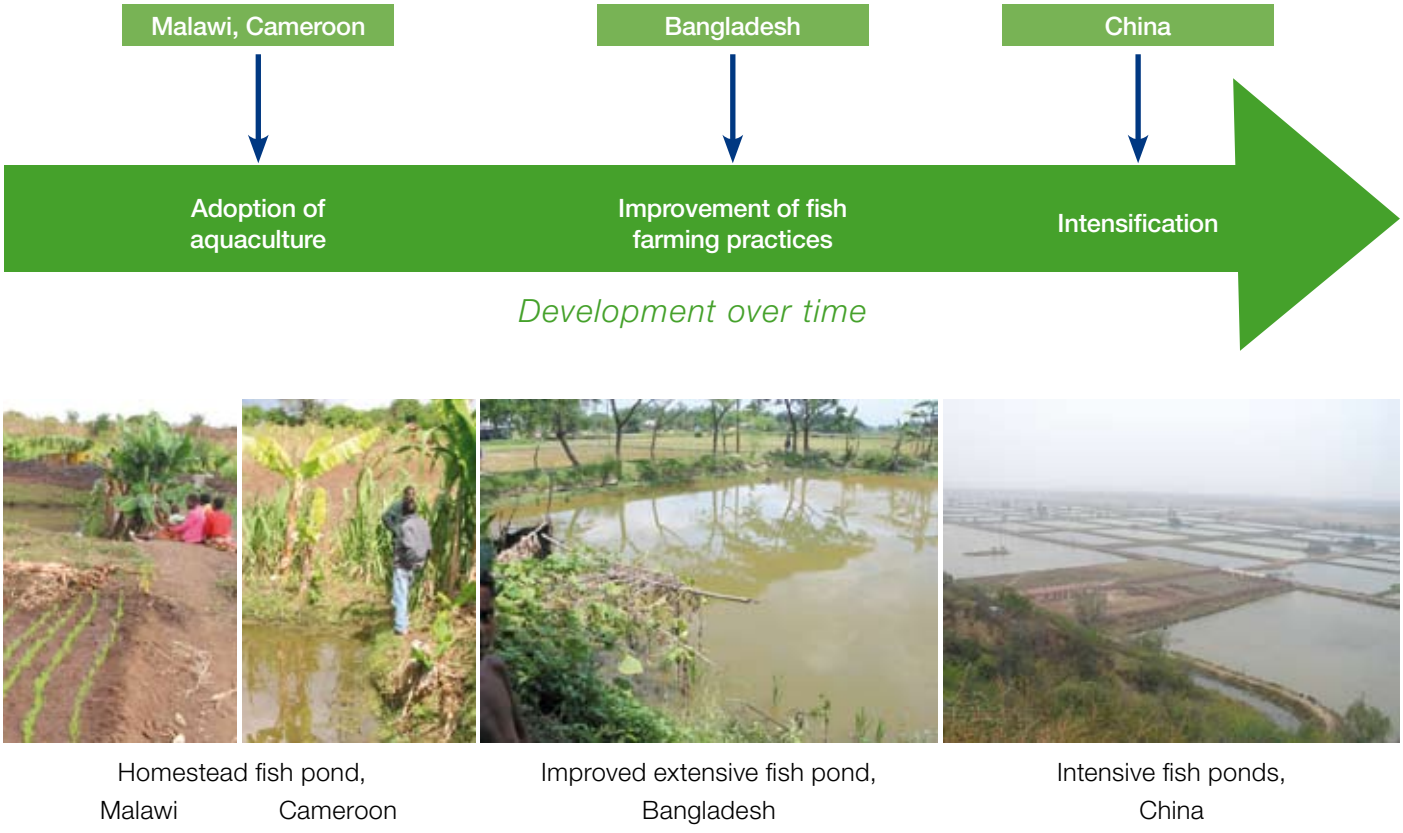
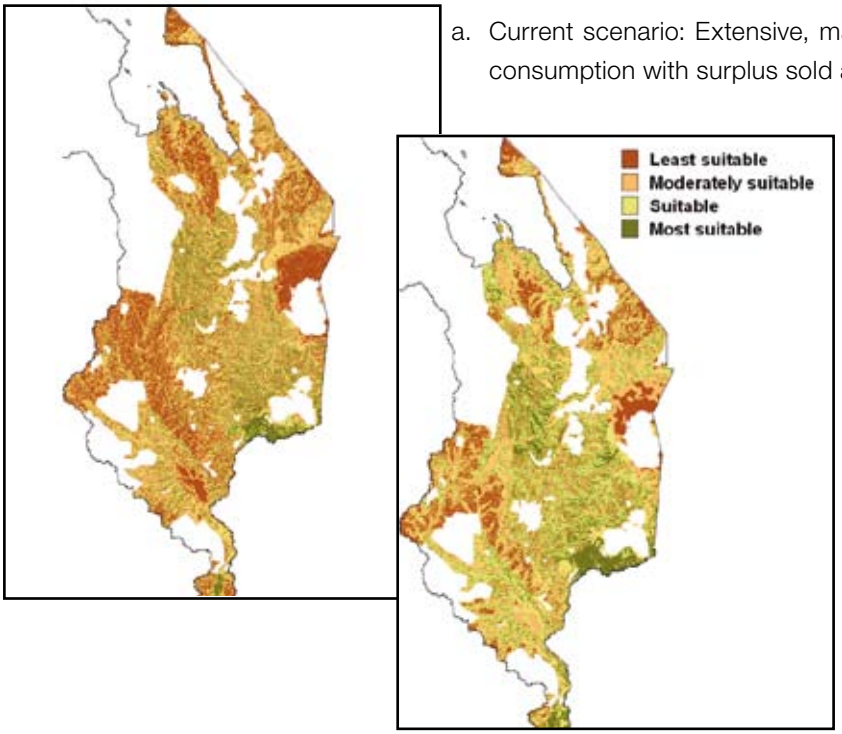


Figure 2. The pilot countries of Recommendation Domains for Pond Aquaculture occupy different stages in the developmental spectrum of aquaculture adoption and intensification



a. Current scenario: Extensive, mainly for home consumption with surplus sold at pond side

b. Future scenario: Semi-intensive, for the domestic market

Figure 3. Overall suitability for freshwater pond aquaculture in the Southern Region of Malawi

areas to determine if interventions can overcome them and, if so, identify appropriate ones. In Figure 4, two locations in Henan Province, China, that are both rated "moderately suitable" are shown to be constrained by different limitations. The location in the northeast is deficient in land and water resources, but the location in the west is constrained by poor access to inputs and markets — two factors that are relatively amenable to intervention.

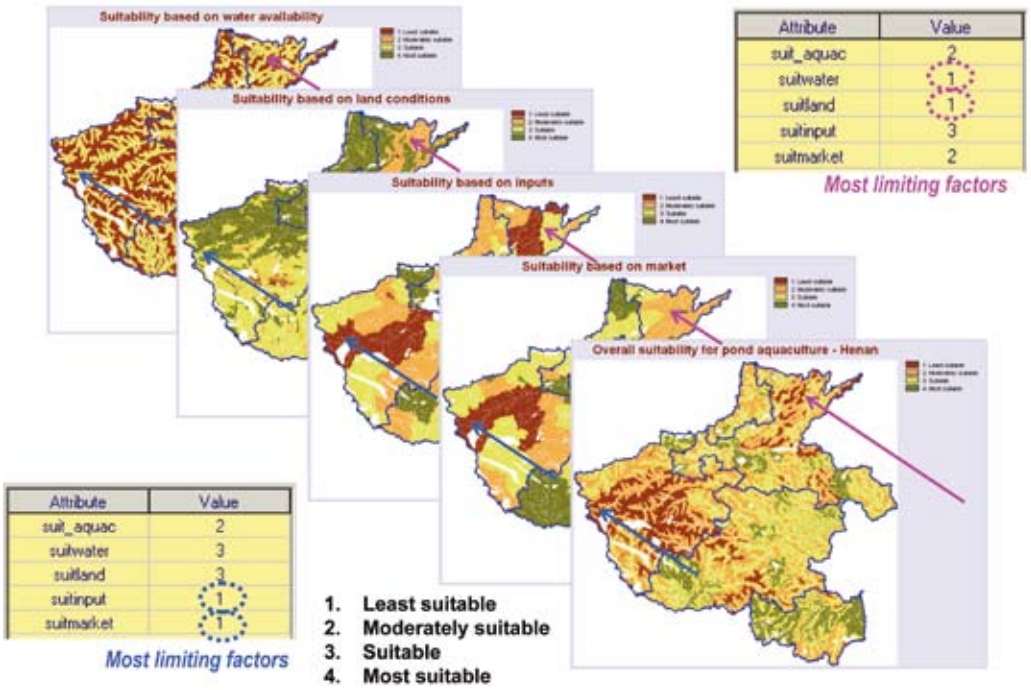


Figure 4. Querying the map of aquaculture suitability for Henan Province, China, reveals that different factors limit potential at two locations rated as moderately suitable

A stakeholder whose particular job is to analyze and improve market access would prefer a different approach to querying the map. Figure 5 demonstrates how this stakeholder can readily determine which moderately suitable areas of Cameroon are constrained specifically by poor market access.

The modeling system can be applied to assess different production systems and target technologies, with the influencing factors and their relative influence adjusted accordingly. It is applicable at different geographic scales, though its use for detailed mapping can be constrained by insufficient geographically comprehensive data. GIS-based modeling is commonly conducted for regional assessment, planning and management. The subsequent siting of fishponds requires on-the-ground investigation in the regions highlighted by GIS modeling.

GIS requires quantifiable data that are comprehensively mapped over the area of interest. However, many factors that are not readily quantifiable, let alone mapped — particularly social, cultural and institutional factors — partly determine whether a particular aquaculture technology is sustainably adopted. In many situations these "soft" factors have an overriding influence on technology adoption, yet they have heretofore been excluded from GIS analysis and modeling.

GIS modeling is therefore complemented in the project with another set of modeling tools based on Bayesian networks, which can incorporate factors of a qualitative or probabilistic nature — for illustrative purposes, factors that influence farmers' perceptions about a particular aquaculture technology. The outcome of the modeling is a reading of the probability of farmers' positive perception of the target technology, which indicates the likelihood that they will adopt it.

Figure 6 shows the result of analyzing farmers' perception of the most common small-scale pond culture system in Bangladesh, which is improved extensive polyculture of Indian carps and tilapia. In this case, the modeling was conducted for eight regions identified by local stakeholders as having distinct characteristics of pond aquaculture development. The most positive perception (63%) occurs where freshwater

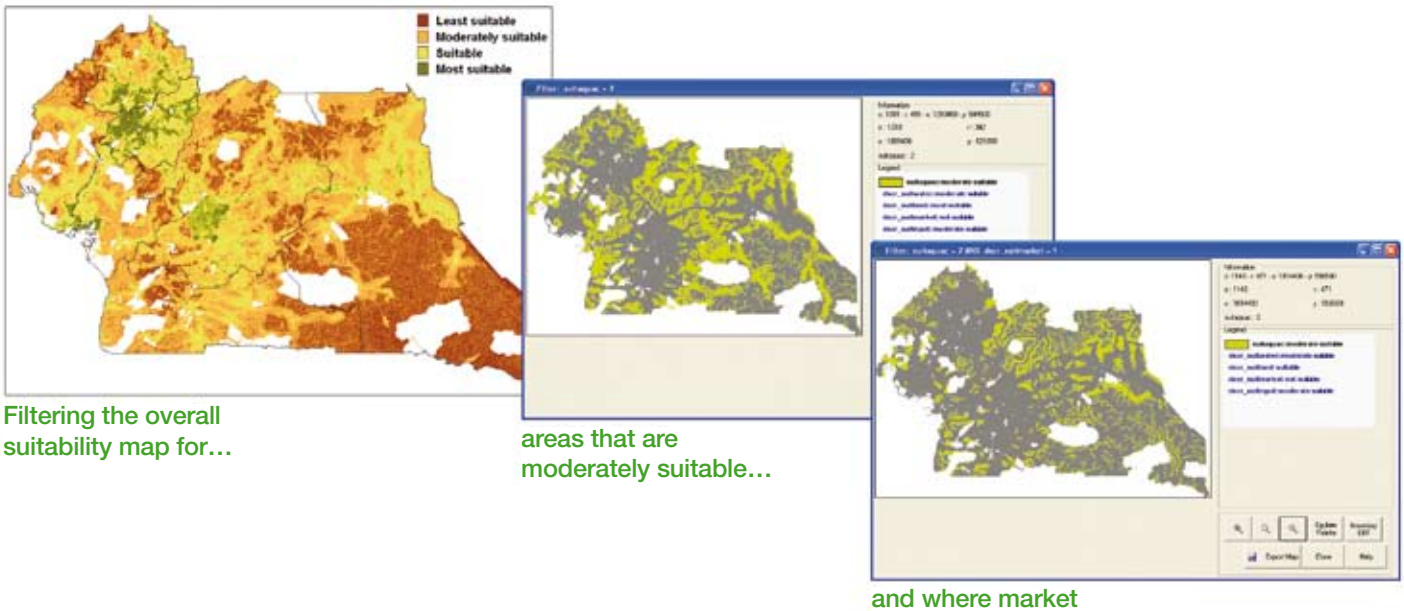


Figure 5. This approach to querying the suitability map for Cameroon reveals where a particular constraint (in this case, market access) occurs in moderately suitable areas

pond aquaculture is most widespread and developed, and the least (54% and 56%) occurs in regions with low-lying, flood-prone depressions.

While most of the factors influencing farmers' perceptions of a particular aquaculture technology cannot be readily mapped, the result from Bayesian network modeling of regions can be mapped, as shown in Figure 6. A mapped result thus obtained can be an input to GIS modeling or added as a map layer when interpreting modeling results.

Bringing together the suitability map for freshwater pond aquaculture and the map showing the production of freshwater fish from ponds (Figure 7), and using the querying tools of the decision support system, helps inform policy decisions for more targeted strategies to develop aquaculture. In Bangladesh, aquaculture potential is already tapped in the most suitable areas (dark green in Figure 7a, corresponding with the sub-districts with high production in Figure 7b). As shown in Figure 6, farmers in these areas are generally positive about aquaculture. Conditions are ripe for intensifying the culture and introducing higher-value species. This would require bringing in more advanced technologies;

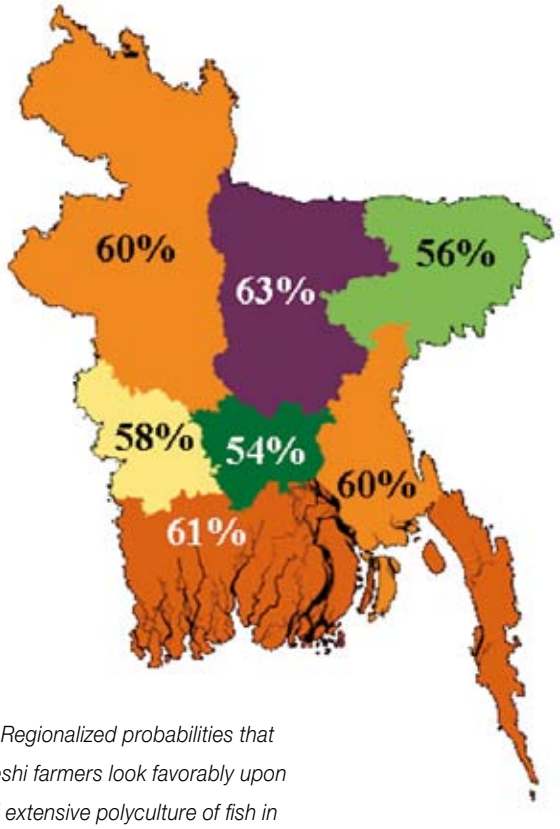
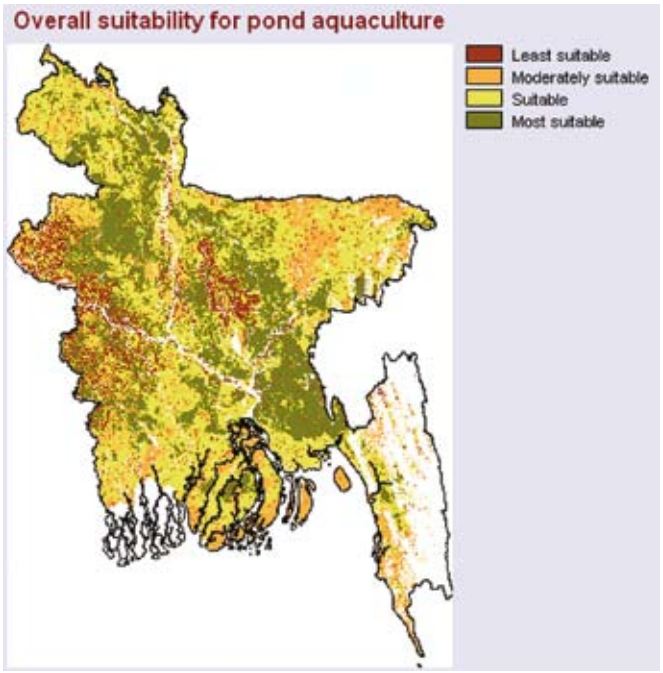
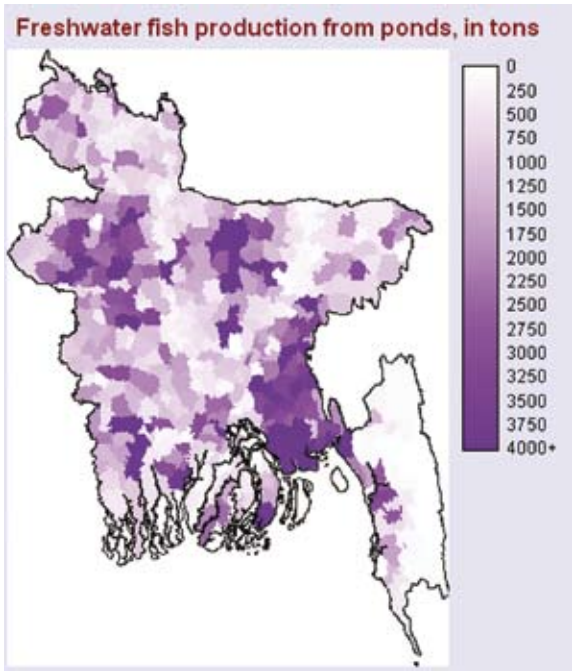


Figure 6. Regionalized probabilities that Bangladeshi farmers look favorably upon improved extensive polyculture of fish in ponds, based on Bayesian network modeling



a. Suitability assessment for improved intensive polyculture



b. Freshwater fish production from ponds, by upazila (sub-district), 2005

Figure 7. Freshwater pond aquaculture in Bangladesh

improving the quality of extension services, feed and seed; and enhancing marketing to add value to the aquaculture products.

The main constraints faced in the least-suitable areas (dark brown in Figure 7a) are inadequate water availability and land condition. The high cost of overcoming these constraints means low comparative advantage for aquaculture and unlikely development in these areas. Areas of intermediate suitability (yellow and orange in Figure 7a) face constraining conditions regarding inputs, markets and institutional support. Improved extensive smallholders systems will likely maintain their predominance in these areas, where the focus should be on making production more efficient by helping farmers overcome location-specific constraints.

CONCLUSION

Together, the GIS and Bayesian network models constitute a decision-support toolkit for stakeholders to help focus aquaculture development in the most promising locations. In less-ideal areas, analysis identifies local constraints on successful adoption and how best to overcome them. The tools can also explore scenarios under evolving conditions: How will patterns of suitability alter if new road construction improves market access? How, if climate change affects rainfall and the reliability of water supply?

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The WorldFish Center
PO Box 500 GPO, 10670 Penang, Malaysia
Tel: +(60-4) 626 1606 Fax: +(60-4) 626 5530
Email: worldfishcenter@cgiar.org