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A comparison of resource use in shrimp farming, part 1: Land

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The intensity of shrimp production could be greatly increased without any additional direct land use for shrimp farms



In this first of three parts, Prof. Boyd discusses land use in shrimp farming in the five major farmed shrimp-exporting countries – Ecuador, India, Indonesia, Thailand and Vietnam – and suggests that the intensity of shrimp production could be greatly increased without any additional direct land use for shrimp farms. Photo by Darryl Jory.

Land use is one of the most critical aspects of natural resource conservation. There is a dual concern: conservation of natural habitats and having sufficient cropland to supply the present and future demand for food and fiber production.

The amount of food produced globally increased more than threefold since 1950, but the world population also increased by a factor of three. Food available per capita is actually slightly greater today than in the 1950s. However, land use for agriculture is only about 10 percent more than in 1950. About 38 percent of the world's land surface is used for food production; thus, had agriculture not become more intensive, there would not have been enough land to provide the demand for food by humans and their domesticated livestock.

Land use in shrimp farming

The data presented here on land use in shrimp farming were obtained from surveys of Pacific whiteleg shrimp (*Litopenaeus vannamei*) farms in the five major exporting countries of farmed shrimp. The number of farms included in the effort is as follows: 101 in Ecuador; 89 in India; 1,341 in Indonesia; 34 in Thailand; and 30 in Vietnam. The data were summarized in greater detail in a **review article** (<https://doi.org/10.1002/aff2.23>)(see *Aquaculture, Fish, and Fisheries* 2021, 1-13).

Shrimp farming requires land on which to build and operate farms. The land necessary for farms is typically between 1.2 and 2.2 times the water surface area of the production ponds. In the survey, averages of the land to production surface area ratio (LWR) ranged from 1.22 in Ecuador to 2.04 in Thailand (Table 1). The average LWR for the five leading shrimp exporting countries was 1.67.



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Boyd, Land Use, Table 1

		Area (ha/farm)				
Country	LWR	Production ponds	Reservoirs	Canals	Settling basins	Embankments and other
Ecuador	1.24	141	8.76	9.03	11.29	5.6
India	1.33	5.15	0.34	0.2	---	1.15
Indonesia	1.77	2.79	1.08	1.32	0.1	0.65
Thailand	2.04	6.84	3.6	0.34	0.86	2.31
Vietnam	1.95	1.77	0.31	0.16	0.09	1.12

Table 1. The farm area to production pond area ratio (LWR) and areas devoted to different earthen infrastructure at shrimp farms in the five major exporting countries.

One meaningful index of land use at farms is the area required per metric ton (MT) shrimp produced each year. The direct farmland use for shrimp aquaculture ranged from 0.09 hectares per metric ton (ha/MT) in Indonesia to 0.20 ha/MT in India (Table 2) with a weighted average of 0.15 ha/MT.

Boyd, Land Use, Table 2

		Production (t/ha)			Land use (ha/t shrimp)		
Country	Crop	Annual	FCR	Direct farm	Feed	Total	
Ecuador	1.96	7.03	1.32	0.18	0.27	0.46	
India	3.45	6.67	1.48	0.2	0.3	0.5	
Indonesia	10.01	19.81	1.41	0.09	0.28	0.37	
Thailand	7.33	17.31	1.49	0.12	0.3	0.42	
Vietnam	5.59	10.92	1.36	0.18	0.27	0.45	

Table 2. Crop and annual pond production, FCR and land use for shrimp production on the five major shrimp exporting countries.

Feed-based farming

Data in Table 2 are for the production of whiteleg shrimp by feed-based farming. A small fraction of whiteleg shrimp and a large portion of black tiger shrimp are produced without or with very little feed by extensive culture. Extensive shrimp farming requires about 1.8 million hectares of direct farm area as compared to 1.7 million hectares for feed-based shrimp farms. Extensive farms produced only 11.4 percent of global shrimp production in 2018. Six million metric tons of shrimp were farmed in 2018. The direct farmland use for extensive production was about 2.5 ha/MT.

Land for extensive shrimp farming is almost entirely within the intertidal zone. On the other hand, feed-based shrimp culture is usually done in farms located above the highest tide level. Most of the destruction of mangroves and other wetland areas attributed to shrimp farming has resulted from extensive shrimp farming. Extensive shrimp farms should not be encouraged and governments should not allow further expansion of extensive shrimp farms within the intertidal zone. Of course, it would create serious local, social problems to prohibit operation of existing extensive farms.



Land use for aquaculture production

Space requirements for aquaculture include the culture water area and associated physical culture facilities as well as the land used to raise plant-based feed ingredients.



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Feed-based shrimp farming requires feeds that contain plant-based ingredients produced on cropland. The amount of land needed for shrimp feed ingredients for seven formulations of shrimp feed varied from 0.14 to 0.34 ha/MT with an average of 0.202 ha/MT. The land necessary for feed ingredients per MT depends on both land use per MT of feed and the FCR (land/MT feed \times FCR = land use for feed/MT shrimp). Land used for feed in the five countries was similar (0.27–0.30 ha/MT shrimp). The weighted average for all countries was 0.28 ha/MT shrimp.

The land use for feed exceeds the land use necessary for direct farm use in feed-based shrimp farming (Table 2). Land for shrimp farms is in the coastal area that typically has a higher ecological value than upland areas for agriculture. Moreover, all types of meat production rely heavily on feeds. When one eats a portion of shrimp, they most likely forego a portion of some other meat, which typically required feed.

The average land requirement for broiler chicken feed of 0.21 ha/MT is similar to that of shrimp feed. Pig and beef cattle feed requires more land on average, 0.307 ha/MT and 0.247 ha/MT, than does shrimp feed. Shrimp farming likely does not increase world land use for food production, because more feed does result from the tradeoff of a portion of shrimp for a portion of another meat.

Land also is used to produce sugar and molasses used in some kinds of intensive shrimp farming. Raw sugar requires 0.09 ha/MT and molasses 0.02 ha/MT. Compared to feed relatively little land is required for carbohydrate sources applied to ponds.

The total land use per tonne of shrimp (direct farm area + land for feed ingredients + land for carbohydrate sources) ranged from 0.37 ha/MT in Indonesia to 0.50 ha/MT in India (Table 2) with a weighted average for the five countries of 0.43 ha/MT.

Reducing land use in shrimp farming

The two main ways of reducing land use for shrimp production are to improve the FCR and to intensify production in ponds. The LWR also is a factor, but in several countries, the low LWR is the result of less use of reservoirs and settling basins. Greater use of reservoirs and settling basins as seen particularly in Thailand should be encouraged. The on-farm areas devoted to the different types of earthen infrastructure at farms are provided in Table 1.

These land use calculations include farms with semi-intensive, intensive, and hyper-intensive production that used feed and most also used aeration. Feed-based production land use of 0.43 ha/MT is much less than the 2.5 ha/MT necessary for extensive production.

Data in Table 2 were for farms producing 4 to 8 MT/ha/crop (based on pond area) to more than 20 MT/ha/crop. There is an opportunity to greatly increase the intensity of shrimp production without any additional direct land use for shrimp farms.

Editor's note: This article was corrected to include the statement: "Extensive shrimp farms should not be encouraged and governments should not allow further expansion of extensive shrimp farms within the intertidal zone." It previously stated that "intensive" farms should not be encouraged. We regret the error.

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