



ISSN Print: 2618-060X
 ISSN Online: 2618-0618
 NAAS Rating (2026): 5.20
 IJRA 2026; SP-9(10): 25-29
www.agronomyjournals.com
 Received: 31-07-2026
 Accepted: 22-09-2026
 Published: 02-10-2026

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Indigenous technical knowledge in aquaculture: Practices, evidence and scope for scientific validation

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DOI: <https://www.doi.org/10.33545/2618060X.2026.v9.i10Sa.6761>

ABSTRACT

Aquaculture systems are managed through a combination of formal technical recommendations and experience developed by farming communities. Indigenous Technical Knowledge (ITK) includes locally developed practices used for pond preparation, water management, stocking, feeding, fish health, harvesting and post-harvest handling. This review examines published evidence on such practices in aquaculture, with emphasis on their reported applications, perceived effectiveness and the need for scientific validation. The literature documents ITK in pond construction and maintenance, water-quality management, stocking, feed management, use of piscicidal plants and fish attractants, post-harvest handling, and fish-health management. Several practices have been assessed as rational or effective in specific locations, whereas others remain insufficiently tested. The available evidence therefore supports treating ITK as a source of locally adapted practices that can be evaluated and, where appropriate, integrated with established aquaculture methods. Further work should focus on systematic documentation, controlled validation, safety, economic performance and applicability under defined production conditions.

Keywords: Indigenous Technical Knowledge, Traditional knowledge, Aquaculture, Fish farming, Traditional practices, Scientific validation, Sustainable aquaculture

1. Introduction

Aquaculture is practiced under a wide range of environmental, social and economic conditions. Consequently, production practices developed by farming communities often reflect local water availability, climate, materials, species and resource constraints. Indigenous Technical Knowledge (ITK) refers to knowledge and practices developed through experience and transmitted within communities. Such knowledge is commonly based on observation, repeated use and adaptation to local conditions (Grenier, 1998; Ponnusamy *et al.*, 2009) [1, 2].

In aquaculture, ITK has been reported for pond construction and renovation, water and soil management, stocking, feeding, fish-health management, predator control, weather-related decisions, harvesting and post-harvest handling (Das *et al.*, 2013; Devi *et al.*, 2014; Gangadhar *et al.*, 2016) [3, 4, 5]. These practices commonly use materials that are readily available within the farming environment. Their importance is particularly evident in small-scale systems, where access to purchased inputs and specialised technical services may be limited.

Published studies also show that the value of an indigenous practice cannot be assumed solely from its continued use. Devi *et al.* (2014) [4] assessed the rationality and perceived effectiveness of several practices in Assam and recommended validation and refinement before wider application. Similar findings were reported by Devi *et al.* (2021) [6], who documented 23 ITKs in fish production and found that only a subset had been assessed for scientific rationale and perceived effectiveness. Thus, the appropriate approach is to document the practice, identify its intended function and test its performance under defined conditions.

The need for validation is particularly important where traditional practices involve direct application of plant materials, animal products or other substances to culture water. Piscicidal plants, for example, may contain biologically active compounds, but their effects depend on plant species, plant part, preparation, dose and exposure conditions (Dutta *et al.*, 2019; Narzary *et al.*, 2023) [7, 8]. Likewise, traditional disease-management practices require assessment of efficacy, dosage, fish welfare, water quality and possible effects on non-target organisms.

ITK may therefore be considered a complementary source of locally relevant knowledge rather than a substitute for established aquaculture science. Practices with demonstrated performance can be further assessed for technical feasibility, cost, safety and compatibility with current production systems. This approach also provides a basis for collaboration among farmers, researchers and extension personnel in testing and refining locally developed practices.

Although a number of studies have documented ITK in Indian aquaculture and fisheries, the evidence is distributed across individual regions and production activities. A synthesis is useful for identifying recurring

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practice areas, distinguishing documented use from demonstrated effectiveness, and defining research needs.

Accordingly, this review synthesizes published information on ITK associated with aquaculture production, covering pond preparation, water-quality management, stocking, feeding, piscicidal plants and fish attractants, post-harvest handling, and fish-health management. Particular attention is given to the evidence available for each practice and to the requirements for scientific validation.

2. Methodology

A literature search was conducted using Google Scholar, Google and relevant academic databases. Search terms included “Indigenous Technical Knowledge,” “traditional knowledge,” “indigenous practices,” “traditional aquaculture practices,” “fish farming,” “aquaculture,” “traditional fish culture,” “local knowledge” and “sustainable aquaculture.” Research articles, review papers, books, book chapters

and institutional reports relevant to ITK in aquaculture and associated fisheries practices were considered.

Supplementary information was obtained through communication with researchers, aquaculture professionals, extension personnel and experienced fish farmers. Observations from field-level extension activities were used only as contextual information and were not treated as independently validated evidence.

The literature was grouped into the following themes: pond preparation and renovation, water-quality management, stocking, feed management, piscicidal plants and fish attractants, post-harvest practices, and fish-health management. Findings were compared across studies, with particular attention to the method used to document each practice and whether its rationality or effectiveness had been assessed.

3. Results and Discussion

3.1 ITK related to pond preparation and renovation

Author's and year	Paper title	Methodology	Major findings
Kalita, Choudhury & Ojha (2004)	Indigenous technical knowledge on pond construction and maintenance, fish seed transportation, and fish health management in Assam hills	Interview schedule; 80 fishers in the Assam Hills Zone.	Farmers used low-lying sites and embankment ponds. Bamboo structures were used for spillways and protection of pond dykes, reflecting adaptation to heavy rainfall and local terrain.
Devi <i>et al.</i> (2014)	Assessment of applicability of Indigenous Technical Knowledge (ITK) in aquaculture as perceived by fish farmers in Assam	Survey of 80 fish farmers and 30 fisheries experts using interviews, observation and assessment of perceived effectiveness.	Four pond-preparation practices were documented: squeeze testing of soil, hole testing of water-holding capacity, bamboo fencing and bamboo-pipe spillways. The latter two were assessed favourably in the study.
Das <i>et al.</i> (2013)	Indigenous technical knowledge for pond maintenance, fish health management and fish seed in Tripura, India	Semi-structured interviews with 160 farmers from 16 villages.	Farmers used locally available materials to manage predators, unwanted organisms, aquatic weeds and algal problems in ponds.

Published studies indicate that pond-management practices are closely linked to local environmental conditions. Kalita *et al.* (2004) [9] documented the use of low-lying sites, embankment ponds, bamboo fencing and traditional spillways in the Assam hills. Devi *et al.* (2014) [4] similarly reported bamboo fencing and bamboo-pipe spillways among the documented ITKs in Assam and found these prac-

tices to be rational or effective according to the assessment used in that study. These observations indicate the practical use of locally available materials for pond construction and protection, but their performance should be evaluated against site-specific engineering and hydrological requirements.

3.2 ITK related to water quality management

Author's and year	Paper title	Methodology	Major findings
Devi <i>et al.</i> (2014)	Assessment of applicability of Indigenous Technical Knowledge (ITK) in aquaculture as perceived by fish farmers in Assam	Survey of 80 farmers; interviews, observation and focus-group discussions, followed by expert assessment.	Practices included the use of banana stem, banana ash, straw or husk, cow urine and bamboo-based surface agitation for pond-water management. Banana ash and surface agitation were assessed as rational in the study.
Das <i>et al.</i> (2013)	Indigenous technical knowledge for pond maintenance, fish health management and fish seed in Tripura, India	Semi-structured interviews with 160 farmers.	Water-management practices included plant materials and cattle urine for algal-bloom management and locally developed methods for judging pH and turbidity.
Devi <i>et al.</i> (2021)	Perceived effectiveness of Indigenous Technical Knowledge on fish production practices in Assam	Documentation and assessment of 23 ITKs covering fish-production activities.	Water-quality management accounted for 27.78% of the documented ITKs. The study identified scientific rationale for several practices but recommended further validation.

Water-quality management is another recurring component of ITK. Devi *et al.* (2014) [4] documented practices involving banana stem, banana ash, straw or husk, cow urine and manual disturbance of the water surface. Among these, banana ash and bamboo-based water agitation were assessed as rational in the study, whereas other practices required further investigation. Das *et al.* (2013) [3] also documented

locally developed methods involving plant materials and livestock products for managing algal growth and other pond conditions. Such practices should be evaluated using measurable water-quality parameters rather than effectiveness being inferred from traditional use alone.

3.3 ITK related to fish seed stocking

Traditional stocking practices may incorporate interactions among cultured fish, crops and pond organisms. *Devi et al. (2014)* [4] documented the use of *Puntius sarana* for aquatic vegetation control and rice-cum-fish culture using common carp among stocking-related ITKs. The same study reported the use of *Labeo gonius* and *L. cal-*

basu in relation to dyke protection, although the evidence for this application was less established. *Das et al. (2013)* [3] documented traditional practices associated with fish-seed production, hatching, transport and reduction of seed mortality. These practices provide useful examples of locally developed management, but their suitability depends on species, stocking density, production system and local conditions.

Author's and year	Paper title	Methodology	Major findings
Devi et al. (2014)	Assessment of applicability of Indigenous Technical Knowledge (ITK) in aquaculture as perceived by fish farmers in Assam	Survey of 80 farmers with interviews, focus-group discussions and observation; rationality and perceived effectiveness were assessed.	Stocking-related practices included <i>Puntius sarana</i> for aquatic-vegetation control, rice-cum-fish culture with common carp, and use of <i>Labeo gonius</i> and <i>L. calbasu</i> in relation to dyke protection.
Das et al. (2013)	Indigenous technical knowledge for pond maintenance, fish health management and fish seed in Tripura, India	Survey of 160 farmers using semi-structured interviews.	Traditional practices were reported for fish-seed production, hatching, transport and reduction of seed mortality, including measures intended to reduce disease contamination during transport.
Gangadhar et al. (2016)	Indigenous technical knowledge in aquaculture sector: A literature review	Review of published literature on indigenous aquaculture practices.	The review grouped ITK across aquaculture operations from site selection and pond construction to breeding, feeding, integrated systems and health management.

3.4 ITK related to fish feed management

Feed management is a major component of documented aquaculture ITK. *Devi et al. (2014)* [4] reported practices involving bamboo, wood, stems and plant branches to encourage periphyton growth, together with plant materials used as feed resources. *Das et al. (2013)* [3] documented a traditional mixture of mustard oil cake and rice

bran, with rice beer included in some cases; reported growth benefits had not been nutritionally validated. *Gangadhar et al. (2016)* [5] similarly described the use of locally available plant materials, agricultural by-products and periphyton-based systems. These practices indicate efforts to reduce dependence on purchased feed, but nutritional composition, digestibility, feed conversion and fish performance require quantitative assessment.

Author's and year	Paper title	Methodology	Major findings
Devi et al. (2014)	Assessment of applicability of Indigenous Technical Knowledge (ITK) in aquaculture as perceived by fish farmers in Assam	Survey and observation of 80 farmers; rationality was assessed by experts and perceived effectiveness by MPEI.	Six feed-management practices were recorded. Examples included placing bamboo, wood, stems or branches to support periphyton and using banana or bamboo leaves as feed resources.
Das et al. (2013)	Indigenous technical knowledge for pond maintenance, fish health management and fish seed in Tripura, India	Semi-structured interviews with 160 farmers.	A traditional feed mixture based on mustard oil cake and rice bran was reported, with rice beer included in some cases. Reported growth benefits required nutritional validation.
Gangadhar et al. (2016)	Indigenous technical knowledge in aquaculture sector: A literature review	Review of literature on traditional aquaculture practices.	The review described locally available plant materials, agricultural by-products and periphyton-based production as recurring components of indigenous feeding practices.

3.5 Piscicidal plants and fish attractants used for catching fish

Piscicidal plants and fish attractants form a distinct group of traditional practices, particularly in relation to fish capture. *Devi et al. (2014)* [4] documented the use of *Duranta* spp. as piscicidal material and branches of saura as fish attractants. *Dutta et al. (2019)* [7] reviewed approximately 114 piscicidal plant species reported from Northeast India and identified several classes of bioactive com-

pounds. *Narzary et al. (2023)* [8] documented six piscicidal species used traditionally in Chirang district of Assam and noted the need for further investigation of their toxicological mechanisms. These findings are relevant to the documentation of traditional knowledge, but use of a plant as a traditional piscicide should not be interpreted as evidence of suitability for aquaculture. Species identification, active compounds, dose-response relationships, non-target effects and environmental persistence require assessment before any aquaculture application is considered.

Author's and year	Paper title	Methodology	Major findings
Devi et al. (2014)	Assessment of applicability of Indigenous Technical Knowledge (ITK) in aquaculture as perceived by fish farmers in Assam	Survey, observation and focus-group discussions with 80 farmers; expert assessment of rationality.	<i>Duranta</i> spp. were reported as piscicidal materials for unwanted fish, while saura branches were used as fish attractants. The latter was assessed more favourably; piscicidal use required further validation.

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Author's and year	Paper title	Methodology	Major findings
Dutta, Singh & Borah (2019)	Piscicidal plants of Northeast India and its future prospect in aquaculture – A comprehensive review	Review of ethnobotanical and scientific literature.	The review compiled about 114 piscicidal plant species reported from Northeast India and discussed bioactive compounds, extraction methods, effective doses and effects on fish.
Narzary <i>et al.</i> (2023)	Ethnobotanically important plants with piscicidal properties used for traditional fishing in Chirang district of Assam, Northeast India	Ethnobotanical field study.	Six plant species were documented as traditional piscicidal plants. Application as paste or aqueous extract was common, while the toxicological mechanisms required further study.
Basumatary & Khangembam (2023)	Ethnobotanical uses of piscicidal plants for fishing by the Bodo Tribes of Kokrajhar, Assam	Survey of eight villages from February 2021–January 2022.	Nine piscicidal plants belonging to seven families were documented. Grinding plants into paste and applying them directly was the most frequently reported method. The authors recommended further research on active ingredients and optimal dosage.

3.6 ITK related to post-harvest practices

Author's and year	Paper title	Methodology	Major findings
Devi <i>et al.</i> (2014)	Assessment of applicability of Indigenous Technical Knowledge (ITK) in aquaculture as perceived by fish farmers in Assam	Survey, observation and focus-group discussions with 80 farmers; rationality and perceived effectiveness were assessed.	Eight post-harvest ITKs were documented, covering live-fish holding, transport, seed marketing and drying. Rice bran was used in thermocol boxes during fish transport.
Panda <i>et al.</i> (2022)	Traditional fish processing in Odisha, India	Study of 72 fisherfolk using questionnaires, interviews, informal conversations and direct observation.	Sun drying was the main preservation method. Fish were dried on earth, mats, palm leaves and bamboo structures made from locally available materials.
Roy <i>et al.</i> (2020)	Traditional knowledge of the fishermen community of Indian Sundarbans: An assessment of rationality and effectiveness	Documentation of indigenous fishing and associated knowledge among fishing communities in the Indian Sundarbans.	The study recorded traditional knowledge related to fishing, natural fish breeding, marketing and other fisheries practices, with rationality and effectiveness assessed by fishers and experts.

Post-harvest practices are represented in the available ITK literature but remain less extensively studied than production practices. *Devi et al.* (2014) [4] reported eight post-harvest ITKs, including practices associated with live-fish holding, transport, seed marketing and drying. *Panda et al.* (2022) [10] documented traditional fish-drying methods in Odisha and reported widespread use of locally constructed drying surfaces and bamboo structures. Such methods can be relevant where access to formal processing infrastructure is limited; however, their per-

formance should be assessed with respect to hygiene, contamination, drying rate, storage stability and product quality.

The available evidence therefore supports documenting traditional post-harvest methods while assessing them against current food-safety and quality requirements. Improvements can be directed at the points where contamination, inadequate drying or poor storage conditions are identified.

3.7 ITK related to disease and health management

Author's and year	Paper title	Methodology	Major findings
Kalita, Choudhury & Ojha (2004)	Indigenous technical knowledge on pond construction and maintenance, fish seed transportation, and fish health management in Assam hills	Interview-based documentation involving 80 fishers.	Traditional practices addressed low dissolved oxygen, turbidity, <i>Argulus</i> , leeches and Epizootic Ulcerative Syndrome, within a broader set of pond, seed-transport and fish-health practices.
Das <i>et al.</i> (2013)	Indigenous technical knowledge for pond maintenance, fish health management and fish seed in Tripura, India	Semi-structured interviews with 160 farmers from 16 villages.	Farmers reported practices for managing EUS and external parasites and for reducing disease contamination during fish-seed transport.
Devi <i>et al.</i> (2014)	Assessment of applicability of Indigenous Technical Knowledge (ITK) in aquaculture as perceived by fish farmers in Assam	Interviews, focus-group discussions and observation involving 80 farmers; expert rationality assessment and MPEI.	Five disease and pest-management ITKs were documented. Turmeric with lime and salt with neem were reported for EUS, while old gunny bags were used to collect <i>Argulus</i> eggs.
Devi <i>et al.</i> (2021)	Perceived effectiveness of Indigenous Technical Knowledge on fish production practices in Assam	Documentation of 23 ITKs followed by assessment of awareness, adoption, scientific rationale and perceived effectiveness.	Disease and pest management formed a major ITK category. Seven of 17 practices evaluated for effectiveness were perceived as highly effective by both farmers and experts in the study area.

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Fish-health management is another area in which local experience is frequently reported. Kalita *et al.* (2004) [9] and Das *et al.* (2013) [3] documented traditional responses to external parasites, disease symptoms, turbidity and low dissolved oxygen. Devi *et al.* (2014) [4] reported practices involving turmeric, lime, salt, neem and physical removal of parasite eggs, with some practices receiving high perceived-effectiveness scores in the study population.

Perceived effectiveness does not establish therapeutic efficacy. Traditional health-management practices should therefore be tested under controlled laboratory and field conditions, with attention to active components, dose, treatment response, toxicity, fish welfare and effects on water quality. The distinction between a documented practice, a farmer's perception of effectiveness and experimentally demonstrated efficacy should be maintained when interpreting ITK evidence.

4. Conclusion

The literature reviewed here shows that aquaculture communities use locally developed practices across several stages of production, including pond preparation, water-quality management, stocking, feeding, fish health and post-harvest handling. These practices are closely associated with local environmental conditions and the availability of materials and resources (Das *et al.*, 2013; Devi *et al.*, 2014; Gangadhar *et al.*, 2016) [3, 4, 5].

The evidence is mixed. Some practices have been assessed as rational or effective within specific study areas, while others remain based mainly on reported use or farmer perception (Devi *et al.*, 2014; Devi *et al.*, 2021) [4, 6]. Practices involving plant-derived piscicides and disease-management materials require caution because biological activity and safety can vary with species, preparation and dose (Dutta *et al.*, 2019; Narzary *et al.*, 2023) [7, 8].

ITK should therefore be treated as a source of testable, location-specific practices rather than as evidence of efficacy. Future studies should document the practice in sufficient detail, identify the intended mechanism or function, and evaluate technical performance, safety, economic feasibility and environmental effects under controlled and field conditions.

A practical framework for integrating ITK into aquaculture would involve four stages: documentation of the practice and its local context; assessment of scientific rationale; experimental and field validation; and evaluation of cost, safety and scalability. Greater documentation is also needed from regions and production systems that remain poorly represented in the literature.

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How to cite this article: Bhandari PT, Thavai A, Shinde SV, Hareendran S, Mangale S, Bhardwaj A, et al. Indigenous technical knowledge in aquaculture: Practices, evidence and scope for scientific validation. *International Journal of Research in Agronomy.* 2026;SP-9(10):25-29. doi: <https://www.doi.org/10.33545/2618060X.2026.v9.i10Sa.6761>