Fundamentals of Aquaculture
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Aquaculture
Farming of aquatic organisms including fish, mollusks, crustaceans, other invertebrates and aquatic plants.
Farming implies:
- interventions to enhance production such as:
  -- regular stocking
  -- feeding
  -- protection from predators
- ownership over the stock being cultivated, whether individual or corporate, so that the resulting product is not exploited by the public as a common property resource

Aquaculture by environment
- Freshwater – lakes, reservoirs, rivers
- Brackishwater – river mouths, estuaries, mangrove areas
- Marine (Mariculture) – bays, coral coves, offshore

Production phases
- Hatchery – from broodstocks to eggs to postlarvae or small juveniles (often called ‘fry’ or ‘seed’)
- Nursery – from ‘fry’ to larger juveniles (often called ‘fingerlings’)
- Grow-out – from juveniles to preferred market sizes

Aquaculture by farming system
- Land-based tanks (concrete, fiberglass, canvass, plastic, etc.), for tilapia, freshwater prawn, etc.
- Earthen ponds for milkfish, tiger shrimp, grouper, etc.
- Cages (fixed or floating) for tilapia, milkfish, grouper, snapper, seabass, etc.
- Pens for milkfish, mud crabs, etc.
- Racks, stakes, hanging lines for mussels, oysters, etc.
- Longlines for seaweeds

Aquaculture by level of inputs and management
- Extensive: low stocking density, natural food only, may use fertilizers
- Semi-intensive: moderate stocking density, natural food plus supplemental feeds, greater water change rate, may use pumps
- Intensive: high stocking density, regular feeding, pumps and aeration

Species selection depends on
- Marketability
- Type of water in area where farm is to be located
- Availability of spawning stock (for hatcheries)
- Availability of seedstock (for grow-out)
- Availability of feed and other inputs
- Availability of technology
- Availability of capital

Trophic level considerations
- Herbivores or omnivores (carps, tilapia, milkfish) are generally easier to rear and may subsist on natural food. Even when fed, feed will not require high quantity of animal protein and is therefore cheap. Production cost is low, but market price is also low.
- Carnivores (shrimps, grouper, snapper) require high amount of animal protein and is therefore more expensive to produce. Market price is much higher (more than 10x) than for herbivores. Unit profit margin is generally much higher.

Aquatic species farmed in Southeast Asia

<table>
<thead>
<tr>
<th>Fishes</th>
<th>Freshwater</th>
<th>Marine/Brackishwater</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nile tilapia, common carp, <em>Pangasius</em> catfish, <em>Clarias</em> catfish, gourami, silver barb, Java barb, Mozambique tilapia, milkfish, snakehead, bighead carp, silver carp, grass carp</td>
<td>Milkfish, Mozambique tilapia, seabass, mullets, groupers, rabbitfishes, snappers, Nile tilapia</td>
<td></td>
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</tbody>
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<thead>
<tr>
<th>Crustaceans</th>
<th>Giant river prawn</th>
<th>Tiger shrimp, Pacific white shrimp, Banana shrimp, Indian white shrimp, <em>Metapenaeus</em> shrimps, mud crabs</th>
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<tr>
<th>Mollusks</th>
<th>Blood cockle, green mussel, oysters</th>
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| Seaweeds      | *Kappaphycus alvarezii*, *Eucheuma* spp., *Gracilaria* spp. |
Site selection depends on:
- Target environment
- Desired production system and farming system
- Species

Basic requirements
- Sufficient water supply of good quality
- Free from harmful pollution
- Accessibility
- Free from flooding, erosion, strong winds, strong wave action
- Availability of electrical power
- Proximity to source of inputs
- Proximity to market (depending on species and potential market)
- Soil quality (for ponds)
  -- can hold water
  -- can form stable dikes
  -- not acidic

Examples of good aquaculture sites
- Saltwater hatchery for shrimps, crabs or fish:
  Area far from river, with sandy sea bottom that does not get turbid even with strong wave action; but with good supply of fresh water
- Freshwater hatchery or freshwater fishponds for tilapia, carp, freshwater prawn, catfish, etc.:
  Relatively flat area with sandy-clay-loam or sandy-clay soil, with abundant supply of clean water not contaminated by pesticides from agriculture
- Brackishwater ponds for shrimp or fish:
  Coastal area with elevation above high tide level, with sandy-clay soil, and ready access to clean brackish water (from river or shallow well)
- Freshwater pens and cages for fish
  Shallow areas (3 to 10 m deep) of lakes, with high primary productivity and no industrial pollution
- Marine pens and cages for fish
  Sheltered bays and coves
- Rafts and lines for mussels and oysters
  Shallow bays and coves with high primary productivity and low density of people
- Longlines for seaweeds
  Clean marine waters with no massive freshwater inflow or runoff during the rainy season

Aquaculture in public waters
Farm structures should not impede navigation (boat traffic) nor the fishing activity of the local fishers.

Use of mangrove swamps for aquaculture
Background
- Has long history in Indonesia and the Philippines
- Used primarily for milkfish culture
- Only in recent years (1980s) with strong Japanese market for shrimps that milkfish farms were converted to shrimp farms or mangroves converted to shrimp farms

Why mangrove swamps were used for traditional fish ponds
- Swamps cannot be used for agriculture or for habitation.
- Nobody owns them.
- Regularly watered during high tide
- Can be developed by simply clearing the trees and putting a dike around an area with very little excavation

Why mangroves are not the best site for modern aquaculture
- New technologies require deeper ponds and more excavation.
- Once excavated, soil with high iron sulfide content is exposed and becomes highly acidic
- At high stocking density, regular feeding is required, and higher water exchange rate, which can no longer be provided by tidal action.

Why or when to go into hatchery/nursery business?
- Seed supply is needed for aquaculture development
- Limited land area available
- Skilled hatchery workers are available

Shorter production time (weeks) means less leeway for mistakes. Fast turnover (weeks) means more frequent cash inflow even on a monthly or weekly basis.

Why or when to go into the growout business?
- There is constant demand for fish products
- Land or water area is available
- Technology and inputs are available
- Skills available for selected farming intensity

Slower turnover (months) means cash inflow may come only once or twice a year.