

A manual for improving fish production in Northern Zambia through integrated farming systems



A MANUAL FOR IMPROVING FISH PRODUCTION IN NORTHERN ZAMBIA THROUGH INTEGRATED FARMING SYSTEMS

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Lead farmers interviewed

Further appreciation is extended to lead farmers from selected livelihood enhancement groups (the community entry points for interventions by the Integrated Research in Development for Improved Livelihoods Programme in Northern Province, Zambia [IRDLP]). The livelihood enhancement groups comprised 45 households selected based on vulnerability criteria.

Serge and Susan Nsombo and family, Fube village, Livelihood Enhancement Group 16, Luwingu
Chanda and Prisca Sesantu and family, Fube village, Livelihood Enhancement Group 37, Luwingu
Edison Sinyangwe and family, Kawala village, Livelihood Enhancement Group 156, Mbala
Reuben Siwale and family, Kawala village, Livelihood Enhancement Group 143, Mbala
Evaristo Sikazwe and family, Kawala village, Livelihood Enhancement Group 143, Mbala
Macele Sinyangwe and family, Kawala village, Livelihood Enhancement Group 156, Mbala

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PREFACE

This manual was written as part of the Integrated Research in Development for Improved Livelihoods Programme in Northern Province, Zambia (IRDLP) and is primarily intended for extension agents to use with smallholder farmers engaged in semi-intensive fish farming in Northern Zambia. The IRDLP is an Irish Aid-funded project implemented by WorldFish, Harvest Plus and the Center for International Forestry Research (CIFOR).

Since 2013, the program has supported Self Help Africa's local development program initiatives through the CGIAR Research Program on Aquatic Agricultural Systems (AAS).

The goal of the IRDLP is to help improve the livelihoods, health status, and food and nutrition security of resource-poor households in the Mbala and Luwingu districts in Northern Zambia, especially women and vulnerable groups. This is achieved through generating and providing evidence-based information, scientific technologies and livelihood solutions to trigger community and farmer innovations for positive change.

Once adopted, aquaculture–crop–animal–forestry innovations will improve on-farm productivity, enhance fish yields, provide a reliable source of fish protein and enhance nutrition security.

This manual creates linkages between different smallholder farming systems, showing the opportunities available for diversification and intensification of integrated fish, crop, livestock and forestry systems. The manual provides farmers with methods to optimize their use of on-farm resources for increased fish production.

The manual has been designed for use in Northern Zambia, though the authors hope it will be useful in other parts of Africa as well.

PURPOSE OF THE MANUAL

This manual provides information on how smallholder fish farmers can improve fish production in Northern Zambia, particularly in the Luwingu and Mbala districts, through integrated farming practices.

There are seven guiding steps for setting up a semi-intensive, integrated fish-crop-livestock-agroforestry innovation system for smallholders:

- Explore the farming system to establish an inventory of available on-farm resources.
- Draw a diagrammatic flow chart representing the existing and possible synergies in the system.
- Establish and integrate your pond facilities.
- Introduce various activities in close proximity to each other.
- Commence integration of activities and recycling of otherwise wasted on-farm resources.
- Intensify and diversify integration, with activities supporting each other.
- Reap net economic benefits of integration.

This manual attempts to unearth the untapped potential of the aquatic agricultural systems and forest landscapes in Northern Province, Zambia, which when fully integrated into farming systems will improve the food and nutrition of rural communities. To help generate a practical manual, two families (Sesantu and Nsombo) were interviewed to share their perspectives on and experiences with integrated aquaculture-crop-animal-forest husbandry.

Case study: The Sesantu and Nsombo families

This is the story of the Sesantu and Nsombo families from Luwingu, whose lives were transformed by fish farming. Their story is featured throughout the manual.

The Sesantu family

Meet the Sesantu family: father Chanda, mother Prisca, elder brother Friday, and younger

brothers Aaron, Zachariah and Gift. They live in the village of Chabula in Luwingu, Zambia.

The Sesantu family are different from most of their neighbors. All their children attend or have attended the local primary school that is 5 kilometers from their village. The family have decent clothes to wear. They are healthy because they eat nutritious foods like fish, beans and different varieties of vegetables. When they are sick they can afford to go to a local health clinic. Chanda even has a new bicycle, which he rides 65 kilometers into town to sell his goods.

But the Sesantu family wasn't always this successful.

Two years ago they were like many of their neighbors are now. Even though Chanda and Prisca's children attended primary school, none of their children had finished high school. The three boys always had too much work helping their father till the land for their crops. The family mostly ate vegetables such as



Serge Nsombo (left) and Chanda Sesantu (right).

Chinese cabbage and rape, and sometimes had tomatoes, onions and beans. They never had any money to save.

Times were tough. Chanda found it difficult to provide for his family. They were embarrassed because they had few nice clothes for church, and there was never extra money to buy things for pleasure, like new clothes. You might think that the Sesantu family did not work hard, but that is not true. In fact, they are very hard workers.

They kept their small house clean and tidy, but it was a long way from everything. Prisca would have to walk far to sell vegetables from their garden and fetch firewood for cooking. She made many trips each day.

The family owned and tended a *lima* (50 meters x 50 meters) of maize field, which was far from their home. Getting to and from the field took up much of Chanda's time. He cut and trimmed the trees to prepare the land, then burned the trees and surrounding shrubs to clear the land for planting. After planting he would have to stay in the field from morning until night for

about 6 weeks to scare the birds away. One year he did not, and they ate almost all of the valuable seeds.

But a *lima* of maize was barely enough for the family to live on. If the weather was too wet or too dry, then they would not produce enough maize to eat. At the place where Prisca collected water close to home, the family also had a small vegetable garden where they grew rape and Chinese cabbage, but this needed to be weeded often. They ate some of the vegetables and sold the rest, but after buying fertilizer and pesticides they often just broke even.

The Sesantus also kept four to eight chickens, six ducks and one goat at any one time. They kept them to eat for themselves, but sometimes they had to sell animals if they needed cash quickly. Sometimes the animals would get diseases or thieves would steal them, so the family rarely got to eat their chickens, ducks or goats.



Photo Credit: Albert Nangwa/Wikipedia

Collecting firewood.

The Nsombo family

The Nsombo family's story is similar to the Sesantu family's. Serge, his wife, Susan, and their two-year-old son, Benedict, live in the village of Fube in Luwingu, Zambia. Serge previously worked as a fisher, but he barely made enough money to support his family considering the dwindling fish catch in the wild. With his small earnings he could only buy maize meal. Often Serge would borrow money to support his small family and meet daily needs. But despite the struggle, Serge has big dreams of becoming a teacher someday. Now, as a fish farmer, he hopes he can make and save enough money to pay for teacher training college.

The beginning of change

The two families' day-to-day struggles frustrated them because they had nothing to show for their hard work. Things started to change for them in 2013 when the international development agency Self Help Africa formed livelihood enhancement groups in their villages.

One day, Chanda and Serge attended a livelihood enhancement awareness meeting at their local primary school. The meeting was run by staff from Self Help Africa, WorldFish and the Department of Fisheries. Each livelihood

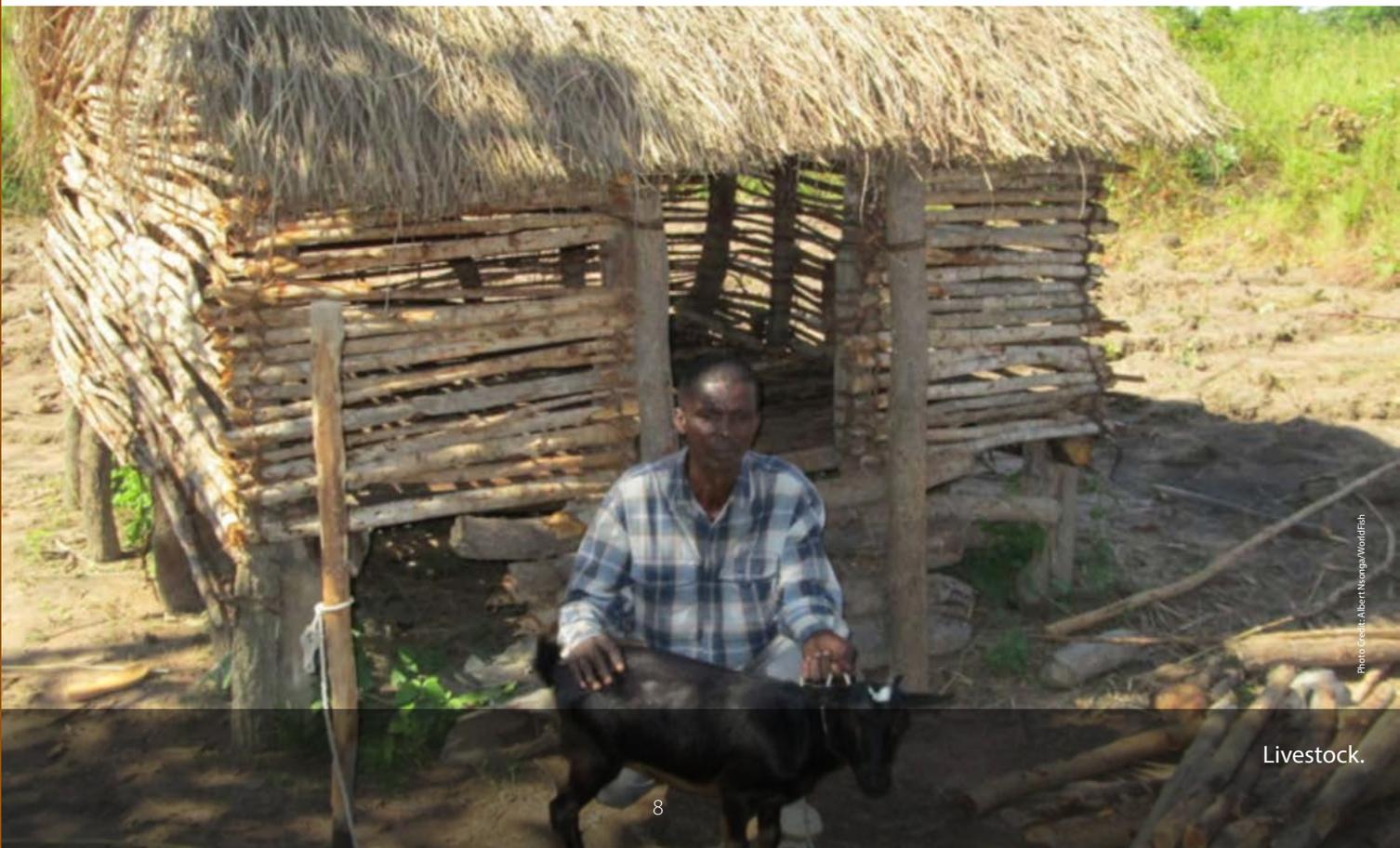
enhancement group was asked to nominate three people to attend a fish farming training workshop in Kasama. Chanda was nominated as a participant for Livelihood Enhancement Group 37, and Serge notes, "I volunteered myself from the livelihood enhancement group, because at the meeting I heard about the many benefits that fish farming could bring to my life."

And that is how things got started for Chanda, Serge and their families.

Becoming fish farmers

At the workshop, the two men learned about fish farming, including the requirements for digging a fishpond, constructing a crib, composting and pond management. The two men were very excited after the training. They were ready to dig their fishponds and couldn't wait to share the news with their wives.

Serge was enthusiastic about what he learned, stating, "After training, I talked to my wife and she too believed fish farming was a good venture for us to embark on. Two weeks after my fish farming training and with the help of WorldFish, my wife and two older kids had surveyed our land, pegged our first fishpond and finished constructing it."



Chanda and his wife also completed construction of their first fishpond over a 3-week period. The next week, WorldFish and Self Help Africa brought fish seed to the two farmers, as well as sample feed, pipes and grass to plant on the dikes of their fishponds to prevent soil erosion. At the time of writing this manual, Serge had constructed a second fishpond and had helped nine other people in his livelihood enhancement group to construct a group fishpond that is managed by group members.

Serge and Chanda were so excited about the progress they had made that they were a little disappointed at first when Albert, their WorldFish representative, said, "We need to stop constructing any more fishponds for now." After talking with Albert and taking a walk to their source of composting materials, fields and water source, Albert said to the two men, "We need to start thinking about INTEGRATION."

The families were given pencils and flipchart paper to map household resource flows so that they could begin to visualize how their current household activities' byproducts were being used. When Albert came back 2 weeks later, the two families were ready. They had conducted a farming systems analysis of their current farming system and had a map of their household resource flows. They had all decided that they wanted to diversify their farming systems and run them in a more efficient manner.

Based on the farming systems analysis and household resource flows identified, the first thing that the Sesantu family decided to do was to shift their vegetable garden from their home to close to their fishponds. This will eventually allow them to have their gardens and fishponds close to their home. They found a suitable location at the end of the fishponds and created a vegetable garden there. Having the gardens near the fishponds made Chanda's life easier. He didn't have to walk a mile and make frequent trips to draw water for the vegetables or pick garden waste for his fishponds. This left some free time for him to help Prisca with other household chores, as well as time in the evenings to hang out with his friends. As his fish farming venture prospers, Chanda plans on building a new tin-roofed house close to his fishponds.

The Sesantu and Nsombo families already help with the different aspects of fish farming activities. Chanda and Serge, as heads of households, are busy, so their families' assistance helps them meet the needs of a productive fishpond. However, although family members have been helping, this has been based on Chanda's or Serge's instructions. For these family members to be effective, they also had to know the reasons behind the everyday jobs. Albert explained why family integration with fish farming was so vital and how the two families could engage their family members in farming in a more efficient manner.

After Serge and Chanda learned about family integration and growing good plants and trees around their homes, they learned an important lesson about spatial integration. What is spatial integration? Albert explained that fish farmers should think about where they are going to place their gardens, fields and animals in relation to their fishponds. He told the fish farmers, "If the farm is organized and things are placed near each other, it will make all of the work easier for the family members." This is often due to having a common water intake.

So the families started planning where to put their gardens and where to build their animal houses. They decided to plant gardens next to their fishponds and to have fields of cassava nearby. That way, it would be easy for Prisca and Susan to pick leaves and put them in the fishpond. They also started building a chicken house directly over the pond, so that chicken manure would fall in the water. It would be less work for them because they wouldn't have to carry manure to fertilize the pond. The farmers have also received *Senna spectabilis* trees, which they plan to plant near the fishponds.

As Albert talked to the farmers, they both started to realize how important gardening is in the fish farming system. Before starting their new gardens, they sat down and thought about planning for the short term and for the long term, caring for the garden, and managing the garden. Albert also explained that many of the things that Chanda and Serge already grew in their fields could be used in their fishponds. He also explained how they could increase their crop production by growing vegetables in the proper soils and practicing crop rotation to prevent diseases.

The Sesantu and Nsombo families had learned a lot about fish farming and integration. They knew that compost material and fish feed can come from many different sources. One major source is wild leaves collected in the bush. The challenge was that the two farmers often found it hard to collect enough high-quality leaves to adequately fertilize their fishponds. This is why, with the help of WorldFish, they have started their own agroforestry project.

In preparation for the rainy season, WorldFish had started a nursery in Mbala at the Self Help Africa office. The nursery stocked 50 tree seedlings (*Senna spectabilis*). From July 2015 to September 2015, 200 tree seedlings were distributed to five fish farmers (three per farmer) living in the Mbala and Luwingu districts. Arrangements were in place to distribute the remaining 30 seedlings and to plant more trees before the end of 2015. At the time of distribution, tree seedlings measured approximately 0.25 to 0.30 m in height. Participating livelihood enhancement group farmers requested different volumes of trees, reflecting the range of sizes and capacities of their smallholdings.

Prisca and Susan have decided that it would be nice if they would eat eggs, chickens and rabbits from time to time. They talked to Albert about this. Albert came to their village with a representative from Self Help Africa and talked to them about how to raise chickens and rabbits so that they could have more meat to eat. They also explained that the manure from the animals should be taken to the fishponds to fertilize the water.

The two women discovered the advantages of raising animals. The meat provided is an excellent source of protein. So they made a plan to increase the number of animals they had. They also thought of ways to build shelters so that chickens would lay more eggs, and they started to build a house for rabbits.

By now the Sesantu and Nsombo families had learned a lot about how to improve their fishponds through family integration, spatial integration, gardening, agriculture, agroforestry, animal husbandry, nutrition and planning. They have a lot of ideas for ways that they can make their farms better. But they also know that it

will take some time. They are realists! They have decided to start with small things. The first year they started working together better as a family. They also planted gardens near their fishponds and made a nursery for *Senna* and *Leucaena* trees. The second year, they plan on moving their home closer to their fishponds. And the third year, they will start keeping rabbits and more chickens.

The Sesantu and Nsombo families are hopeful of a better life. They want to be happy and healthy. Serge wants to save money to attend teacher training college. It will take a lot of hard work and careful planning to get there, but they know that it's worth it!

What is a farming system?

A farming system is made up of different on-farm activities. It may include animals (e.g. chickens, ducks and goats), plants (e.g. mangoes) and farm produce (e.g. millet, cassava and maize). A farming system includes the following:

- how these activities are produced
- who produces them
- when they are produced
- why they are produced
- the crop associations or rotations practiced
- the length and type of land use practiced
- the inputs used (e.g. shovels, hoes, human labor)
- household relationships to local markets, forest products and economic opportunities
- relationships of members within the household.

For example, a fish farming system consists of fishponds, waterways, fish and the associated management system.

What is an integrated farming system?

An integrated farming system combines multiple farming systems by creating relationships between existing household activities. It can involve adapting an existing farm system so that the unwanted harvests from one activity form the inputs for another.

For example, during the hot dry season there is little or no green fodder available in the bush to put in a fishpond. Throughout the entire year Zambians grow gardens and cultivate fields. Why not combine fish farming and gardening? Garden and field wastes can then be used as green manure for your fishpond.

A well-integrated system should work with nature rather than against it. Activities should be arranged so that they help each other, conserve the landscape and recycle resources.

Why practice integration?

Farmers choose to integrate their farming systems for many reasons, based on individual circumstances and locally available resources. Some farmers choose to integrate to increase total output, boost productivity of their outputs or grow their profits.

There are many benefits to integration:

- **Diversification:** If a farming system is well integrated, it will produce multiple products (instead of one product) and will likely depend less on outside resources for production. For example, if you have a bad yield for millet one year, another product will take its place (e.g. vegetables).
- **Less waste:** Integrated farming activities produce less waste. They are more efficient in terms of the amount of production per unit of labor or land.
- **Better land use:** In areas with population pressures, uncertainty about land ownerships, or where shifting cultivation is giving way to more settled agriculture, land use intensification may be important.

Most importantly, integrated farming systems may reduce labor requirements, facilitate farm management and make an attractive pension plan.

Successful fish farming requires basic elements such as sufficient water, land for pond excavation and culturable fish. Increasing fish production and resource use requires identifying and building relationships between fish farming and other existing household activities and members.

Fishponds require large amounts of fertilization, just as some crops often need to be fertilized. The greening of water that you see in your fishpond thrives on concentrations of nitrogen and phosphorus (which can be obtained from ash). As plankton (natural fish feed) composes a major part of the diet of tilapia, the overall production of the fishpond depends greatly upon the amount and quality of compost that you use. Through integration, other farming systems can supply inputs such as fertilizer and compost to the ponds.

A simple example of an integrated system is where fish farming is integrated with vegetable gardens, allowing for ease of resource flow.

Here is an example:

- Garden waste can be used as fish feed and to fertilize the pond.
- Fishpond water can be used to water the garden.

There are many benefits to integrating fish farming with other farm activities such as fields, gardens and raising animals:

- More fish feed is available from waste and compost products. This increases fish production.
- Fishpond mud and water can be used for watering crops. This increases the soil fertility and can increase agricultural production.
- Food production is diversified.

Assessing available resources and farming needs

Before adding fish farming into an integrated system, you must assess what local resources are available. This is called a farming systems analysis and consists of four steps:

- Find out what activities restrict fish production and look for ways to remove these restrictions.

- Make a list of the possible farming activities that can be added or changed to increase production. Decide which of these is the least work, the most cost effective, the most beneficial, the most interesting to the farmer and the most appropriate given local conditions.
- Examine what inputs are required by the proposed changes and whether they are available.
- Identify waste products for each proposed change and how they could be recycled back into the system.

Fish farmers' testimonies on fish farming integration

"Since our homes are closer to the fishponds, it has become easier to feed the fish. It has also become easier to use fertilized fishpond water to water and fertilize my vegetable garden."

– **Serge Nsombo**

"I have kept chickens and therefore easily collect chicken manure and bring it to the fishponds on a weekly basis."

– **Edison Sinyangwe, Mbala, Northern Province**

"I have been able to integrate my vegetable garden into fish farming. I grow vegetables that I didn't really grow before, and I have been able to make a profit by selling vegetables. In one trip, I have been able to make ZMK 50, which I used to buy cooking oil, soap and lotion for my wife."

– **Reuben Siwale, Livelihood Enhancement Group 143, Mbala, Northern Province**

"Since we developed a furrow with the help of World Vision, we now have access to water and are able to grow vegetables such as beans three times a year, while before, vegetables were seasonal."

– **Evaristo Sikazwe, Livelihood Enhancement Group 143, Mbala, Northern Province**

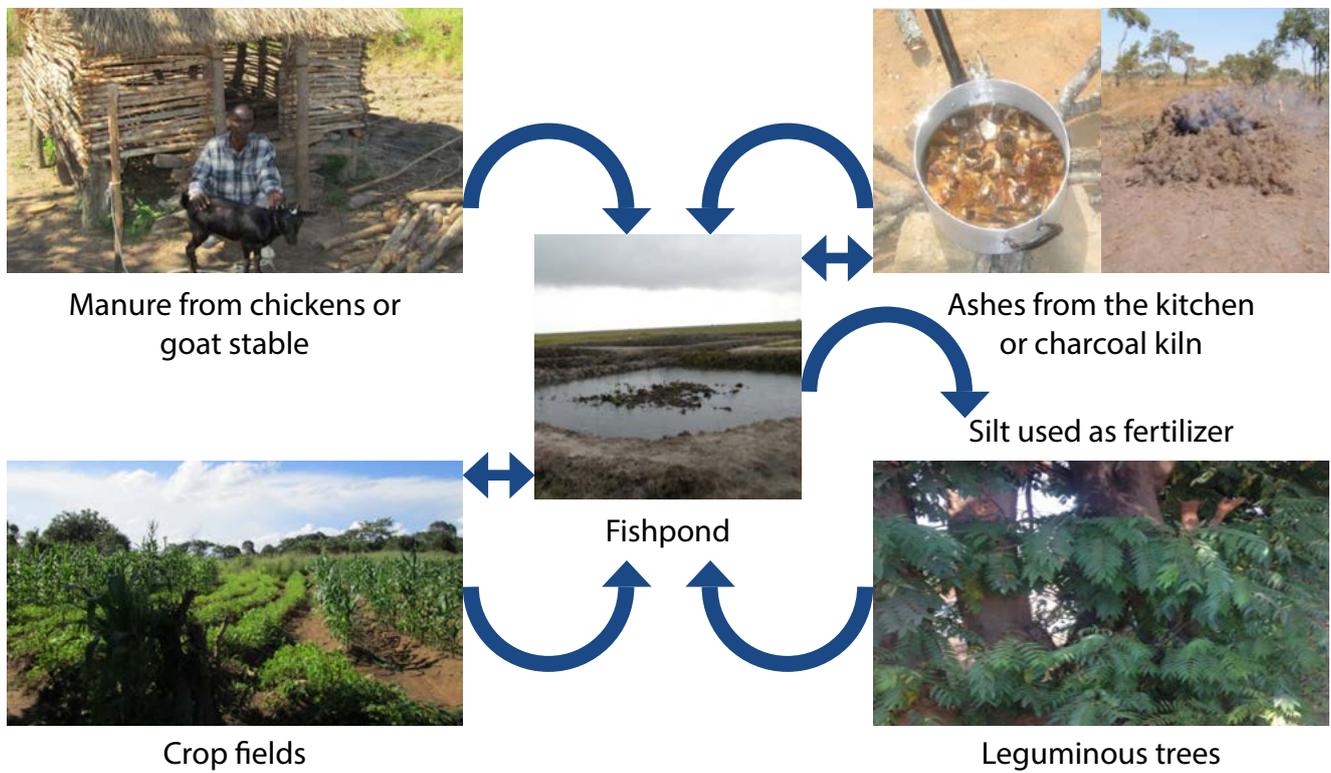


Figure 1. Using garden and kitchen waste to feed fish and fertilize the fishpond.

FAMILY INTEGRATION AND FISH FARMING

What is family integration?

Family integration is when all family members become involved in phases of the fish farming production cycle.

Involving a family in fish farming is like having a football team. In order to win the game, all members of the team need to play their position the best they can.

The head of the household is like the team captain. All captains should use open communication, encourage an enthusiastic attitude and promote a good team spirit.

The head of the household has many obligations and tasks to perform, which can be delegated to family members to share the work. For example, delegated family members can collect materials to add to the compost bin or crib in the fishponds once a week.

An effective integrated husbandry system requires family roles to be shared and integrated. This also promotes family ownership of the integrated system.

Positive reactions from farmers about family integration

“After training, I talked to my wife and she agreed with me to start fish farming. We went and surveyed my land and saw that we have year-round water. My wife, our two kids and I then pegged out our pond.”

– **Seggie Nsombo, Livelihood Enhancement Group 16, Fube village, Luwingu, Northern Zambia**

“I prepare the compost, which my kids put into the compost cribs in the ponds.”

– **Remarkd Seggie Nsombo**



Family displays vegetables harvested from gardens next to ponds.

Designating family integration tasks (an example)

In the Sesantu household, pond management tasks have been allocated to family members based on their strength:

- The father, Chanda, and his oldest son, Friday, do all pond maintenance, including furrows, weeding, and monitoring settlement of dikes, as well as the more serious erosion on the surface of dikes and excavations.
- The mother, Prisca, collects and applies the kitchen scraps and ashes from cooking to the fishpond on Fridays. She is also responsible for record keeping to know how much money they have, how much they can invest, how much to expect after harvesting, and when to invest more money in the business.
- The oldest brother, Friday, collects livestock manure from a neighboring village every Friday evening. He and his youngest brother, Gift, then apply it to the fishpond.

- The middle brothers, Aaron and Zachariah, harvest field waste and leaves from nitrogen-fixing trees, such as *Senna spectabilis*, for the composting crib twice a week.

Although all family members have designated roles, they also know how to perform each other's tasks in case of illnesses or unforeseen circumstances.

Family integration has become a culture for the Sesantus and is routinely applied to other farming activities. They have a schedule to rotate pond maintenance tasks, including watering the vegetable garden and soaking cassava tubers and *nshima* pots in the fishponds. When Chanda is out in the family field cutting and trimming trees, he brings a sack with him to collect leguminous leaves to bring back to the fishpond.

Every trip to the fishpond has a purpose.



Furrow across garden and ponds.

INTEGRATING HOUSEHOLD RESOURCES WITH FISHPONDS

There are many ways to integrate household resources with fishponds:

- Grow fruit trees around the fishponds. This provides fruit to eat, while rotting fruit can be added to the fishponds. Any extra fruit can be sold at the market.
 - Grow leguminous plants in the fields, as this fixes nitrogen and improves soil health.
 - Grow wild plants.
 - Plant year-round leguminous agroforestry trees (such as *Senna spectabilis*) around the pond to be a living fence. The dry or fresh leaves of these trees can also be used to fertilize fishponds.
- Plant vegetables, such as beans, tomatoes, rape and cabbage, in your gardens near the fishponds to provide excess fodder for ponds, while nutrient-rich water from ponds can be used to fertilize the vegetables.

Tip! Ask yourself each time you want to throw away something from the home if you can use it in your fishpond. Be creative and be sure to involve your whole family.



Jacqueline, a female fish farmer in Mbala (posing with a researcher), ready to go into integrated aquaculture farming.

SPATIAL INTEGRATION

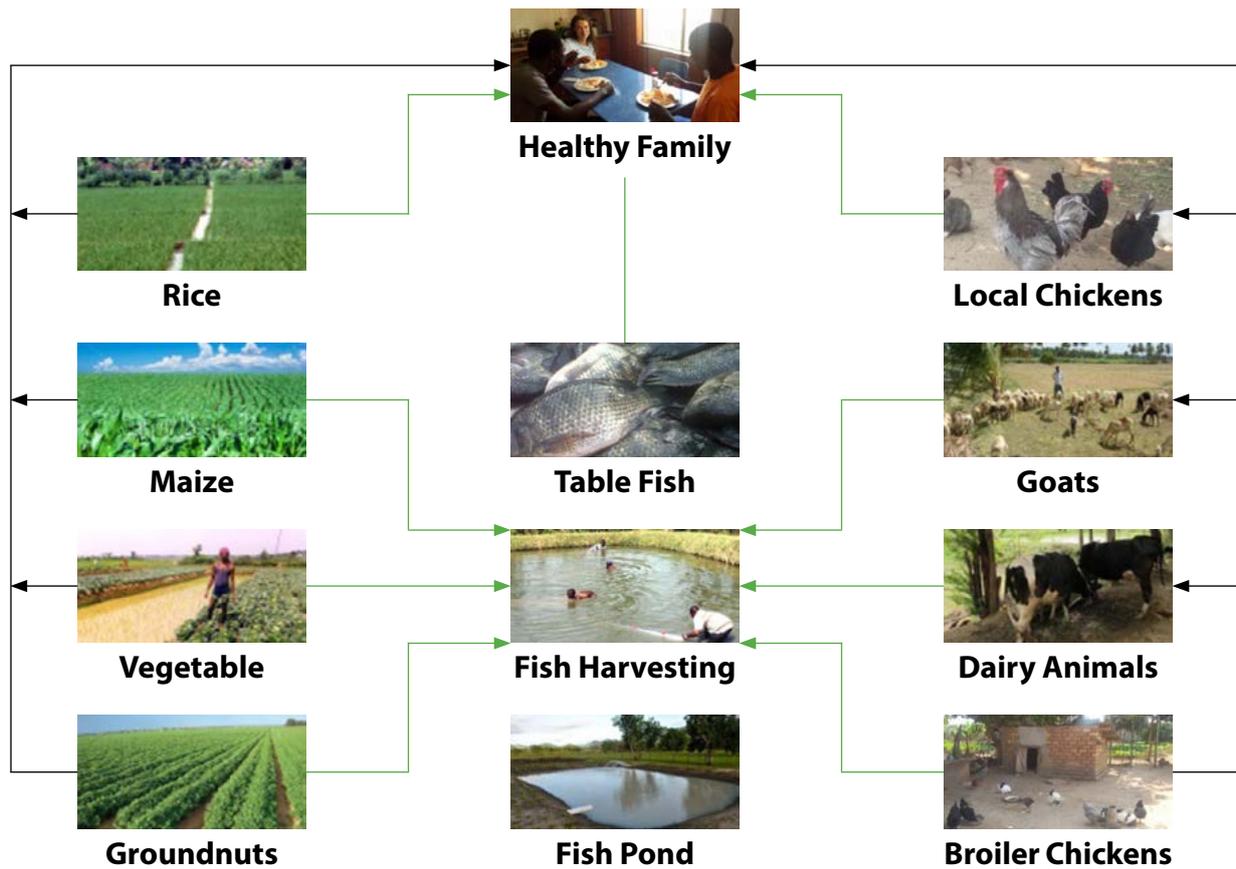
Whether you have a large farm or small plot of land, how you use your space is very important. Spatial integration refers to the location of gardens, fields, animals and fishponds and how they relate to each other.

By placing all activities where they gain the most benefit from other parts of the farm, you will maximize profits from your entire farming system. When you use all your space wisely, it will be easy to raise animals, fish and crops all at one time, and every part of your farm will improve.

The best place for a fishpond is next to your home. This discourages thieves, and it is easier to feed the fish and maintain the pond.

The best place for your garden and fields is also near the pond. No one wants to work all day weeding and pulling unwanted leaves off plants, and then have to carry them to a distant pond. By having the pond close, you can immediately line the vegetable beds with rotten leaves after cleaning out the compost cribs. When you harvest your pond and drain the water, let it run onto the garden and fields. The water acts as fertilizer and will provide much-needed moisture, especially in the hot dry season.

When everything is in one place, fish farming is easy, simple and very profitable (Figure 2).



Benefits: Increased household income
 Reduced poverty levels
 Reduced inputs and increased output

Efficient waste utilization
 More employment avenues
 No waste

Figure 2. Spatial integration.

Gardens and fields are very important in an integrated farming system. Although fields are relatively big and farther away from home than gardens, both can be integrated in close proximity to fishponds to optimally utilize on-farm resources. Many things grown in gardens can be used as inputs for fish farming. Through simple measures like growing vegetables and rotating your crops, you can increase your crop production and prevent diseases. Therefore, it is important to care for and manage your garden adjacent to ponds.

Green fodder from gardens for the compost bin is easily collected if gardens are placed in close proximity to ponds.

Integrating gardening with fish farming

An integrated gardening and fish farming system consists of the following steps:

- Choose the vegetables to plant to determine the right size for your garden.
- Determine the right size for your fishpond.
- Plant your vegetables.
- Raise fish.
- Protect your garden from predators.
- Weed your garden.

- Manage pests.
- Follow good management practices.
- Harvest your garden and fishponds.
- Sell vegetables and fish at the market.
- Reuse garden and pond waste.

Planning your garden

You need to choose which vegetables to grow before planting. This helps you understand how much money and land you will need and the work that needs to be done. Then you need to plan and stake out where your vegetables will be planted. The garden will need to be in close proximity to the ponds to make it easy for resources to flow across the activities.

It is recommended to have a garden of at least 1.5 *acres*. Choosing the right size garden or pond is important. A good-sized garden will produce and provide a good income. If a garden or pond is too big, then it may be hard to take care of. If a garden or pond is too small, then the output may not be beneficial relative to the effort put in.

Planning your fishpond

Fishponds should be between 1.5 and 3.0 *acres*. For every fishpond, you should have at least one garden of the same size.



Mary, an extension agent, planting a leguminous tree to provide fodder for ponds.

Planting your vegetables

Some types of vegetables require a nursery to start growing. Having a nursery allows you to pick the strongest and healthiest-looking seedlings. When transplanting seedlings from a nursery to a new place, great care is needed. Not all of them can survive the shock of being removed from the nursery and replanted. A farmer must not pull the seedling out by the stem; if it is damaged, the plant may die. Instead, pull seedlings out by the leaves, because if one or two come off, they may grow back, not killing the plant.

Raising fish

The fish you are raising, which in most cases is tilapia, also need a nursery. After harvesting, the fingerlings need to be put in the holding pond (nursery). This is temporary “housing” before the fish are “transplanted” (transported) to a large pond. With a holding pond, you can select fish seed (fingerlings) of a uniform size and possibly age and sex. Just like with seedlings, care needs to be taken when handling fingerlings. Make sure your hands are wet so you do not damage their sensitive skin. Then place the fingerlings in the water slowly and make sure the water temperature is not too different so you do not shock them.

Protection from predators

Sometimes a garden needs protection from predators. You should build a natural fence using plants like lantana or pigeon pea or trees like *Senna* and *Leucaena*. The trees or plants that are planted will provide a source of food for the fish. They can also be used as a fertilizer for the vegetables.

Taking care of your garden and fishpond

Weeding

Gardens need to be weeded. A weed competes with crops, plants and vegetables for food, water, light and space. Some of the same concepts apply to fish farming. If you put too many fish in a fishpond, some act as “weeds,” competing with other fish for food and space. In addition, the garden weeds can be removed and placed directly in the compost crib of your pond.

Managing pests

Pests can sometimes cause problems in your garden. They attack the leaves or the vegetables

themselves, which hurts the entire plant. The same can occur in fishponds. If a predator fish or outside species enters your pond, they will compete with your fish for space and food. A predator fish may eat young fish or fingerlings. They may also disturb nests. Keeping the gardens and fishponds close together will allow you to monitor them. To prevent bad things from happening, you can use best practices.

Following good management practices

When gardening and working at the fishpond, follow these good management practices:

When gardening	When working at the fishpond
<ul style="list-style-type: none"> • using proper chemical medications • weeding early • cultivating early • mulching • practicing crop rotation 	<ul style="list-style-type: none"> • using proper screens at the furrow’s intake • slashing to keep the grass on the dikes cut low • keeping the furrow clean

Managing plant diseases

There are different kinds of diseases that damage plants. A fungal disease can reduce the yield and overall production of a crop. Air, soil, insects and seeds spread fungi. Fungal diseases can be controlled with good management. Bacterial diseases can also destroy crops, but cannot be treated with chemicals. Making sure the seeds are “certified” can control these diseases. Physiological diseases are usually caused by a lack of soil nutrients or water.

Fertilizing a garden

The three main fertilizer elements are nitrogen (N), phosphate (P) and potassium (K). Nitrogen helps the plant grow quickly and have a good color. Phosphate helps with root growth and producing fruits or vegetables quickly. Potassium encourages the intake of food and helps the crop’s overall yield.

Inorganic fertilizers contain nitrogen, phosphate and potassium in different quantities. They are often used for growing maize. Micronutrients are nutrients needed in smaller amounts. Some examples are copper, iron, calcium, sulfur and magnesium. Compost items, such as leaves, kitchen waste, weeds and things used in your fishpond,

contain micronutrients, are cheaper and more easily obtained than inorganic fertilizers, and therefore can also be used as fertilizer in your garden.

After you make the beds for planting, mix fertilizer into the soil, add water and let it sit for 1 week before planting seeds.

Garden protection and making beds

Wind is a factor to consider in some areas. A windbreak fence may be built around nurseries and gardens. It can be either natural or artificially put up. This also helps protect against animal predation. Thatch can also be used to shade seedlings and protect them from too much sun.

Plan your garden based on the climate and land features. In dry areas, sunken vegetable beds can be used to help collect water. On the land, it helps if rows of vegetables follow the contour line to reduce erosion. In very wet areas, it will help to raise vegetable beds and nurseries to reduce waterlogging.

Caring for seeds and transplanting

When buying seeds, try to buy from a seed merchant to ensure the seeds are good and will produce. Collecting your own seed is also an option. Use the best seeds from your own

healthy plants. Make sure they are fully mature. Next, dry for several days, and store in a cool, dry place like a tin. Then you can use the seeds in the next growing season.

The following are good planting practices:

- When it comes time to sow the seeds, water the beds before putting the seeds in the earth.
- Make lines in the beds that are about 15–30 centimeters apart, depending on the vegetable.
- Small seeds should be put on the surface and covered lightly.
- Larger seeds should be planted farther down and covered.
- It is important to sow a new batch every few weeks so that you have vegetables regularly.
- It is also important to weed the nursery or seedling area.
- Vegetables should be ready to transplant when they have four true or slightly mature leaves. Give them less water, mulch and shade about 1 week before you transplant to make them strong, tough and ready for transplanting.

Crop rotation

Crop rotation involves several steps. First, divide the land into plots or sections. Plants from the same family are put into the same plot. After each season, the plots are changed so that plants from the same family go into a different plot.



Moving excess silt from pond bottom to the garden.

Crop rotation maximizes the use of the land. If diseases or pests live or survive in the soil, they can attack and harm crops during the next growing season. By changing the place where you plant certain crops, you protect them from being affected by such diseases. On each section of land, you should plant a crop from a different family than the previous crop.

Crop rotation also makes the soil fertile. Different plants take nutrients from the soil as well as provide nutrients to the soil. By rotating crops, you can regulate the soil nutrients and return nutrients to the soil. If you grow root crops in the first section of land this year, you should grow leaf crops in that section next year.

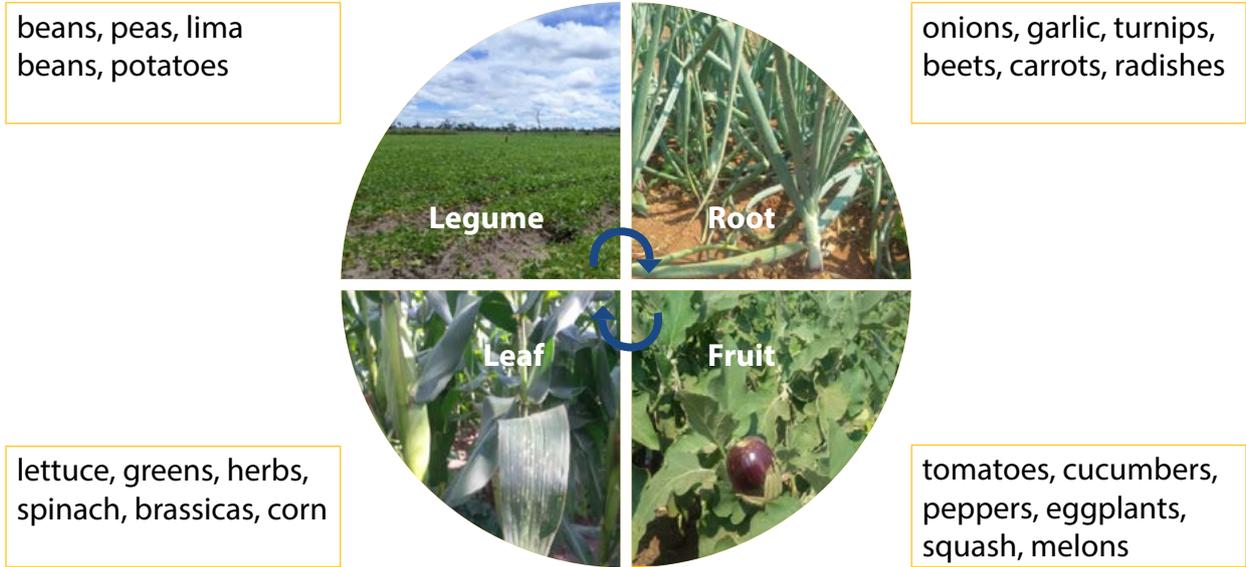


Figure 3. Example of crop rotation.¹



Researcher and a farmer inspecting crops adjacent to ponds.

FEEDING YOUR FISH

Fish need food with plenty of protein in order to grow fast. Plankton is the best feed for fish because it is high in protein.

Growing plankton is similar to growing maize. To grow maize, you need plenty of sunlight and need to apply fertilizers such as compound-D and urea. These fertilizers contain nitrogen, phosphorus and potassium. Plankton needs the same things. It needs lots of sunlight. It also needs plenty of compost that is rich in nitrogen, phosphorus and potassium.

If you fill your compost cribs with quality leaves, fresh manure and ash, lots of plankton will grow. Then your fish will have plenty of plankton to eat.

You should also give your fish high-protein foods, such as cassava leaves, termites, beer

waste or soya bean cake. Young leaves have more protein than old dry leaves. For example, young groundnut leaves are very high in protein, but dry groundnut leaves are not. Dry bean leaves and dry maize stalks are also not good to put in the compost crib. For many plants, the best time to use the leaves in the compost or for food is before the plant starts to make flowers. So, if you are feeding your fish with blackjack (*kanunka*) that has seeds on it, you are too late. You should pick the blackjack when the leaves are young and soft.

Many leaves found in the bush are not good fertilizer for plankton. If you use many hard or dry leaves in your fishpond, you won't make much plankton for the fish to eat. Also, if you only feed your fish foods that are low in protein, such as cassava and cabbage, they will not grow quickly.



A bloomy (green) pond indicates presence of plankton.

Harvesting your gardens and fishponds

Gardens usually take a specific amount of time to grow. This depends on temperature, rainfall and types of vegetables. Knowing when to harvest requires you to observe your garden closely. Most vegetables (like tomatoes, cabbage and onions) may be ready at different times in a short period of time. It is beneficial to plan your garden harvests ahead of time to coordinate with the demand. This depends on water availability and market demand.

Fishponds are usually harvested after 5–7 months. You need to plan when you will harvest, making sure buyers are well aware of

the schedule, and also prepare fingerlings for restocking.

Your harvest schedule may depend on factors such as personal and family events, weather, or farm activities. If possible, you should plan to harvest your garden at a different time than your fishpond. If you do this you can make sure you and your family have a supply of food or money that can be spread out over a long period of time.

Once harvest day comes, you must ensure that you have a market readily available to avoid loss of fish due to spoilage.



Selling vegetables and fish at the market

Vegetables and fresh fish need to be washed and taken quickly to market. They should be fresh and undamaged upon arrival at the market to attract customers. They need to be kept covered and out of the sun to keep flies away. If you are drying your fish or storing your produce, make sure it is kept in a cool, dry place. A plan for selling should be devised before going to the market. Here are some questions you should ask yourself:

- Are you going to sell in piles? If yes, how many? What will be the price per pile?
- Are you going to sell by kilograms? If yes, what will be the price per kilogram?
- Where are you going to sell?

These questions seem obvious but need to be answered before harvesting. You may need to do some research before you harvest to plan for your sale.

Reusing garden and pond waste

Think about how you can reuse things from your fishponds and gardens. The leaves or discarded vegetables can be used in the compost crib (when they are most needed during the first 4 months of the cycle and throughout the 6-month cycle) in order to produce natural fish food in ponds. The water from the pond can be used to fertilize your garden and as a water source.

Remember, the more plankton and high-protein foods your fish are eating, the faster they will grow.



Photo Credit: Albert Nsanga/WorldFish

An integrated aquaculture demo-site completed and being inspected.

Conclusion

If you start integrating all your farming systems with your fishponds, you will find that you will have more food and profit. Start small, and work your way up. After some time you will find that your farm runs smoothly and your family is happy and healthy!

To practice and manage fish farming sustainably, this manual must be thoroughly understood, especially by smallholder farmers engaged in semi-intensive farming. If any clarification or help is needed, farmers can contact the nearest fisheries office.

NOTES

- ¹ <https://thrivefarm.wordpress.com/2012/04/08/crop-rotation/>
- ² <http://www.tropicamango.com/avocado.html>
- ³ <http://www.tropicamango.com/banana.html>
- ⁴ <http://www.fruitipedia.com/guava.htm>
- ⁵ <http://www.hungerforculture.com/?p=301>
- ⁶ <http://www.almanac.com/plant/lemons-oranges>
- ⁷ <http://www.nda.agric.za/docs/papaya/papaya.htm>
- ⁸ <http://www.gardenersnet.com/flower/africandaisy.htm>
- ⁹ <http://www.gardenersnet.com/vegetable/cowpeas.htm>
- ¹⁰ http://www.zambiaflora.com/speciesdata/species.php?species_id=148630
- ¹¹ <http://www.tropicalpermaculture.com/pigeon-pea.html>
- ¹² <http://southeastfarmpress.com/management/sunn-hemp-nitrogen-source>
- ¹³ <http://blogs.worldwatch.org/nourishingtheplanet/africa-eggplant-the-fruit-that-is-enjoyed-as-a-vegetable/>
- ¹⁴ <http://blog.worldagroforestry.org/index.php/2013/07/04/trees-and-food-security-in-africa-whats-the-link/>
- ¹⁵ <http://www.fao.org/ag/AGP/AGPC/doc/publicat/gutt-shel/x5556e06.htm>
- ¹⁶ <http://www.fao.org/ag/AGP/AGPC/doc/publicat/gutt-shel/x5556e07.htm>
- ¹⁷ <https://www.pinterest.com/pin/85498092901432541/>
- ¹⁸ <http://www.flickrriver.com/photos/iita-media-library/tags/transport/>
- ¹⁹ <http://ebeyfarm.blogspot.com/2010/09/chickens-are-luxury-but-not-in-africa.html>
- ²⁰ <http://www.cityfarmer.info/2009/12/page/3/>

What to grow near the home and around fishponds

Fruit trees

Most fruit trees are seasonal and can be planted in an orchard close to ponds to provide fruit for human consumption, while excess and fallen fruit can be added to the pond crib. Leaves can be composted in the crib as well. Fruit trees should, however, not be planted too close to ponds lest roots penetrate and destroy the pond dikes (embankments).

AVOCADO ²	
	Local name: KOTAPEELA
	Availability: Summer
	Uses: Avocados are used as a cash crop or for family consumption. Rotten avocados can be used as fish feed.
	Quality: Medium
	Care: A good location is critical to growing an avocado tree. Avocado trees do not have bark to protect them from intense sunlight and must be planted under shade.
BANANA ³	
	Local name: INKONDE, MAKONDI
	Availability: All year
	Uses: Commonly grown around homes, gardens and fields. Bananas are used as a cash crop or for family consumption. Rotten fruit and peels may be used as fish feed and compost. Banana trees can be used as a living fence.
	Quality: Medium
	Care: Bananas love sun and heat, so pick a sunny location where they will receive light most of the day. Fruiting banana plants will stop growing if in a mostly shady location.
GUAVA ⁴	
	Local name: AMAPELA
	Availability: Summer to winter and grown in all the provinces of Zambia
	Uses: For family consumption, and rotten guavas can be used as fish feed. The hard leaves do not compost quickly but can be burned for ash. It can be used as a shade tree.
	Quality: Low
	Care: Guava is grown in many types of soils, including heavy clay to very light sandy soils. High-quality guavas are produced in river basins. They tolerate a soil pH of 4.5–8.2.

MANGO⁵

Local name: MANGO

Availability: Spring through summer and grown in all the provinces of Zambia. Mango ripens between the first and third week of December.

Uses: For family consumption, and rotten mangoes can be used as fish feed. The waxy and hard leaves make poor compost materials but can be burned for ash.

Quality: Medium

Care: Plant mango seeds directly into the ground or in a nursery and then transplant them in the rainy season.

MULBERRY⁶

Local name: MALUBENI

Availability: Seasonal. White mulberries generally come out in early spring, almost 2 months before black mulberries.

Uses: Ripe mulberries are edible. Rotten mulberries and leaves can be used as fish feed.

Quality: Low

Care: Take plant cuttings of mulberry in the rainy season.

ORANGE, LEMON, MANDARIN⁶

Local name: AMACHUNGWA, INDIMU

Availability: In summer, but lemon and orange trees are virtually everywhere in Zambia.

Uses: Fruits can be eaten, or extra fruit can be sold. Rotten fruit can be used as compost in your fishpond. Peels can be used to keep frogs out of the fishpond.

Quality: Low

Care: On average, fruit bearing begins when the trees are between 3 and 6 years old. Exact timing depends on the type of citrus (lemon, orange, etc.), cultivar, climate, health of the plant and its care.

**PAPAYA⁷**

Local name: POPO

Availability: Can be grown easily and all year in Zambia

Uses: Rotten papayas and leaves can be used as fish feed.

Quality: Very good for vitamin A

Care: Can be grown from seeds. Papayas can be planted at any time of the year, but grow best in late summer (April) with low moisture in the soils. Plant the seeds in December when there is enough moisture. Put five seeds to a hole. Do not put any compost or manure into the holes. Keep plants moist when young.

Plants

Both food crops and fodder plants must be grown in close proximity to the ponds. Plants such as cover crops help mitigate soil erosion, while leguminous plants and crops help maintain and even improve soil nutrients. Soil nutrients will eventually be beneficial to the fishponds by helping fertilize the water.

COWPEA, ALSO CALLED BLACK-EYED PEA⁹	
	Local name: ILANDA
	Availability: All year
	Uses: A staple food crop that provides good protein. Leaves can be used as feed and compost. Plant also improves soil fertility because it fixes nitrogen in the soil. Ideal for ground cover.
	Quality: High
	Care: Grow cowpeas in full sun. They prefer rich, well-draining soil. Add compost prior to planting. Apply a side dressing of fertilizer to give these plants a fast start as soon as they germinate.
LATANA CAMARA¹⁰	
	Local name: LANTANA, ZAZAMINA
	Availability: Commonly available throughout Zambia, all year
	Uses: Can be used as a living fence around fishponds. Leaves make good compost as they decompose quickly.
	Quality: High
	Care: Lantana grows quickly and produces a lot of leaves for composting in fishponds.
PIGEON PEA¹¹	
	Local name: IMPONSO, NGOLYOLYO, MYAM'NBOLO
	Availability: All year
	Uses: A staple food crop that provides good protein. Leaves, flowers, seed pods and seeds all make nutritious animal food and can be used as fish feed and compost. Plant improves soil fertility by adding nitrogen to soil and can be used as a living fence.
	Quality: High
	Care: Sow seeds directly into the soil.
SUNN HEMP¹²	
	Local name: ZUMBA, SUNHEMP
	Availability: Commonly available throughout Zambia, all year
	Uses: Improves soil fertility (the plants can produce 90 kilograms of nitrogen per acre).
	Quality: Medium
	Care: Broadcast seed on ground to plant and weed where necessary.

Wild plants and fruits for fishponds

A lot of composting materials are produced in the rainy season, but it is important to have enough fish feed and composting materials year-round. Many varieties of wild plants can be used as compost. A few examples of these wild plants are provided below.

PIGWEEED	
	Local name: AMARANTH, BONDWE, LENGA-LENGA, MULENG'I
	Availability: Very common, as it grows as a weed throughout Zambia. Most abundant during the rainy season.
	Uses: Good source of protein and rich in vitamin A. It can be used as a high-quality food for fish and livestock.
	Quality: Very good
	Care: Seeds can be gathered and spread over a field to grow the plant.

BLACKJACK	
	Local name: KANUNKA, NSONZONZU, KASOKOPYO
	Availability: Very common, as it grows as a weed throughout Zambia. Most abundant during the rainy season.
	Uses: Leaves can be used as fish feed.
	Quality: Very good
	Care: Seeds can be gathered and spread over a field to grow the plant.

CACIA TREE	
	Local name: UMUSASE
	Availability: Available year-round
	Uses: It is a good nitrogen-fixing plant and the leaves can be used as compost or used directly to feed fish.
	Quality: Leaves are rich in nitrogen and can be used as fertilizer. However, application should be regulated based on bloom color (avoid heavy bloom, which is toxic to fish).
	Care: Since it is a shrub, it propagates (spreads) through its seeds or clippings.

WILD LOQUAT OR SUGAR PLUM	
	Local name: AMASUKU
	Availability: October to December
	Uses: A nutritious fruit that helps to stabilize blood pressure. It can be used as fish feed and for compost. It can be used for agricultural and forestry purposes, around homes and boundaries. The flowers also make good honey.
	Quality: Very good
	Care: It can be propagated by seed, cuttings or root suckers.

Natural fences

A natural fence is a fence made from shrubs, trees or flowering bushes. Common plants used for living fences in Northern Province include beans, lantana (*zazamina*) and pigeon pea (*ngolyolyo*).

Benefits of living fences

Living fences provide many benefits: They are an attractive way to show a farmer's property boundaries, serve as security and prevent predators around your fields and fishponds. As the adage says, "Good fences make good neighbors."

Living fences are a year-round source of fresh compost materials for your fishponds that can be used weekly. They can be planted near the fishpond or house to reduce the time it takes to find and collect compost materials. They often do not require fertilizing, and they can last for many years, providing a continuous and timely supply of compost.

How to plant and care for a living fence

There are different types of living fences. Each type requires slightly different care. We will discuss the most common fence in Northern Province.

Pigeon pea (ngolyolyo)

Planting pigeon pea is similar to planting any other legume or bean. You simply prepare the soil for planting and put the seed in the ground. Unlike beans, however, you do not need to mound the dirt. You can put the seed just below the surface of the dirt.

The seeds should be planted 30 centimeters apart as you would plant bean seeds. The disadvantage of pigeon pea is that it does not grow quickly. You must wait about 8 months before pruning the plant and using it as compost. During that time, you must continue to remove weeds and ensure the fence has sufficient water.



Photo Credit: Albert Nsenga/WorlFish

A living fence using one of the leguminous plants.

Growing garden vegetables

Growing garden vegetables is good for both home consumption and waste supply to ponds as compost or direct supplementary feed to fish.

CARROT	
	Local name: KAROTI
	Availability: Carrot seeds are available throughout the year in Zambia.
	Uses: After harvesting, the carrot tops and leaves can be used in the compost crib of your pond. The roots can be dried or eaten fresh.
	Quality: Medium
	Care: Carrots can be grown in cool to warm temperatures, but are sensitive to high soil temperature. The seeds should be planted in lines about 30 centimeters apart with 6–7 centimeters of space between plants.

CABBAGE	
	Local name: KABIKI
	Availability: Commonly grown in gardens as an annual vegetable crop for its dense-leaved heads. It is available throughout the year.
	Uses: For household consumption. Cabbage waste may be used as fish or animal feed or compost material for fishponds.
	Quality: Medium
	Care: Growing cabbage is easy, so long as you pick varieties suitable to your area. Good crop husbandry, such as managing insects, will help your crop do well.

CHINESE CABBAGE	
	Local name: N/A
	Availability: Chinese cabbage is commonly grown in gardens and can be grown year-round if a water source is available.
	Uses: For household consumption. Waste leaves may be used for fish or animal feed.
	Quality: Medium
	Care: Grows well under cool, moist conditions. Chinese cabbage should be started in a nursery. Plant 500 grams of seed per hectare. After one month, seedlings should be transplanted.

CUCUMBER	
	Local name: ICIBIMBI
	Availability: Cucumbers are commonly grown in gardens and can be kept year-round if a water source is available.
	Uses: For household consumption. Waste leaves and produce may be used for fish or animal feed.
	Quality: Medium
	Care: Cucumbers thrive when the weather is hot and water is plentiful. Plant seedlings 90 to 150 centimeters apart, depending on the variety (check the stick tag). For vines trained on a trellis, space plants 1 foot apart.

AFRICAN EGGPLANT¹³



Local name: INDIMWA, IMPWA

Availability: Commonly grown in gardens and can be kept year-round if a water source is available.

Uses: For household consumption. Once harvested, they can be stored for up to 3 months, and some consumers dry the fruit to eat later in the year. Waste leaves and vegetables may be used for fish or animal feed.

Quality: Medium

Care: Requires regular weeding and typically can be harvested after 70–90 days.

SWEET AND HOT PEPPERS



Local name: IPILIPILI

Availability: Peppers can be found throughout Zambia.

Uses: Peppers are often used to add spice to foods. They can also be added to your compost crib.

Quality: Low

Care: Do not grow peppers near tobacco. Peppers should be started in a nursery in raised beds. They require shade and plenty of water. Transplant after the plants have four true leaves. They can be harvested after about 8 weeks and will continue to produce for many weeks.

LETTUCE



Local name: N/A

Availability: Seeds can be found throughout Zambia, although lettuce is not widely grown.

Uses: Lettuce leaves can be eaten by people or fish.

Quality: Low

Care: Lettuce requires good rainfall. It can grow in a wide variety of soils. It should be started in a nursery. Sow the seeds 1 centimeters deep. It is important to shade and thin plants out when they have two true leaves. Transplant when they reach about 7 centimeters high. It may help to add manure to the soil. Keep the soil moist or the lettuce will taste bitter. Harvest when the center is fully developed, usually after 6–12 weeks. If the plants begin to have seeds, they are to harvest.

ONION



Local name: NSAPULA

Availability: Onions are grown year-round.

Uses: For household consumption. The leaves are few, but make good compost material because they decompose quickly.

Quality: Medium

Care: Onions like firm, sandy loam soil. Fertilize soil with D-compound, and again with urea 1 month after planting. Onions require a nursery. Transplant when they are about half the thickness of a pencil. Onions may be directly sown into a garden, but this will not be as successful and thinning out is needed.

RAPE

Local name: LEPU, UMUSALU

Availability: Rape is commonly grown in gardens, especially in *dambo* (wetland) areas or along streams. If grown near a water source, it is available throughout the year.

Uses: For household consumption. Waste leaves are good for fish feed or animal fodder.

Quality: Medium, due to small number of leaves produced

Care: Rape should be started in a nursery. It requires a lot of water. When harvesting, the lower leaves on the stem should be picked. Rape may be susceptible to disease or damage by insects.

TOMATO

Local name: TOMATO

Availability: Tomatoes are commonly grown in gardens, in *dambo* areas, and along streams and furrows. They can be grown throughout the year if planted near a water source.

Uses: For household consumption. Rotten tomatoes can be fed to fish or composted. The stalks can be burned and used as ash or placed directly in the compost bin.

Quality: Good

Care: Tomatoes can adapt to many conditions, but wet conditions cause diseases. Tomatoes should be started in a nursery and can be transplanted when they are 10–15 centimeters high. Organic soil is the best for growing tomatoes. During the dry season, these vegetables require lots of water. Generally, they should be staked so vines do not sag. Trim side stems and leaves close to the ground to prevent diseases. When four to six branches with fruit have set, it is suggested to remove the top point to regulate growth.

Crops and vegetables grown in fields

BEAN

Local name: CHILEMBA, MAKUNDI

Availability: Beans are common field crops in many areas of Zambia. They can be grown year-round near a water source.

Uses: Beans and leaves are used for household consumption. After beans have been removed from the pods, the pods may be used for compost or burned for ash. Leaves can be used for animal food or compost for fishponds. Dried plants after harvest can be burned for ash and put in the compost crib. Beans also increase the amount of nitrogen in the soil.

Quality: High

Care: Beans can be grown with other crops. When growing beans, you should use land with good drainage or with a slight slope. Beans grow best with 85 days of rain and 10 days of dry weather. Plant at the start of the rainy season, or delay planting if the rainy season is long. For dry beans, harvest when the pods begin to dry out. For green beans, harvest about 9 weeks after sowing and continue to harvest for 2 months. It is important to practice crop rotation with beans.

CASSAVA



Local name: TUTE, MAKAMBA, KATAPA

Availability: Grown in most areas of Zambia

Uses: The root is often used for family consumption or to sell for cash. The leaves are an excellent protein source for humans, fish and livestock. The leaves and cassava peelings can be used as compost. Soaking cassava in the fishpond can help create a green bloom (*amenshi aya katapa katapa*), which is food for fish.

Quality: High

Care: Requires weeding and may take a year or two to grow depending on the variety.

GROUNDNUT



Local name: IMBALALA

Availability: Grown in fields in most areas of Zambia during the rainy season and available throughout the year

Uses: The root is used for household consumption and is a good protein source. The leaves decompose quickly when composted and make good fodder for animals. The stem and shells can be burned for high-quality ash. Shells can also be used to line chicken nesting boxes. Groundnuts are nitrogen fixing so they can help improve soil fertility.

Quality: High

Care: Plant groundnuts from the previous year at the beginning of the rainy season.

IRISH POTATO



Local name: IMBATATA

Availability: During the cold and dry seasons from June to October

Uses: Commonly grown for household consumption. Leaves and peelings are excellent compost and feed for fish and livestock.

Quality: Low

Care: Planted in November and requires well-drained soil. Harvest after 3–4 months.

MAIZE



Local name: AMATABA

Availability: During the rainy season from February to March

Uses: Maize is grown for eating and to sell for profit. The leaves are not soft but can be used as compost. After harvesting, the stalks can be burned and the ash used for compost. Maize meal and husks make excellent fish feed and rabbit food. *Nshima* can also be used as fish feed. Mill sweepings can be fed to fish in your fishpond.

Quality: High

Care: Seed is planted in November and routine weeding is required. Fertilizers (both basal and top) are applied subsequently.

MILLET



Local name: AMALE

Availability: All year and harvested at the end of the rainy season

Uses: For household consumption. Millet waste generated from pounding can be used as compost in your fishpond.

Quality: Medium

Care: Commonly planted in slash and burn (*chitemene*) farming systems and requires minimal attention.

PUMPKIN



Local name: ICIPUSHI, CIBWABWA

Availability: Pumpkins can grow year-round if water is available. They tend to grow best in the rainy season.

Uses: For household consumption. The green leaves are good for compost. The pumpkin skins or rotting pumpkins can be used for compost. Break these into small pieces before throwing them into your compost crib so they can rot quickly.

Quality: Good

Care: Seeds can be planted directly. They can be planted with other crops.

SORGHUM



Local name: AMASAKA

Availability: The peak of the sorghum harvest is at the end of the rainy season from February to March.

Uses: Sorghum is grown for household consumption. The leaves are not very soft but can be used for compost.

Quality: Medium

Care: Little care is required and sorghum grows well in the rainy season.

SWEET POTATO



Local name: IFYUMBU, KALEMBULA, NTAMBA, KASIMBWILA

Availability: Grown in most areas of Zambia. It can be grown throughout the year near streams and furrows.

Uses: Roots and leaves are commonly used for household consumption. Leaves and peelings are excellent compost and feed for fish and livestock. Roots cannot be used for compost.

Quality: High

Care: Sweet potatoes are drought resistant. Harvest 4–6 months after planting.

SUNFLOWER



Local name: KALOLESHA KASUBA

Availability: Grown commonly throughout Zambia as a field crop. It is available mostly during the rainy season.

Uses: Seeds are often collected and made into cooking oil. The seeds are rich in fats and proteins, and can be eaten directly. The leaves and stalks may be composted or fed to rabbits. Stalks and flowers may also be burned and the ash put in the fishpond. Seed cakes left after making oil from seeds can be stored for a long time.

Quality: High

Care: Seeds should be planted in the rainy season.

Agroforestry

Compost and fish feed can come from many different sources, including rotten fruit, vegetable scraps and kitchen waste. Another source is wild leaves.

Wild leaves can be collected from the bush, but finding enough high-quality leaves can be hard. A good way to ensure a constant supply of leaves is to plant trees in a nursery on your farm. This is also known as agroforestry.

Creating a nursery

Creating a nursery takes 7 weeks and involves three steps:

- Collect and prepare seeds for planting.
- Build a nursery.
- Transplant seedlings.

Collect and prepare seeds for planting

The first thing you need to do is collect your own seeds, mostly leguminous seeds. Your local forestry department can likely supply seeds. You can also collect them from the bush or a neighbor who has the tree of your choice.

Once you have collected the seeds, prepare them by scratching the seed coat and then soaking them in cold water overnight. The next day, you will notice that your seeds are swollen. This means they are ready for planting.

Build a nursery

To plant your seeds, you need to build a nursery. Use a location that is rich in composted soil or has good topsoil. Once you plant your seeds in polythene pots, cover your nursery with thatch for 2 weeks. It is good practice to make a grass fence (1 meter high) around the nursery to protect the seedlings from dogs, chickens and children.

Transplanting seedlings

After 7 weeks, the seedlings should be ready to be transplanted. To prepare them for transplanting, gradually decrease the frequency of watering to harden the seedlings. Make sure you dig holes that are at least 1 meter apart so your trees have plenty of room to grow. Watering and keeping the area free of weeds is vital, so this must be done daily for the first year after planting. The trees can be planted near ponds to reinforce integration.

Nitrogenous leaves provide excellent fertilizer for ponds.¹⁴

Integrating agroforestry with fish farming

Agroforestry is a system in which farmers plant trees to be used as resources and inputs on their farm. Put simply, it is the use of trees to support agriculture and fish farming activities.

Agroforestry programs are simple to initiate and relatively cheap to establish. Trees can give many benefits:

- providing compost material for fish farming.
- improving soil fertility.
- stabilizing the land to avoid erosion.
- encouraging moisture retention.
- supplying firewood and fodder for livestock.

Trees such as golden cassia (*Senna spectabilis*) and legumes such as mimosoid trees (*Leucaena leucocephala*) or pigeon peas (*Cajanus cajan*) have leaves that are rich in nitrogen. When the leaves are placed in compost cribs, they can quickly create a large bloom or greening of your fishpond water.

These trees have a low carbon-to-nitrogen ratio in their composition, which helps them to decompose quickly. Fish can also feed directly upon the softer leaves. These trees keep their leaves throughout the year, even during the hot dry season, so you have a sustainable, year-round source of high-quality compost. By planting these trees near your fishponds or home, you can decrease the time spent finding and collecting compost.

Planting trees can increase soil fertility in your fields and gardens, and certain legumes can increase nitrogen levels in the soil. Planting golden cassia or *ngolyolyo* in a field can replenish the soil with nitrogen so that you do not have to use much fertilizer. Then you will not have to burn a lot of trees in the *chitemene* system.

With increasing deforestation in Zambia, much farmland has lost its nutrient-rich topsoil due to erosion from wind and rain. All year-round, trees and shrubs help stabilize the earth with their roots so that the rich soil stays locked in and ready for planting. The roots also hold water in the soil. A farmer who plants trees benefits from better-quality soil and more soil and field space to plant crops.



Feed your fish lots of high-quality vegetables.

Trees grown for fishponds

GOLDEN CASSIA TREE	
	<p>Local name: GOLDEN CASSIA</p>
	<p>Availability: <i>Senna spectabilis</i> is grown as a decorative tree in many towns throughout Zambia. It is available throughout the year.</p>
	<p>Uses: It produces a large quantity of leaves, which are kept during most seasons of the year. These can be used as compost or fed directly in small amounts to animals. The leaves decompose quickly and are nitrogen rich.</p>
	<p>Quality: High</p>
<p>Care: Treat seeds before planting. You can either soak your seeds in hot water overnight or cut the seeds and soak in cold water. Plant cassia in well-drained soil that is not prone to standing water. Provide cassia with 6 hours or more of daily sunlight. Water garden cassia approximately once a week with 2.5 to 5 centimeters of water. When the trees reach about 100 centimeters high, cut the tops and throw them in your fishpond. The plants will branch out and provide a lot of leaves. You can cut the trees like this every year.</p>	
LEUCAENA LUECOCEPHALA¹⁵	
	<p>Local name: LEUCAENA, LUSHINA, LUSINA</p>
	<p>Availability: This tree is available throughout the year. Leucaena has nitrogen-rich leaves that are good for compost in fishponds. It is not recommended to use only leucaena in your fishpond.</p>
	<p>Uses: Leaves of leucaena are highly nutritious for ruminants like rabbits and for fodder. Leucaena can also be used to intercrop with cereal crops. Leucaena hedges are useful as windbreaks and firebreaks, the latter because they suppress understory grass growth.</p>
	<p>Quality: High</p>
<p>Care: Leucaena can be planted by seed or using a stem. Large areas are best planted by seed in rows in fully prepared seed beds or into handmade ridges in existing grasslands. Use seeding rates of 1–2 kg/hectare at depths of 2–3 centimeters in rows 3–10 meters apart. Sowings are best made early in the growing season when rainfall is reliable. Use good weed control measures (cultivation and herbicides) to minimize competition, as leucaena seedlings are susceptible to competition in the root zone.</p>	
GLIRICIDIA SEPIUM¹⁶	
	<p>Local name: MOTHER OF COCOA, TREE OF IRON</p>
	<p>Availability: This tree is available throughout the year. <i>Gliricidia</i> has nitrogen-rich leaves that are good for compost in fishponds</p>
	<p>Uses: Leaves can be used as livestock fodder as well as compost for fishponds. Trees help improve the soil by fixing nitrogen. They can be used to make living fences, to stabilize soils and prevent erosion, to shade plantation crops, as an ornament, and as traditional medicine for eczema.</p>
	<p>Quality: Medium</p>
<p>Care: Soak seeds in hot water and let cool for 24 hours before planting. Then plant seeds, or plant cuttings of other <i>Gliricidia</i> plants.</p>	

Raising animals

Integrating animal husbandry with fish farming

Raising animals, such as chickens and rabbits, has many benefits. The meat and eggs provided are a good source of protein that is needed especially for growing children. Animal manure is an excellent fertilizer for gardens and for fishponds. Animals are also a good source of income. They can be sold in an emergency if you need money for school or medical fees.

Raising animals along with crops and fishponds creates a diverse farm. If your crops or fishponds fail, you still have animals for food and income.

Choosing animals to raise

Every type of livestock needs some kind of care every day. Even if they roam free during the day, they still need to be put in a shelter at night, and the shelter should be cleaned regularly to prevent disease.

Before you start raising animals, you need to carefully plan how you will find the time and feed to raise them properly. You need to do the following:

- Plan how you will take care of them if you need to go away.
- See a local veterinarian to find out what diseases the animal you want to raise can get, and how these diseases can be prevented.
- Discuss with your family how each member can help care for the animals.
- Look at a calendar and think of what you will have to feed the animals each month.

If you find that you have plenty of spare time, energy and lots of crops with which to feed animals, you may consider raising pigs or even cattle. But remember that they will not be healthy unless they have enough to eat. They will also destroy crops if they do not have a good shelter. If you decide you do not have very much time to care for animals or very many crops to feed them, then you should raise chickens, goats, rabbits or ducks, which are easier to feed.

Whatever animals you decide to raise, plan carefully, feed them well, build a good shelter, clean it often and use the waste in the fishpond or garden.



Animal shelter adjacent to pond and gardens.¹⁷

Cattle

Cattle are useful in fish farming and farming in general. Cattle can be used for activities such as clearing land, plowing fields and transporting goods to the market. Cattle provide financial security for the farmer and family. Finally, cattle are good to eat and are a good source of protein.

Cow manure can be used as fertilizer in fishponds, gardens and fields. Cow manure contains a lot of nitrogen, phosphorus and potassium. It is important to use the freshest manure possible because older manure does not break down quickly. Cow manure is not as good for fertilizing fishponds as chicken manure, but it is easy to get a lot of manure from just one cow. Manure should be put into fishponds once a week. The nitrogen-rich manure will help make a bloom of green water in the fishpond, and will therefore feed the fish.

Housing

You need a cattle enclosure to house them at night. This will provide an easy way to gather the manure. The housing unit must be easily accessed and in close proximity to your home and ponds to allow for easy collection of manure.

Feeding

Cattle usually feed on green fodder and are therefore on free range. During the dry season they can subsist on crop byproducts.



Photo Credit: Albert Nanya/WikiMedia

Cattle can provide adequate manure when kept in an enclosure.¹⁸

Chickens

Housing

One of the reasons farmers do not have chicken manure to put in their fishponds is because when chickens roam free, it is impossible to collect the manure. But when chickens are kept in an enclosure, manure is easy to collect.

There are a variety of enclosures you can build, ranging from a small pen where you close chickens in every evening to fully enclosed houses, which chickens never leave.

Choosing the right enclosure depends on how much feed you have available and how much manure you want to use in your fishpond. If you do not have much feed and only have one fishpond, you could build an enclosure to keep your chickens in just at night. This would provide enough manure for your fishpond. However, if you have more than one fishpond and can provide enough feed to chickens, you could build a fully enclosed structure. Only choose an enclosed structure if you can provide all their food, because they are not able to scavenge.

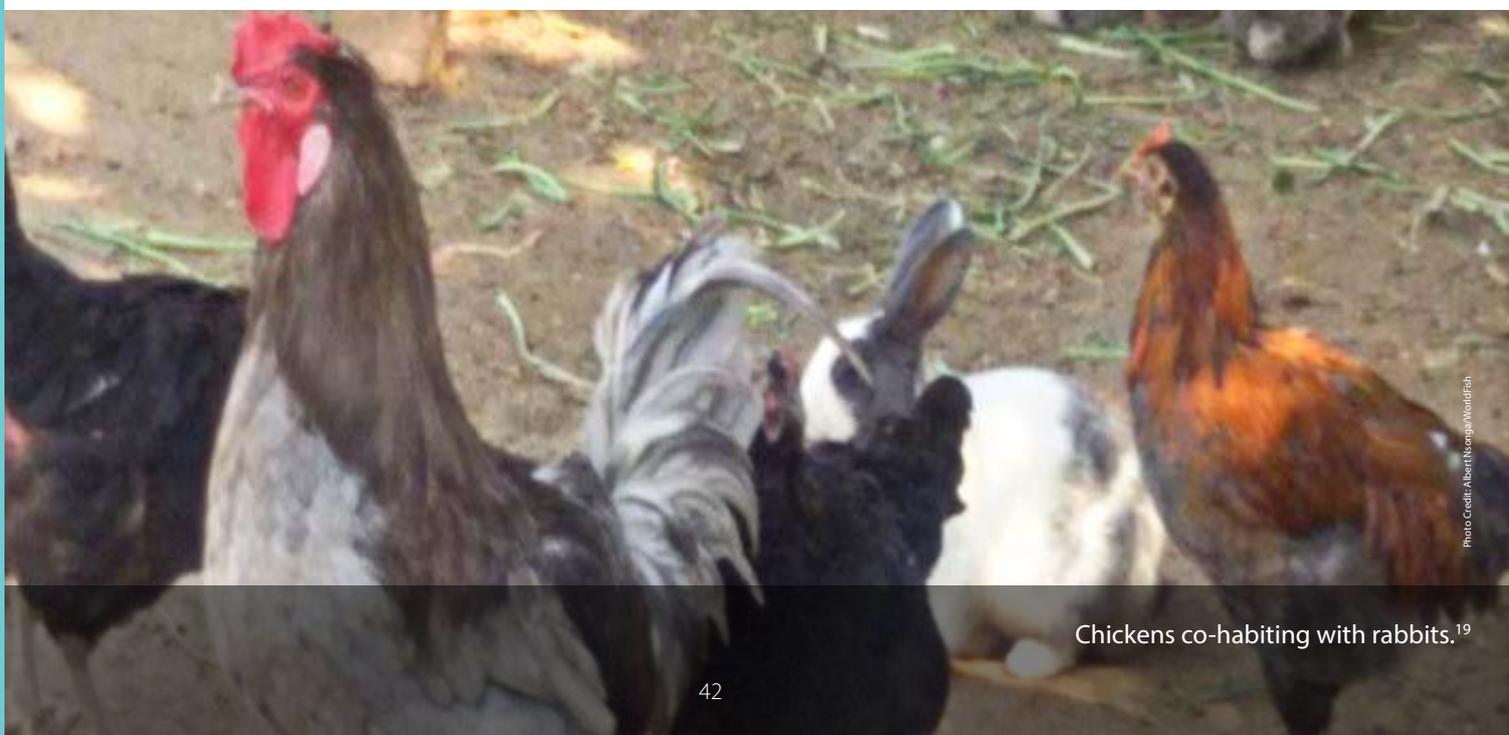
A common design is the raised makeshift shelter. These are fully enclosed structures. They can be built on wooden poles, or on brick poles in areas where termites are a problem. A series of 1-meter-high wooden or burnt brick pillars are constructed on the ground. The floor of the house is built out of wooden slats or logs that are spaced 2.5 centimeters apart and are at least 2.5 centimeters wide. This allows manure to fall below the house, which makes collection easy and prevents disease from stagnant manure sitting in the chicken house.

The walls of the house are made of brick or wood. If the house is made of brick, you must include small windows to provide ventilation, which prevents disease. The roof can be made of thatch or iron sheets. If thatch is used, the thatch job must be very well done so that rain does not leak into the chicken house. It is important to realize that this house is not suitable for young chickens, because the ventilation, which is necessary to prevent disease, causes the house to be too cold.

Feeding

While it is possible to grow all the food that a chicken needs on a village farm, most fish farmers are not interested in doing this.

You can add protein to your chickens' diet while benefiting your fishpond. During the dry season, you can make chicken mash. This is a mixture of a number of edibles, which could even be leftovers. They could include cassava, maize, bread and banana peels.



Chickens co-habiting with rabbits.¹⁹

Ducks

Raising ducks is an easy and useful way to integrate fish farming with animal husbandry.

Ducks can thrive when left to roam freely. However, this is not the best way to raise them, especially if you have a fishpond. Ducks have been known to destroy gardens, especially young plants. Sometimes they also root around fishponds, disturbing nests and eating aquatic insects and plants, as well as small fish.

Housing

Ducks can be very beneficial to fish farming, but need to be kept in an enclosed area to prevent damage.

Duck shelters can be built either in or outside your fishpond. Shelters built in the fishpond are more beneficial because manure and food scraps will be directly deposited into the fishpond. For example, one duck can produce 7 kilograms of fresh manure in 35 days.

Shelters such as floating rafts or built-in enclosures will work. The requirements for these shelters are simple. They need dry and wet areas, and must have protection from the wind and direct sunlight. The shelter should also be cleaned periodically.

Female ducks can start breeding at 28 weeks. Males need about 32 weeks before reaching sexual maturity. Usually 10–20 eggs will be laid. It takes 33–35 days before eggs will hatch. Ducks can have 3–4 clutches a year. They are good mothers and are often used to incubate and hatch other poultry eggs. However, males will attack and kill ducklings and should be separated from ducklings until they are 3–4 weeks old. Ducklings should be kept and fed in a warm place, such as a kitchen, in order to prevent attacks from predators. It is ideal to have one male for five or six females, especially if kept in an enclosure. It is recommended that ponds be stocked at a rate of 15 ducks per 100 square meters.

A common duck found in Zambia is the Muscovy duck. Most mature males weigh about 5 kilograms, while females weigh about 2.5 kilograms. Their feet have sharp claws, which can make them difficult to handle. Both sexes raise a crest of feathers when alarmed. The easiest way to tell their gender is by comparing their size difference. The coloration varies from black to white, blue, buff or iridescent. In most areas ducks can be found near water and almost always eating.

Feeding

Ducks feed on greenery as well as grain. Anything that can be used as fish feed can also be used to feed ducks. Ducks are scavengers by nature, so they also dig in the ground for worms and insects.



Domesticated ducks in an enclosure provide quality manure for ponds.

Goats

Many people in Zambian villages keep goats because they are easy to feed and rarely get sick. Goat manure is good compost for fishponds, but you must manage them a certain way to use the manure effectively.

Housing

To use goat manure in fishponds, you need a good way to collect and prepare it. Most farmers do this by building an enclosure for them to sleep in at night. Then, in the morning, they sweep out the goat house and put the manure in the fishpond. The enclosure should be strong and have a good roof. It should be close to the fishpond with a large door so it is easy to sweep the manure out and into the fishpond. Goat manure is very hard, so it should be pounded into dust or smaller pieces before it is put into the fishpond. This helps the manure rot quickly; otherwise it may not rot for weeks or months.

Feeding

Feeding goats is very simple because they will eat almost anything. You can feed them household scraps, garden waste, plant leaves and even grass. Goats prefer to browse, so you should try to give them many different types of plants and not just the same food all the time. You must also watch your goats closely because if they roam freely around the village, they can be destructive and eat gardens and crops.

Guinea pigs

Guinea pigs are useful for fish farmers that lack manure to put in their fishponds yet do not have the space, time or resources to raise larger animals. There are many benefits to raising guinea pigs. They are small and take up little space. They can be raised inside the farmer's house, so a separate house does not need to be built for them.

A guinea pig does not need a special diet and can be fed on resources that already exist on the farm. Guinea pigs reproduce quickly, are disease resistant and provide a good source of protein.

Housing

A guinea pig can live in almost anything, ranging from a cardboard box to a basket, so be creative. In fact, some farmers even let guinea pigs roam freely in their homes.

As a fish farmer, you need to consider how to collect manure when designing a guinea pig cage. Manure should be easy to remove from the cage, which means the cage should have a removable top or a side door.

For each guinea pig, you should have at least a space about the size of a 20-liter jam gallon or can lying on its side. This means if you are raising one male and one female guinea pig, and you plan to breed them, you should create two cages the size of three jam cans each. Guinea pigs will often produce 2–3 young per litter, and as they grow older they will need their own cage, which is why you must build a second cage.

Feeding

Guinea pigs are easy to feed and can survive on scraps that you can find around your farm. They should be fed twice daily just like you feed your fish. Each guinea pig has a slightly different appetite so you have to experiment with the types and amounts of food you give. If your guinea pig finishes eating too quickly, you should feed it a larger amount. If your guinea pig finishes its food slowly, you should feed it less. If you are interested in raising guinea pigs but do not know where to get them, or you want more information about guinea pigs, talk to your local agricultural officer.



Mr. Chileshe, a farmer in Northern Province, holding his guinea pig.²⁰

Pigs

There are many advantages to raising pigs. Pigs are easily integrated into most farming systems and are beneficial to fish farming because of the high content of nitrogen, potassium and phosphorous in their manure. This manure can be used to fertilize fishponds by creating green water, which is the best food for fish. Pig manure can be used to fertilize gardens, which will increase vegetable-growing productivity.

Female pigs will have up to two litters a year with up to 15 piglets per litter. Because pig manure is so rich in nitrogen and because pigs reproduce well, they are a good choice for a farmer who is interested in building a multiple fishpond system.

Housing

It is important to build a good pen for your pigs. A pig pen can be built from local materials and should be as close to the fishponds as possible. A pen should have a large entrance to make it easy to gather manure regularly, at least once a week. The closer the pig pen is to the fishponds, the easier it is to clean and the less time it takes to feed your fish.

Some farmers have had success building their pig pens directly over the fishponds. A well-maintained and clean pig pen means a healthy pig.

Feeding

Pigs eat both meat and vegetables. In fact, pigs will eat just about anything. This includes maize, millet, bean leaves, sweet potatoes and any left overs from meals.

Pigs must be fed roughly 2 kilograms per pig per day. They will not be able to find adequate food free ranging around the village. If pigs are left to look for food, they will certainly go to gardens and crops in the village. This could cause problems for your family and your neighbors.

The more you feed your pigs, the healthier they will be. A healthy pig is less likely to become infected with disease and less likely to spread diseases.



A pig pen should have a large enough entrance to make it easy to gather manure regularly.

Rabbits

There are good reasons to raise rabbits. Rabbits are a good source of protein, and they reproduce often, so a family with well-managed rabbits can eat one adult rabbit a week.

The initial investment for getting started with rabbits is low. Rabbits take up very little space and easily survive on garden scraps and bush plants.

A house for rabbits is called a hutch. Rabbits are not prone to disease, so if the rabbit hutch is kept clean, the rabbits will remain healthy. Rabbit manure is also a good source of compost for fishponds.

Housing

Rabbits are capable of producing many young; therefore it is important to build good housing for them. A rabbit hutch should be built so it stands 1 meters above the ground. This will protect the rabbits from red ants. It should also be self-cleaning by using small-gauge wire or slats as the flooring. This will make it easy to keep a clean hutch and collect the rabbit manure, which falls on the ground under the hutch.

Female rabbits are called does. Does will produce 6–8 young per litter, and they will have three litters per year. A male rabbit is called a buck. A buck can mate with 10 different does. A buck is productive for 2–4 years and a doe is productive for 2–3 years.

The hutch should be divided into at least three different compartments to separate males from females. It should also have a waterproof roof that opens from the top. This will protect the rabbits from rain and predators, and will make it easy to move the rabbits and clean the hutch. A good rabbit hutch should have open sides or a place the rabbits can find light.

Feeding

Many things from the garden, fields and bush can be fed to rabbits. Rabbits eat sweet potato leaves, cassava leaves, wild beans, garden scraps, maize, millet, sorghum, banana leaves and much more.

It is important to feed rabbits twice a day, but not overfeed them. Rabbits also like to have something to chew on. Some things should not be fed to rabbits, such as tomato leaves and Irish potato leaves that are limp or rotting. It is important to have some source of salt (even traditionally brined) for the rabbits. If a male rabbit is fed properly, he can reach a weight of 2 kilograms in only 8 weeks.



Rabbits eating garden waste.



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