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A Review of Topography in Fish Culture in Nigeria Part Two

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Abstract: A review of topography in culture in Nigeria was reviewed to enable the fish culturists know the basic principles to design and build fishponds, reservoirs and small dams and use existing topographical maps. All physical features of fish farms depend directly on the site topography. The exact plan of the fish farm need be followed. Do this by ensuring the position to build each structure. Soil quality varies and depends on the topography of the area. Topographical method can be used for maps showing the different kinds of soil present in an area of land. In this part, integrated farming, using pumps, how to plan your fish farm considering its size and complexity, laying out ponds according to their use, laying out the access roads on your farm, laying out the canals on your farm , Level differences on your fish farm, If you are building a barrage pond, A pump might be necessary and living on your fish farm are considered. The topography measurements reviewed are height measurement, measurement of differences in height, methods for measurement of height differences, calculating differences in height, the line level, the flexible tube water level, the T bone level, the improved T - bone, the bamboo sighting level, the hand level, Contouring Mason's level, The A - frame level, The a frame and plumb line level, contouring with non-sighting levels, contouring with sighting level and graded lines of slope to enable the fish culturists know these basic principles to design and build fishponds, reservoirs and small dams and use existing topographical maps.

Key words: Contouring, Fish farm plans, graded lines, height measurements, integrated fish farming

INTRODUCTION

Distances are measured in different ways. Long distances are measured and maintained along a straight line. Slopes are determined through horizontal distances rather than ground distance. The best choice for a dam site is a narrowing valley with sleep slope walls and small gradient. In the absence of an existing topographical map to detect such a valley, it can be measured to determine its suitability for a good dam site. If the best site is chosen, topographical methods unveil the level of work on site. Survey the site in the desired plan by measuring the distances, directions, areas, slopes and heights. Draw a detailed topographical plan to make these measurements. The plan shows the position of boundaries, different heights of landforms such as hills and location of existing physical features (FAO, 2002).

The features include paths, roads, streams, spring, forest, rocks and buildings. Such a plan is very important because it provides information on the basic horizontal and vertical elements of the area, facilitating the fish farm design. It provides information on the direction of water flow, position of water supply canal and pond drainage ditches. This forms the basis for estimating the quantity and cost of mud to be excavated.

All physical features of fish farms depend directly on the site topography. These features include the type, number, size, and shape of the fishponds and how they are placed in relation to each other. Water supply and drainage type also depend on the site topography. Topographical methods guide a detailed site survey and fish farm design. Ensure a regular adequate water supply. A Water supply canal with an appropriate size and bottom slope can solve the problem. Stake out water supply canal along its centre line. Maintain a definite width, depth and canal length; and estimate the level of soil to be removed at each point (FAO, 2002).

Stake out the bottom area of each pond for proper disposal of the excavated soil. This allows a natural drainage of all water out from the ponds, for effective fish harvest and pond management. Stake out the dykes of each pond and determine where to add or remove soil. There is need to mark the location, height and width of each dykes as well as the slopes of their walls. Perpendicular (crossing) and parallel (side-by-side) lines can do the job.

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The exact plan of the fish farm need be followed. Do this by ensuring the position to build each structure. Check these locations during construction. Height differences between different parts of the farm need be measured to ensure natural water flow in the right direction. Water will have to flow from the water source to the ponds, from pond inlets to the outlets and from the outlets into drainage ditch, which transports water away from the farm site (FAO, 1980).

It is important to learn the use of simple topographic methods for:

- Estimating the surface areaandwater volume of ponds
- Determining the water flow system of a steam
- Using a weir
- Measuring water head pipes and siphons
- Dam site selection
- Estimating the volume of a reservoir

Soil quality varies and depends on the topography of the area. Shallow soil is found on sloppy land and deep soil is found on flat land, for instance, alluvial soil which is found in sedimentation plains, contains large amounts of clay. The clay in this soil aids in water retainsion and buffers the materials for building of dams. Topographical method can be used for maps showing the different kinds of soil present in an area of land. The commonly used topographical methods are reconnaissance surveys and detailed soil surveys (FAO, 2006).

Most topographical methods are based on lines. Lines are of two types:

- Lines of measurement
- Lines of sight

Lines of measurement can be horizontal or vertical or follow the ground level (FAO, 1980). These lines are clearly plotted in the field with markers to show the exact path measured. A line of measurement can be:

- A straight line drawn in one direction between two marked end-points
- A broken line drawn in more than one direction between two marked points, with each point in the new direction
- A curved line, marked like a broken line, but with closely spaced marker, that clearly follows the curve

A line of sight is an imaginary line starting from the surveyors' eye to a fixed point; lines of sight are either horizontal or oblique (between horizontal and vertical). Lines of measurement are always plotted on the ground either as one straight-line or as many interconnected straight lines. Pegs, small concrete pillars, simple wooden stakes or ranging poles are used as markers to indicate the direction of the line (FAO, 1980).

Lines of sight are straight lines. The reference point is marked with either a ranging pole or a leveling staff. Vertical lines of measurement can be formed with a plumb line. Straight pieces of wooden pegs with diameter ranging from 3 to 8 cm and length ranging from 0.1 to 1.0 m can be used for pegging the line. Shape the pieces at one end with a knife to make the ground. Pegs carved from hard wood last longer and when coated with engine oil, prevents rotting (FAO, 1994).

Apart from wooden pegs, iron pegs made of cut pieces of iron rod or tube of diameter ranging from 1.3 to 2.0 cm, and long wire nails can be used. Iron pegs last longer than wooden pegs, but are more expensive and less portable for fieldwork. Mark any long-term reference point with a small, upright pillar made of concrete. Such pillars should range from 15 to 30 cm^2 and 10 to 60 cm high. The pillars can be placed on a small concrete base built on the site. The peg or pillar need marked point for accurate measurements because; the marked point determines the measurement position or measurement instrument placement position. A nail can be driven into the flat top of the wooden peg or set a nail into the concrete pillar top (FAO, 2002).

Ranging poles are the most commonly used markers in topographical surveys. Ranging poles are long, thin poles used in marking a point on the ground seen from a distance. A personal ranging pole can easily be prepared from a wooden pole of length ranging from 2 to 3 m and thickness 3 to 4 cm. Shape the lower end into a point for easy penetration into the ground. Cut a slit 5 cm deep into the topside of the other end. Paint from the top in alternating red and white sections to the end of the pole.

A ranging pole can be sighted from a long distance. Fasten two small flags of different colors, one above the other, near the pole top. A 15×25 cm piece of white cardboard in the slit at the pole top can also be used. Ranging poles are driven vertically into the ground. Walk few steps backwards and watch to ensure that the poles are vertical. Walk one-quarter the distance around the pole and check from the side for straightness. Adjust it until both front and side views are vertical (FAO, 2002).

A ranging pole can be centered over a marker and placed in position for a period of time. This can be done using a series of guys. Guys are ropes or wires tied around the poles and fastened to pegs in the soil. Guys can also be used with poles on hard soil, difficult to drive deep in a vertical position. In this part: Features of a fish pond, Different kinds of pond, Advantages and disadvantages of these types of pond, Basic pond types, Characteristics of shallow and deep ponds, Setting out a straight line between two points, Prolonging a line, Horizontal distance

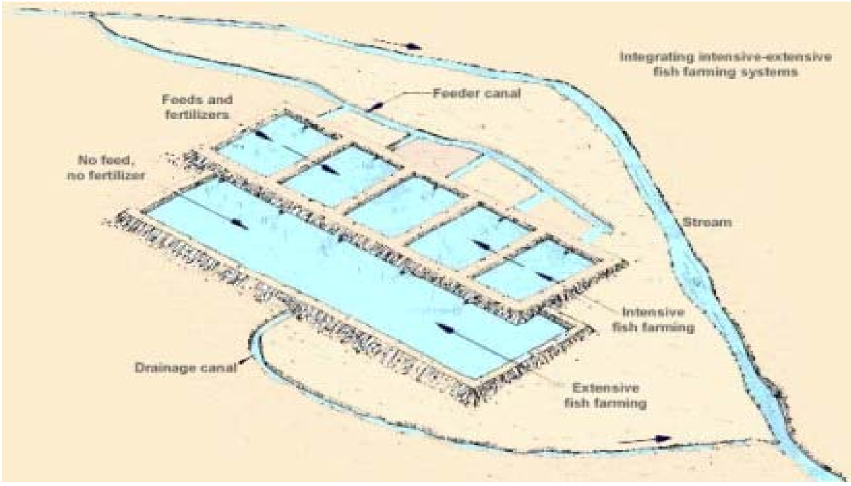


Fig. 1: Integrating intensive- extensive fish farming systems

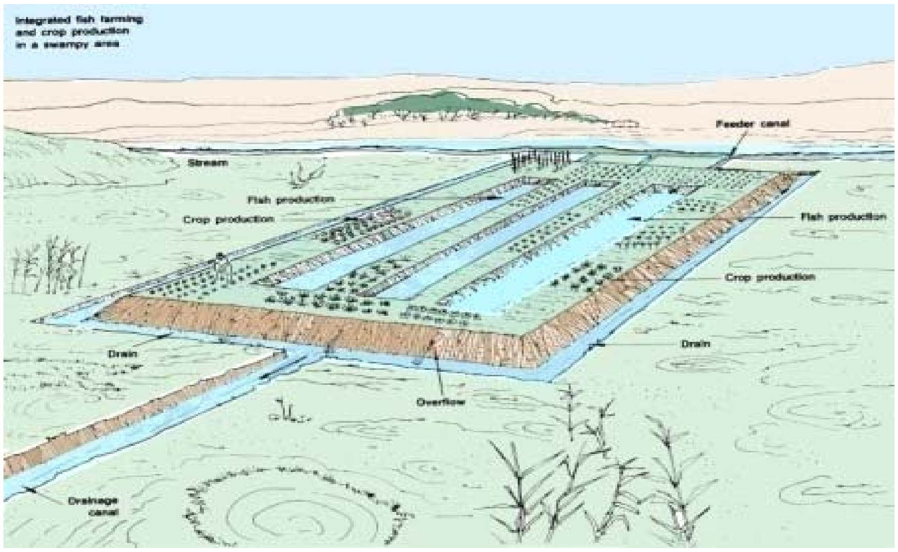


Fig. 2: Integrating fish farming and crop production

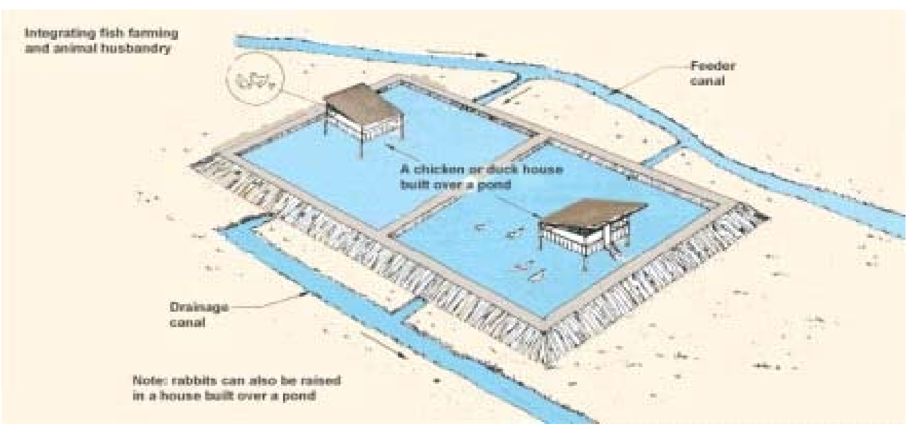


Fig. 3: Integrating fish farming and animal husbandry

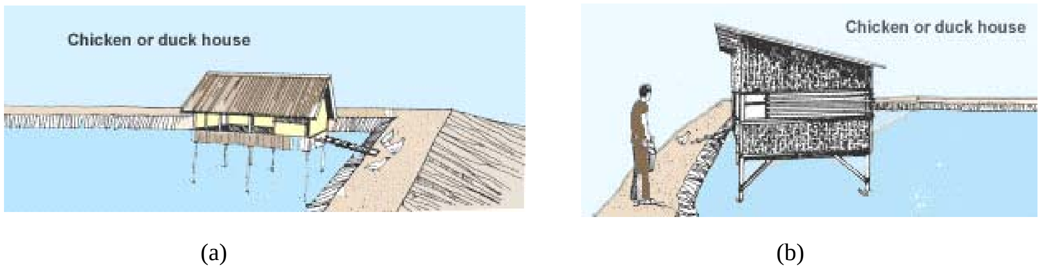


Fig. 4: Chicken or duck houses

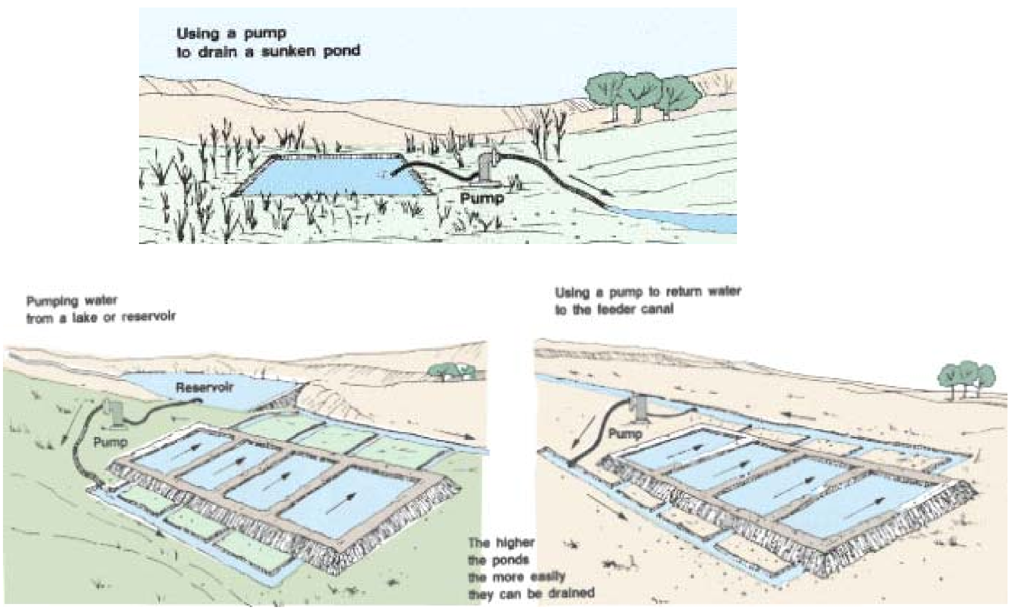


Fig. 5: Using a pump

measurement, Pace count, Chaining, Clisimeter and Stadia method is reviewed to provide the basic knowledge needed to build good, efficient and reliable pond systems.

Integrated farming : The production of fish in ponds can easily be integrated with agricultural production, particularly on sloping ground (Fig. 1-4). On the slope itself, trees may produce wood, fuel and food. The forest cover will protect the soil well and control erosion. A reservoir to store water during the dry season may be built and used for fish and agricultural production. At the lower end of the slope, fish ponds can be built. Various kinds of animals can be raised next to these ponds and can provide fertilizer for them. Water from the ponds may be used for watering adjacent gardens and crops. Mud that accumulates on the bottom of the ponds can periodically be removed to fertilize surrounding crops (Ajana, 2003).

Integrated fish farming: On your fish farm you may combine two production systems in two separate groups of ponds (Ajana, 2003):

- An intensive system where fish are densely stocked and where their growth is sustained by adequate feeding, using fertilizers and feeds
- An extensive system where fish are stocked at a lower density and where their growth relies only on the presence of natural food; the production of this natural food is enhanced by the rich water draining out of the intensive system into the extensive one

Using pumps: Pumping is not normally used in those layouts fed from streams or reservoirs but can be used for sunken ponds and sometimes to supply diversion ponds from a lake or reservoir (Fig. 5). In times of severe water shortage, pumps can be used to recycle the waste water, drawn from the drainage canals and fed back to the feeder canals. By using pumps where manual methods would be limited, you can sometimes take advantage of sites or plan your ponds more flexibly. However, using a pump involves additional costs, and re-using the waste water may cause problems to the fish. Recycling should only be considered in an emergency. Note: In some cases drainage water may be returned to the supply.

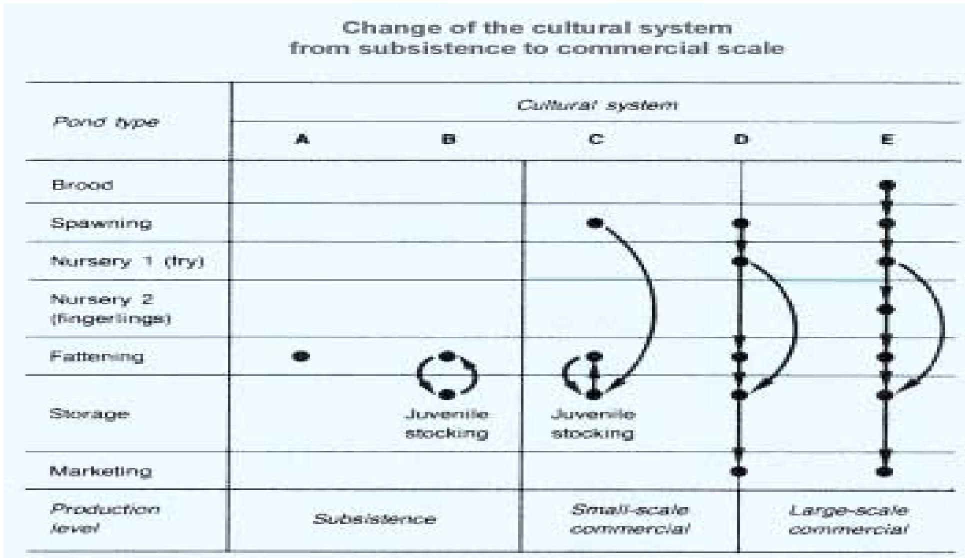


Fig. 6: Changes of the cultural system from subsistence to commercial scale

How to plan your fish farm considering its size and complexity: The size of a fish farm will vary according to the level of production you wish to reach (Fig. 6). The greater the potential fish production, the greater the investment, and the greater the farm size. The number and size of ponds increase as the fish farm increases in scale. The culture system also becomes more complete, with special ponds for brood stock, fry and fingerlings, and storage, as well as the main ponds for producing food fish (Amarnighe; 1987).

Subsistence fish farmers do not need more than one or two small ponds, which are used as fattening ponds and sometimes also as breeding/nursery ponds (culture system A). This system can be improved by adding one or more small storage ponds to keep the harvested juveniles alive while the fattening pond is harvested, repaired and refilled with water (culture system B).

Small-scale commercial fish farms usually add one or more spawning ponds and nursery ponds, making the farm independent as far as seeds are concerned (culture systems C and D). Pond numbers and sizes slightly increase. One or more storage ponds can also be used for marketing.

Large-scale commercial fish farms may have the most complete range of fish-rearing facilities, including brood ponds and nursery ponds (Culture systems D and E). Pond numbers and sizes greatly increase. As the fish-rearing facilities increase in size and become more complex, other facilities (the support infrastructure) also become important. These may include roads, power production and distribution, feeds production and storage, workshops, office/laboratory, hatchery, housing, etc. The layout becomes more difficult to design as the fish farm grows in å size and complexity. Remember, the design of large farms is best done by a specialized engineer. However, to lay out a smaller-scale farm, the following guidelines will be useful (Amarnighe, 1987).

Laying out ponds according to their use: Ideally, the entire pond area should be visible from the main office/service building area at the centre of the farm. For very big farms, it may be necessary to group the ponds, each with its own small working centre. Lay out the brood ponds, spawning ponds and storage ponds so that they are well protected against poaching, easily accessible by vehicle, easily drainable and well supplied with good quality water. Lay out the nursery ponds between the spawning ponds and the fattening ponds. Provide easy access for at least a mini-tractor and its trailer. Lay out the fattening ponds to allow good access for feeds, fertilizers and equipment as well as easy transfer of harvested fish to storage ponds or the outside market (Amarnighe, 1987).

Laying out the access roads on your farm: To have better control over incoming and outgoing traffic, restrict access to the farm to one point only. It is sometimes preferable to group most of the service buildings near this access point. Limit the canal crossings to the minimum. Build road crossings on the feeder canals rather than on drainage canals, as these are usually narrower and easier to cross. This might require keeping the main access road along the higher side of the farm. Provide access as near

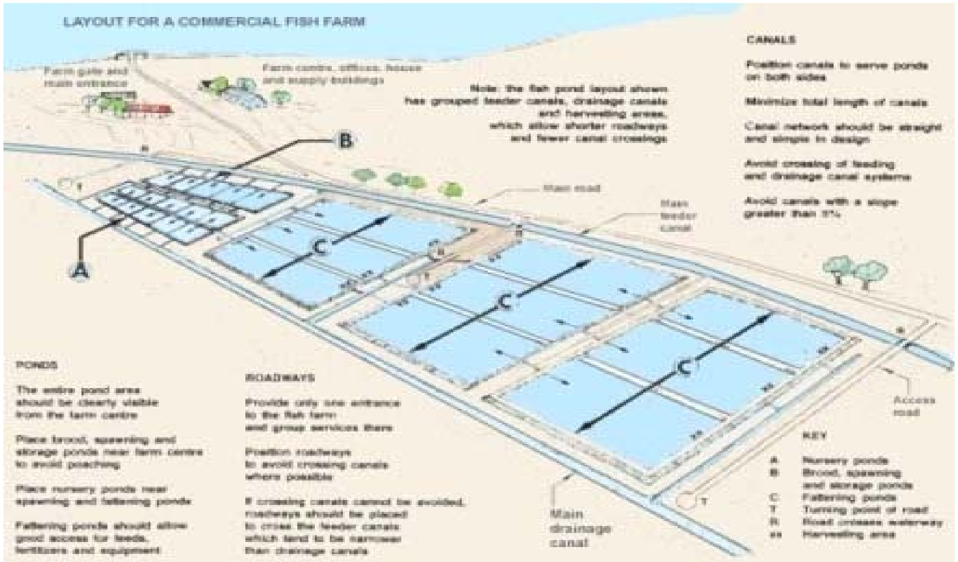
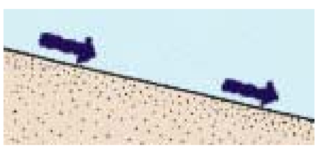


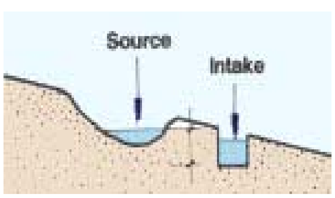
Fig. 7: Layout for a commercial fish farm



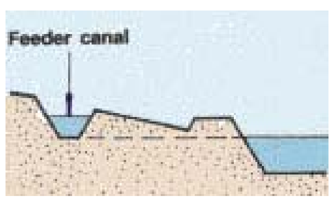
(a)

(b)

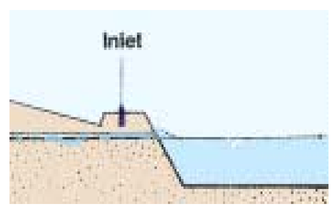
(c)



(d)



(e)



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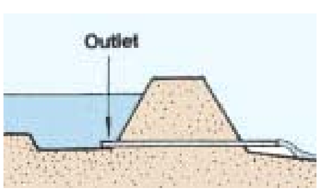
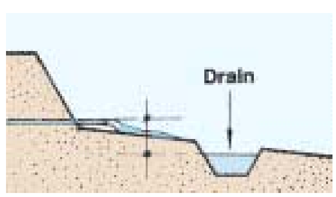


(g)



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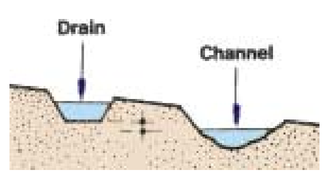


(I)

Fig. 8: Barrage ponds or diversion ponds fed by gravity

as possible to the harvesting area of the fish ponds. By a grouping harvesting areas together, a single access point can serve several ponds. Have good access on the farm itself to the main water control structures. Try to make sure they are all within the farm boundary. Design access roads and their turning points according to the particular type of vehicle you plan to use on them: the narrower the road, the cheaper it is to build and maintain (Amarnighe, 1987).

Laying out the canals on your farm: Try to make each canal serve ponds on both sides. Try to minimize the total length of canals, unless it makes laying out the ponds too difficult or their construction too expensive (Glover, 1986). Try to make canal networks reasonably straight and simple. Minimize the number of junctions. Try to avoid drainage and feeder canals that have to cross each other. Try to avoid canals that have to run down a slope steeper than 5 % (Fig. 7).

Level differences on your fish farm: When laying out your fish farm and, later, when designing your fish ponds, it is important that you clearly understand how the elevation of the various structures has to change progressively to ensure a gravity water flow (Glover, 1986). If you plan to have either barrage ponds or diversion ponds fed by gravity (Fig. 8), remember:

- Water flows down from the highest to the lowest point
- The water surface in a pond is always horizontal
- The pond bottom should be above the water table at harvest
- The bottom of the main water intake should be below the minimum level of the water source
- The bottom of the feeder canal should be at or above the maximum pond water level
- The pond inlet should be located at or above the maximum pond water level
- The start of the pond outlet should be at the lowest point of the pond.
- The end of the pond outlet should be at or above the water level in the drain.
- The end of the drain should be at or above the maximum water level in the natural channel.

If you are building a barrage pond: In the case of a barrage pond fed directly by a small stream (Fig. 9), it is easy to determine the difference in level (X) required between the maximum water level upstream and the maximum level down stream from the pond that will provide enough depth of water in the barrage pond (Hem, 1989). X should be at least 0.80 m.

X = The difference in level required between the maximum water level upstream and the maximum water level downstream
a = The difference in level required between the top of the dam and the maximum water level in the pond (freeboard)
b = The difference in level required between the end of the pond outlet and the maximum water level downstream

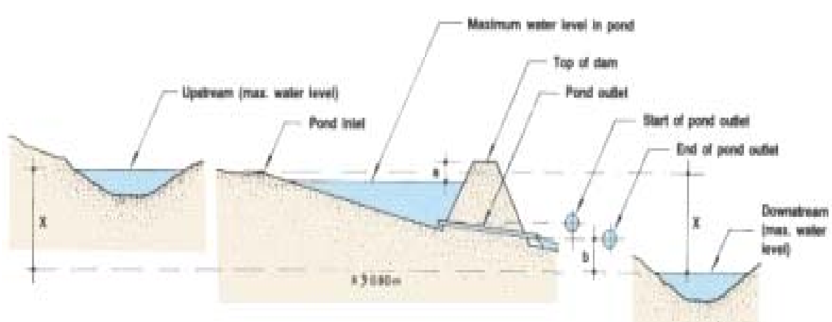


Fig. 9: Barrage pond level differences

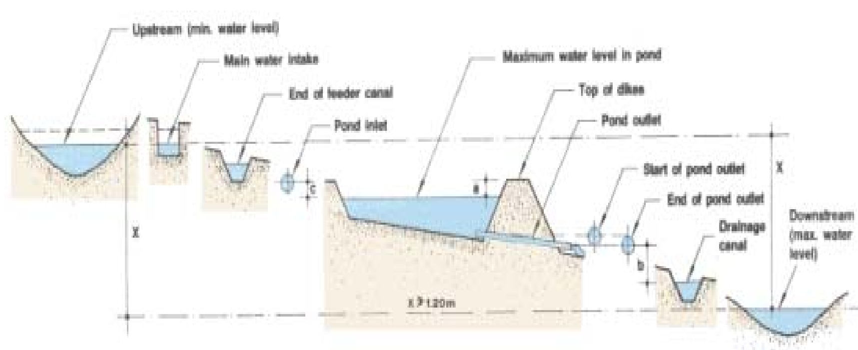
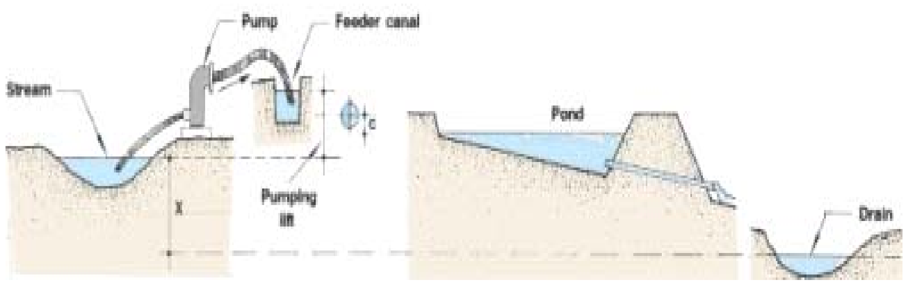
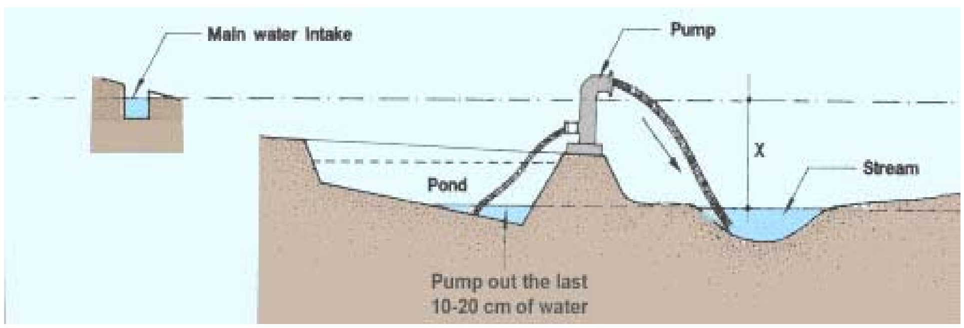


Fig. 10: Diversion ponds level differences



(a): Pond filling



(b): Pond draining

Fig. 11: Pumping of water up from a stream in to feeder canal

If you are building a diversion pond: In the case of a diversion pond fed from a stream through a main water intake and a feeder canal, it is easy to determine the difference in level (X) required between minimum water level at the main intake and maximum water level at the end of the drain. X should be at least 1.20 m (Fig. 10).

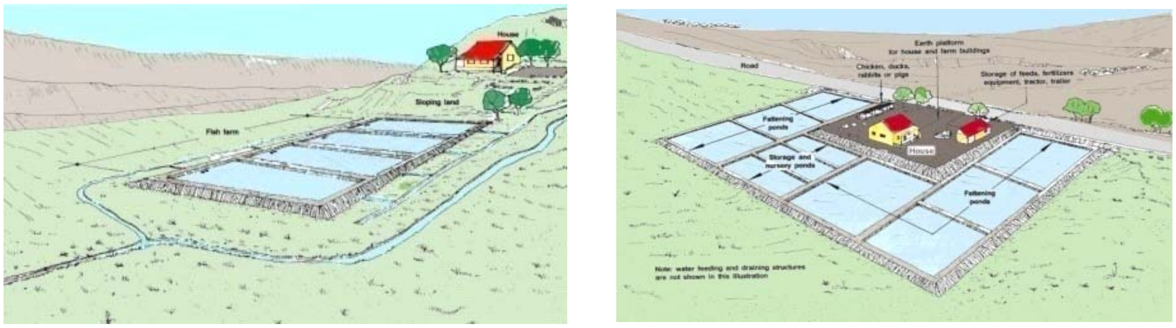
X = The difference in level required between the minimum water level at the main intake and the maximum water level at the end of the drainage canal
a = The difference in level required between the top of the dikes and the maximum water level in the pond
b = The difference in level required between the end of the pond outlet and the maximum water level in the drainage canal
c = The difference in level required between the pond inlet and the maximum water level in the pond

A pump might be necessary: If the topography of the site does not allow you to create these differences in level, and you can afford a pump, it is sometimes possible to pump water up from a stream into a feeder canal, or more often, to pump the last 10-20 cm of water out from a draining pond (Fig. 11). In these cases, you can reduce the values of X, but you must be sure that the cost of pumping is acceptable (Hem, 1989).

Living on your fish farm: It is always desirable that somebody lives on your fish farm next to your ponds, not only for security reasons but also to be able to manage the farm properly (Fig. 12) If the fish farm is built on sloping land, it is best to site the housing at a higher level, so that ponds can be observed from there (Wilcox, 1985).

- If the fish farm is built on flat land, you may need to site the housing on a raised platform served by a road; such a platform could also be used for storage of equipment or feeds or fertilizers, and for small animal husbandry.
- If the fish farm is built on flat land, you may need to site the housing on a raised platform served by a road; such a platform could also be used for storage of equipment or feeds or fertilizers, and for small animal husbandry.

Height measurement: Differences in height between two points are measured with a device called “a level”. It is named a level because it gives a true horizontal line. The height of each point is measured by, its vertical distance



(a): The housing at a higher level (b): The housing on a raised platform

Fig. 12: Living on the fish farm

above and below the horizontal line. The horizontal line can be formed in two ways, depending on the type of measuring device used in determining the heights of points. If a non-sighting device is used, the horizontal line will be formed by a straight edge, a line level or water level. If a sighting level is used, the horizontal line will be formed by, prolonging a line of sight. It is better to use sighting levels together with a vertical graduated scale, which measures the height of the line of sight at each station (FAO, 2002).

A ruler with a vertical graduated scale is called a leveling staff. Several models can be bought from the market. However, it can also be manufactured locally. Leveling staffs range form 2 to 5 cm long, foldable or telescopic and made of plastic coated wood or aluminum. Self-reading leveling staffs are graduated in meters, decimeters and centimeters. These graduations are upside down for easy reading of the values with a telescope. On a target leveling staff, there is a movable “target” with a reference line positioned at a fixed height (FAO, 2002).

A local leveling staff can be prepared with a straight length of wood, 2 to 3 m long and 5 to 10 cm wide. Mark graduations clearly every 10 cm on it. It is best to paint the leveling staff white and mark the graduations on it in red. Make these graduations bold for easy and accurate reading from a distance. A leveling staff can also be prepared by gluing one or more graduated measuring tapes to a straight piece of wood 2 to 3 m long. Glue the tapes lengthwise end to end.

To read the small graduations accurately, reduce the distances. Take measurements or rely on an assistant’s reading. Other models of leveling staff are used for contouring and setting graded lines of slope (FAO, 2002).

Measurement of differences in height: In fish culture, the difference is height between two points must often be measured. To construct a pond, dyke heights and the depths of pond bottom dug need be determined. Height and depth measurements are needed to choose the routes of water supply canals from the source to the pond. Reservoirs also need height measurements to determine its shoreline (FAO, 1983).

Three main problems can be encountered in the measurement of height differences. Measure any difference in height among a series of points on the grand and compare them. From the comparison results, calculate the height of given points and sketch a map. This is called surveying the levels of the points (Leveling). Locate points, which are at the same height. This is called laying out contour lines (Contouring). Locate points, which have a given difference in height. In this case, set out lines of slopes with a definite gradient (FAO, 1983).

Methods for measurement of height differences: There are several ways to measure height differences. The method of measurement used depends on several factors. Table 1 compares the method

Calculating differences in height: If the average slope between two points is known, the height difference between them can easily be calculated. Measure the horizontal distance D is meters between point A and B. To calculate the height difference (H) in meters, multiply D by the slope S expressed in hundreds.

$$H = D \times S$$

Example:

If the distance measured (D) = 20 m and S = s% = 0.5

The height difference (H) = 20 m × 0.05 = 1.0 m

If the vertical angle ABC is measured in degrees, the height difference AC can be calculated from either the ground distance BC along the slope

$$AC = BC \text{ Sin } ABC$$

Obtain sin ABC from sine Table; or the horizontal distance BA

Table 1:Methods for measuring differences in height

Method	Distance, M	Accuracy	Remark	People, Equipment
Non-sighting levels				
Straight edge level	2.5 to 3	Medium to high	Easy to transport quick to operate	1 person, mansions level 1 measuring scale
Line level water level	20	Medium	Very easy to transport. Quick to operate for high ground	3 people, a mansions level 2 measuring scales
Flexible tube	10 to 15	High	Awkward to transport very quick to operate for clear rough ground. Avoid water loss	2 people, 2 measuring scales
Sighting levels				
T-bone level	10	Low to medium	Rough measurement useful for canals and pipelines	2 People, 1 leveling staff
Bamboo level	15-20	Low to medium	Greatly affected by wind	2 People, 1 leveling staff
Improved 7 - bone level	15-20	Medium	Especially good for dykes and future water level	2 People, mansions level 1 leveling staff
Hand level	10-15	Low	Rough, quick method best when rested on a pole	2 people. 1 hand level 1 staff leveling
Surveyors level and theodolit	Over 100	Very high	Experience, delicate, a utomatic leveling with stanch in hairs	2 People, experience level, tripod 1 special leveling staff

FAO (2006)

$$AC = BA \text{ Tan } ABC$$

Obtain tangent ABC from Tangent Table.

Example:
Vertical angle ABC = 7 degrees, calculate AC
If BC = 47 m. From sine Table, sin 7° = 0.12187
AC = 47 m × 0.12187 = 5.72798 m = 5.73 m
If BA = 46.7 m. From tangent table, tan 7° = 0.1228
AC = 46.7 m × 0.1228 = 5.73476 = 5. 73 m

Horizontal distance can also be estimated from height differences. (FAO, 1994) On sloppy ground, there is need to correct distance measurement along the ground to find the horizontal distances. Distance measurement can be corrected using the slope discussed earlier. Distance measurement can also be corrected using the height difference measurement in the formula:

$$\text{Horizontal Distance} = (G^2 - H^2)\ 1/2$$

where, G = AB, the distance measurement (in meters) along the sloping ground and H = AC, the height difference (in meters) between the two points.

Example:
If the distance AB = 45 m along the sloping ground, The height difference AC from point A to point B equals 9 m, The horizontal distance:

$$CB = (45\text{ m})^2 - (9\text{ m}^2)^{1/2} = (2025\text{ m}^2 - 81\text{ m}^2)^{½}$$
$$= (1944\text{ m}^2)^{1/2} = 44.1\text{ m}$$

Straight edge level: simple device can be prepared for measuring height difference with a mansions level and a wooden straight edge. To prepare a straight edge, provide a piece of wood heavy enough to resist warping and 2.5 02to 3.0 m long. The piece of wood must be cut carefully to maintain straight and squared off edges. When the straight edge is cut, hold one end to the eye and sight along the top and bottom edges to find the straightest.

Using light string, lash a mansions level securely to the mid point of the straightest edge of the straight edge. Make sure that the mansions level is parallel to the edge. Set one end of the straight edge level on the ground at the highest point A, and make the other end up or down until the edge is horizontal, using the spirit level as a guide. Measure the vertical distance from point B on the ground to the bottom of the straight edge level, using a graduated ruler. If the distance AB between the two points is greater than the length AC of the straight edge level, the intermediate points C D E and F can be measured and add up all the height to obtain the total height (FAO, 1994).

The line level: A mansions level and a cord form the basis of the line level. It is a simple device used for a relatively long distance (20 m minimum). A team of three people is required to work. Two leveling staffs and marking pins are needed. A cheap mansions level with a wooden case can be used in producing a line level.

Screw a strong screw eye into each end face on the centerline close to the top. Tie one of two 10 m long cord to each screw eye. Wrap the loose ends of the cords with string to reinforce them. The line level can be used for leveling. The rear person places a leveling staff on the starting point A. of the line level surveyed. The end of one cord is put against the 1m gradations of the staff. The front person takes a leveling staff, a marking pin and the end of the other cord, walks away from the rear person, following the direction of the line surveyed; stop the rear person when the cord is well stretched.

Table 2: Height difference obtained with the line level

Station	Rear (cm) measurement	Front measurement	Difference (cm)
1	100	96	4
2	100	89	11
3	100	92	8
Total			23

FAO (1980)

The front person places the second leveling staff vertically in to the ground, making sure that it is on the line being leveled. The end of the cord is pulled until the centerline level is as horizontal as possible. Mark the point with marking pin. The center person stands between the rear and front people. He looks at the masons' level and signals the front person to move the end of the cord up or down the levelling staff, until the spirit level indicates that the line is horizontal. If necessary, the rear person also moves that end of the cord up or down to prevent the masons level from touching the ground (FAO, 2006).

The rear person reads the height of that end of the cord on the leveling staff. The front person does the same. Be sure to double-check all measurements. Write down the measurement carefully, putting the rear person's measurements in another column to avoid confusion. The front person removes the leveling staff from the ground and replaces it with a marking pin. The team progressed forward along the line, repeating the same procedure. The rear person stops at the marking pin, the front persons had placed for previous measurements. To calculate the height difference for the entire line, find the height differences for each station by subtraction. Add up all the difference to find the total difference (Table 2).

The flexible tube water level: The is a simple device for measuring level distances, using a piece of transparent water horse 10 to 15 m long and two leveling staffs. In the absence of two leveling staffs, two straight pieces of wood, 4×2 cm wide and 2 m long can be used. Mark off a measuring scale in centimeters on each, or measuring tapes and glue them lengthwise to the piece of wood. When the centimeter scales on the piece of wood is marked, place them side by side and align their tops and bottoms to be sure that both scales are at the same level. If the scale marking begins 10cm from the bottom of the wood, this beginning can be easily noticed even when the tall vegetations are measured. Make sure that the bottom of each staff is flat or has a reference line (FAO, 1980).

Lay the two leveling staffs side by side in front, with their scales facing you. With a strong, string, lash the plastic hose along the length of the inside edges of the measuring scales. Make sure that the end of the hose is equal with the tops of the staffs. Make sure that the ends of the hose are equal with the tops of the staffs. The middle part of the hose will loosen between the two poles. When the hose is fastened to the poles, tie the string around the hose tightly, but take care not to pinch the hose. Make sure that the ends of the hose are lashed to the scales. Place the two measuring scales side by side, with their scales aligned, in a vertical position. Slowly fill the hose with water, taking care to eliminate any air bubbles, until the level is 1 m high in each of the upright sections of the hose when held together. Plug each end of the hose with a cork or another kind of stopper to avoid losing water when carrying the level. When water is lost, align the scales and refill with water to1 m.

To use the water level, a team of two people is required to work. The rear person stands at the starting point A of the line and places one of the measuring scales in a vertical position on the ground. The front person, carrying the other measuring scale and a marking pin, walks ahead along the line in the direction of the point needed to find the difference in levels. When the end of the hose is reached, the measurement scale is placed in a vertical position on the ground. Make sure that the leveling staff is directly on the line.

When the measuring scales are in position, both persons remove the plug in their ends of the hose. This is to ensure that the water in the hose falls to the correct level. Read the measuring scale comparing your eyes level and the water surface in the hose. Replace the plugs in the ends of the water surface in the hose. Note down the measurement in a special table, which enables the calculation of the height differences accurately. The front person marks the point with a marking pin. Progress forward, repeating the same procedure along the line. At the end of each section, the rear person takes a position at the marking pin left by the front person.

The T-bone level: This is a very simple level particularly useful for setting out canals or pipeline centerlines. It is used together with a leveling staff, held by an assistant. To make a T-bone level provide two 5×2.5 cm pieces of wood, 1m long. Along the 2.5 cm face of on epiece,draw the centerline Make a shallow groove along the line with a saw.

Lay the other piece of wood lengthwise on the ground and center the grooved piece, grooved side up, perpendicularly across it in a "T" shape. Make sure that their topsides are even and form 90°. Nail the grooved piece in position to the other piece and add two support struts to hold it in place. The total device height should be 1 m. To improve the level accuracy, make the horizontal top piece 1.5 m.

The T-bone level is used for leveling. At the starting point A of the line level surveyed, stand with the T-bone level. Hold the base of the level firmly on the ground, avoiding stones or other object, which might cause it to wobble. Be sure the support is held vertically. Let the assistant and hold the leveling staff in a vertical position of the next point B of the line, 10 m away. Sight along the edge of the groove, as though a gun was sighted towards the graduation of the leveling staff.

On the leveling staff, read the height corresponding to the T-bone sighting line and record it. The assistant can assist by slowly moving a brightly colored marker, such as a pencil or a pen, up and down along the leveling staff until it levels with the T-bone top edge. The assistant reads the height differences. Since the T-bone level is 1 m high; obtain the height differences between two points by subtracting 1 m from the reading on the levelling staff.

The improved T-bone: To construct an improved T-bone level, a mansions level can be added to the original device to make it's sighting line horizontal. It can be used for longer distances, particularly to set out the top levels of pond dykes and to determine the water level of future reservoirs.

Provide a mason's level with a wooden case and attach two metal sight pieces to its ends. Cut two strips from a flattened mason's level 2 cm longer than its height. Cut a V-notch 1cm deep in one end of each strip. Nail the strips to the ends of the mason's level with the notches sticking up to create a line of sight along the top of the mason's level.

Provide two-piece of wood, each 5×2.5 cm thick and 1 m long. Assemble them with wooden support strutsso that:

- The top piece forms 90º with the support piece and is centered in a T-shape
- The widest face of the top piece is horizontal to provide a flat surface
- Center the modified mason's level on the top piece and attach it. Measure exactly 1 m from the sighting line at the top of the mason's level down the supporting piece. Clearly mark this reference line, with the paint or with a narrow piece of wood nailed across the support. Below this mark, shape the support into a point

Both improved T-bone level and simple T-bone level can be used in a similar way, except that:

- First drive the improved T-bone level into the ground, down to the reference line
- Adjust the top board with the mason's level to make it horizontal
- Set the sighting line with the metal sights attached to the mason's level

The sighting line will be 1 m above point A where the improved T-bone level is positioned with this knowledge, the other points B, C--- G of the sight 1m higher than the leveling station A can easily be determined by standing on the same point and leveling around in a circle.

The bamboo sighting level: A simple device for leveling can be constructed from a small bamboo tube and several pieces of wood. It should be used with a leveling staff and is very sensitive to wind and breeze. When in use, make sure that the sighting tube remains horizontal during height. Construct the device with a piece of bamboo 45 m long and a few centimeters in diameter. Remove the inside membrane between its section by drilling or by driving a long object such as a metal rod through the tube.

Across one end of the bamboo tube, glue two pieces of wire or thread at right angles to form a central sighting point, cover the other end of the tube with tape. Waterproof plastic or electrical tape is best. Pierce the tape at its center with a small nail to make a sighting hole. When the sighting level is used, look through the hole and read the measurement at where the two threads cross.

Place a small weight on the bamboo tube movable along the tube to balance it. A hose clip makes a good balance and can be tightened to properly position it once it has been horizontally adjusted. Lash two 45 cm wood strips to opposite sides near the ends, so that a triangle is formed with the bamboo tube. Drill a hole through each wooden strip at a point 7 cm from the top. Provide a 2 cm vertical staff, and drill a hole through it near the top. The triangle-sighting device will hang from it.

To allow the triangle move freely, place small blocks of wood or short segments of bamboo between the wooden strips of the triangle where they cross at the top between the triangle and the vertical staff. Loosely bolt the triangle through the wooden blocks or bamboo segments, to the hole in the vertical staff. This sighting device should be 1.50 m from the ground. The height is convenient for both calculation and sighting. With the bamboo sighting tube perpendicular to support staff, measure the vertical distance from the center of the tube to the bottom of the staff. Mark a reference line 1.50 m below the line of sight.

To adjust the bamboo sighting level, place the bamboo sighting level close to a 2 m measuring scale or leveling staff. Read the height scale by sighting at it through the small hole and reading the number that line up with the crossed threads. Move the measuring scale to a point, 15m away and at the same level. Check that the point is at the same level with a straight - edge level. Sight again through the bamboo tube and read the height on the scale to see if it is the same as before. Check to see that the triangle is hanging freely by moving it with the finger. Check the reading through the bamboo tube again to see if the result is the same. If the reading at the 15 m-point is not the same as the reading from the point where the bamboo level and measuring scale were side by side. Adjust the balance weight on the bamboo sighting. Move weight towards the rear if the 15 m reading is lower; move it forward if the reading is higher. Place the bamboo sighting level and the measuring scale or staff side by side and take a new reading. Move the scale or staff 15m away, and check the reading. Repeat this process until the two readings are the same.

If there is a small difference between the two readings after several repetitions, it may be caused by a light difference in level between the two points. Interchange the bamboo level positions and the scale, putting the level at the 15 m point and the measuring scale at the 0 m point. Take another reading.

Divide the difference in the reading by two. Make the bamboo tube horizontal by moving the balance weight along it. When the reading from 15 m away is within 2 cm of the reading taken with the bamboo level and the scale side by side, the bamboo level is accurate.

To use the bamboo sighting level, there is need to work in a team of two people. The distance surveyed each time depends on the leveling staff graduations. In most cases, it is 20 m. You can level in either one or two directions. In either case, the bamboo level should be placed at each station so that the sighting line is 1.50 m above ground level.

To level in one direction only, place the bamboo sighting level in a vertical position at point A, the beginning of the line surveyed. An assistant walks ahead 15 to 20 m along the line and place the leveling staff in a vertical position, point B; and mark point B with a stake. Take a reading on the leveling staff from point A to point B and record it. Move forward to point B, and set up the bamboo sighting level at where the stake was. An assistant walks ahead another 15 to 20 cm along the line.

The leveling staff is placed there in a vertical position at point C, which is marked with another stake. Take a reading on the leveling staff from point B to point C. Repeat this procedure until the entire line have been surveyed. Carefully record all reading in tabular form and calculate the heights of the various points needed. When the surveyed line end is reached, calculate the total height difference between the beginning and the end.

To level in two directions, two lengths of a line can be measured from a central point by sighting with the bamboo level in two directions. This system gives two readings for each point, except the first and last. The accuracy of the work can be checked, by comparing the Forward Reading (FF) and Backward Reading (BR). An assistant places the levelling staff in a vertical position at the starting point A on the line surveyed.

Walk ahead 15 to 20 m along the line and place the bamboo level at point B. Take a backward reading (BR) from point B to point A. the assistant paces this distance to you, and pace the same distance past you to the next point C ahead, where the leveling staff is placed. Turn the bamboo level around at point B and take a Forward Reading (FR) from point B to point C. Repeat this process until the entire line is surveyed. Record all readings in a table and calculate the height difference between the surveyed points

The hand level: The hand level is a readymade tool for estimation of differences in level. Its range in the field should not exceed 15 m. You can borrow a hand level from a local survey station or buy from a hardware store. The hand level is made up to a sighting channel, a spirit level and a mirror. These allow reading, taking place; and ensures that the line is horizontal. The directions for using the hand level are similar to that of bamboo sighting level, except that:

- It can be held in the hand
- The height of the sighting line is the vertical distance from the ground to the eye level
- The bubble of the spirit level must be centered while taking the reading

More accurate results can be obtained if the hand level is resting on the top of a wooden pole of convient height. In this case, the height of the pole becomes the height of the sighting line. For accurate leveling over long distances, surveyors use modern instruments called surveyor's level or theodolite. These instruments are expensive and can be damaged easily. Only skilled personnel should operate, adjust or repair them.

Surveying a small farm may not need much accuracy of the instrument. Cheaper devices can be used. A surveyor's level or theodolite can be used with a modern levelling staff for best accuracy. The levelling staff is set vertically down, since the sighting devices on the surveyor's instruments invert the images, making them appear upside down.

A surveyor's level is a telescope, fitted with cross wires for sighting; and attached to a leveling staff mounted on a tripod. In older instruments, the horizontality of the sighting line was adjusted with a sensitive spirits. level and fine threaded adjusting screws. In more recently made instruments (self leveling or automatic levels), the line of sight is automatically brought to the horizontal, making surveying operations much easier. The telescope magnifies distance objects for more visibility of graduation on a levelling staff.

Theodolites are commonly used to measure horizontal angles, vertical angles and height differences. Most surveyor's levels and theodolites are equipped with

Table 3: Contour leveling methods

Method	Distance, M	Accuracy	Remark	People, Equipment
Contouring levels				
A - Frame	4	Medium	Awkward to transport	to transport1 or 2 People mason's level
A - Frame, plumb line	4	Medium to high	Fast to use	1 or 2 people, plumb line
4 - Frame water level	25	Medium to high	Awkward but quick. Aroid water loss	Avoid water loss2 people, target levelling staff
Semi - circular water level	100	Medium	Faster for longer distances. Avoid water loss	2 people, target levelling staff
Non Sighting levels				
Straight - edges level	2.5 to 3	Medium to high	Easy transport fast	1 person, mason's level
Line level	20	Medium	Very easy to transport quick to operate useful or rough ground	3 people, mason's level 2 measuring scales
Flexible tube water level	10 to 15	High to very high	Awkward to transport very quickly Avoid water loss	2 people, 2 measuring scales
Sighting levels				
Bamboo level	15 to 20	Low to Medium	Greatly affected by wind	2 people, 1 levelling staff.
Hand level	10 to 15	Low	Rough, fast	2 people, 1 levelling staff, hand level
Surveyor's level	More than 100	Very high	Expensive, delicate	2 people, 1 levelling staff surveyor's level
Slope measuring devices				
Clinometer, Clisimeter	10-15	Low to high	See table -3.6	2 people, levelling staff

stadia hairs. This allows for the determination of distance during level surveyors. Height differences are measured, using the horizontal sighting line as a reference, as described for the bamboo sighting level. These differences are recorded and calculated. Lengthy lines can be surveyed much faster without measuring many intermediate stations.

Contouring: There are several types of simple levels. These levels can be used in the field for leveling, finding and marking all point at the same height along the centerline of a future water supply canal. In this case, the height difference between various points on the line would be made equal to zero. These points make up contour line. The processes are referred to as contouring. Other levels and slope measuring devices for contouring are also discussed. There are several ways of laying contour lines (Table 3).

In nearly all-leveling instrument, horizontality is shown by, a spirit level. This is small level made of an elongated or circular glass tube. The tube is nearly filled with a liquid (spirit), leaving enough space to form an air bubble. In the elongated spirit level, a point near the middle of the tube is selected as the zero point, and clearly marked. Graduations can be added on either side of the point up with the center of the level, the zero point lines up with the center of the level, and is clearly marked by a small circle. When the air bubble is at the zero point, the level is horizontal.

Mason's level: The mason's level is a simple tool used during building operations. It is used to set out horizontal lines when measuring short distances on sloping ground FAO (1983). and height difference determination. A mason's level consists of a rectangular wooden case with a small spirit level mounted in one of its narrow faces. The mason's level can also be made of metal. Glass spirit levels are highly breakable, and should be handled very carefully.

The case varies in length. Accuracy improves with increase in length. The cheapest mason's levels are relatively short (25 m long). They are generally available in hard ware stores. When a mason's level is horizontal, the bubble of the spirit level lies exactly at its zero point. When the air bubble moves away from the zero point, it shows that the level is no longer horizontal. There is either an uphill or a downhill slope. The direction in which, the bubble moves, always indicate the direction of the highest point on the slope.

The A-Frame level: A simple device for contouring can be made from three pieces of wood and mason's level. This device works the same principle as the straight edge level, but is easier and faster to use. To prepare a local A-frame level, provide three pieces of staff wood, at least 2×6 cm thick. Two of the three pieces should be 2.8 m long and the other 2m long. The A- frame made from these three pieces will be 1.70m high, 4 m long, small and easy to a handle. Attach the 2.80 m long leg pieces 30 cm down from their tops by drilling a hole through the center of each piece and bolting them loosely together. Adjust the legs until they are 4m apart at the bottom.

Measure up 1.60 m from the bottom of each leg and loosely attach the 2 m cross piece by drilling and bolting it to the legs. The cross pieces should be 1 m above the ground. Cut the bottom of the legs level, so that they rest evenly on the ground when the A frame is upright. To do this, stand the A-frame upright on its legs at the base.

Make a mark along the legs, level with top of this piece of wood and cut the legs at the mark.

The A- frame level can be adjusted. Place the A-frame upright, resting the legs on two points at the same level. Put the mason's level at the middle of the crosspiece and check to see if it is horizontal. If it is not, adjust it by moving the cross piece slightly or by cutting a little off one leg. When the cross piece is horizontal, tighten all the bolts on the A-frame. To check the horizontality, turn the A frame around. With the mason's level, check to see that the cross piece is still horizontal. Using light string, lash the mason's level securely to the cross piece at is mid point.

To use the A- frame for contouring; with a marking pin, mark point A where contouring begins. Place one leg of the A Frame at this point. Move the other leg uphill or downhill until the mason's level shows a horizontal position. At this point place another marking pin B. Move the A-Frame up to the second point B. Find the next horizontal point C and mark it. Repeat this process until the length of the contour line AE is plotted.

The A-frame and plumb line level: This is a simple device similar to the A-frame, except that a plumb replaces mason's level line. The device is used in the same way as the standard A frame for contouring. To construct A-frame and plumb line level, construct the A-frame as described above. Screw a small hook or derive a nail into the frame near its summit. Attach a plumb line to the hook or nail. The plumb line should be sufficient for the plumb or reach below the cross piece of the frame. The taller the frame, the more effective the level can measure height difference.

A-frame and plumb line level can be adjusted. Place the A frame upright with its legs resting on two points at the same level. When the plumb line comes to rest, mark the position of its string on the topside of the cross piece of the A-frame. Place the A -frame the other way round, so that its its legs are reversed on the same horizontal points. When the plumb line stops, mark the position of the string on the crosspiece.

Make a permanent mark on the front side of the cross piece at the precise mid point between the two marks, indicating where the legs of the A frame are exactly at the same level. Slow the movement of the plumb line (in windy weather) letting it rub slightly against the cross piece of the A frame.

The H- frame water level: The H frame water level is a simple device constructed from a light wooden frame and some clear plastic piping partly filled with water. Like the flexible tube, water level, it is based on the principle that, under atmospheric pressure, the free surface of interconnected water columns will reach equal heights, which follow a horizontal line.

The H-frame water level can be constructed from two 5×5 cm thick pieces of staff wood 1m long and one 5×5 cm piece 2.5 cm long. Join the three pieces of wood together to form an "H" shape, using strong nails or bolts. The horizontal piece of the frame should be 20 cm above ground level. The two upright legs should form 90° angles with the horizontal piece. Provide 3.90 cm of clear, non reinforced plastic tubing with an inside diameter of 1.2 cm. Using soft wire or string, secure it to the upper faces of two vertical pieces. Tie or bind the plastic tube tightly to the wooden pieces, but be careful not to pinch the tube.

If the plastic tubes are not enough, use 1.90 m of dark rubber or plastic piping or metal water piping, and two 1 m lengths of clear plastic tubing. Connect one length of clear tubing to each end of the dark piping with a hose clip. Tie the dark piping to the horizontal piece of the H frame and the clear tube lengths to the two vertical pieces.Pour water into the tube until the level reaches halfway up each tube end to prevent water losses during transportation.

The H- frame water level can be adjusted with the aid of an assistant. Place the H- frame upright, with its legs resting on two points at exactly the same level. Remove the two stoppers from the tube end and look at the water level in each tube from the side. Both of you should lightly mark each vertical leg, level with the water level in the tubes. Turn the H- frame around and place its legs, reversed on the same points. Lightly mark the water level on each vertical leg.

Make a permanent mark on each leg at the precise mid point between the two previous marks. When the water reaches the same level in the tubes, it indicates horizontality. Replace the stopper for transportation. It is best to check this adjustment before each contouring survey. If any water was spilt from the tube, adjust the device by adding water as necessary.

To use the H- frame water level for contouring, place the rear leg of the H- frame at the starting point A. Remove the stoppers from the tube ends. Move the forward leg uphill or downhill until the top water level reaches the permanent mark made on the leg. Mark the position of the forward leg at point B with a peg and replace the stopper in the tube ends. Move the frame forward, place the rear leg at the marked point B, and repeat the previous procedure. Continue in this way until the contour end in line AB is reached. It is easier to work with an assistant. The assistant moves the forward leg until the horizontal level is found. Ensure that the water level on the rear leg lies opposite the permanent mark.

The semi circular water level: The semi circular water level is a simple device based on the same principle as the H frame water level. Its main advantage is that, it can be used for longer distances without moving it. Only several small pieces of wood and a short piece of clear plastic tubes are needed to construct it. It is a little more difficult to built than the H-frame.

A semi circular water level can be constructed. Provide a 1×10 cm piece of wood 60 cm long and drill through each end of it from the 10×60 cm face. These holes should be wide enough to hold the plastic tube. Drill a small hole in the center of the piece of wood. Prepare two wooden discs with a diameter of 10 cm, and drill small holes in their centers. Nail or screw one of these discs under the center of the piece of wood, aligning the hole in the center of this piece with the hole in the center of this piece with the hole in the disc. Do not block the hole.

Provide a piece of clear plastic tube 80 cm long and 1 to 1.5 cm in diameter. Pass the ends of the tube from below through the holes in the ends of the piece of wood, so that the tube forms a semi circle on the side the disc is. The two ends should extend above the piece of wood by 10 cm. Keep the tube in the place by putting a hose clip at the point where the tube passes through the hole in the board. Tighten the clip so that the tube does not slip, but be careful not to pinch the tube. The horse slip keeps the tube in place, since it is bigger than the hole.

Construct the supporting leg. Provide a pole 5 cm in diameter and 1.40 m long. Find the center point of one end. Take the second disc prepared and loosely nail it to the pole so that its center hole is over the center of the pole. Attach the semi circular level made earlier to the supporting leg. Use a strong screw, and align the central holes of the wooden disc carefully. Do not tighten the screw too much. The semi circular level should be easily turned around. The flexible tube will be deflected to one side of the pole. Place the device upright on its support and fill the plastic tube with water. The level of the water should reach 4 to 5 cm from each end of the tube. Place a stopper in each end of the tube to prevent water loss during transportation.

The semi circular water level can be used for contouring. Let the assistant place a leveling staff in a vertical position at the starting point A of the contour to be leveled. Since the contouring is done with a sighting level, which does not include a telescope, a target leveling staff should be used. A target leveling staff can be constructed. Provide a straight stick, a piece of bamboo, or a maize stalk 2 m long. Provide another pole or stick 50 cm long and attach it to the first one with string to form a cross. The location of the point where the 50 cm pole is attached, called the target depends on the contour leveled.

To station the semi circular water level, drive its support vertically into the ground at a central point from 1.00 m of the contour line surveyed. Remove the stoppers from ends of the plastic tube. Standing 1 m behind the semi circular water level rotate its upper part and sight along a line joining the two water surface levels in the plastic tube to the leveling staff. Signal the assistant to adjust the target of the leveling staff up or down until it is exactly on the sighting line. The assistant marks the starting point A with a stake and walk 10 m away, where the leveling staff is placed in a vertical position. Rotate the upper part of the water level until the cross on the staff is sighted. Signal the assistant to move the levelling staff uphill or downhill until the fixed target lines up with the sighting line. Mark the point B with a stake. The leveling points can be kept on the same contour AG from the central station X for 100 m.

To continue the same contour line, leave the target leveling staff at point G, and move the level to a new central station, Y. Adjust the height of the target and level contour GM form station Y. Contour with a fixed height difference can also be found.

To do this, keep working from the same station, but change the height of the target on the leveling staff. When point G is reached, let the assistant lower the target by 20 cm. He walks up the hill along line XGH until the target is level with the line of sight, marking point H on the next contour. Continue the second line HN by finding point I on line XF, point J on line EXJ, and so on. If the distance is short enough for clear visibility, the target can be lowered to set a third contour line from the same station.

Contouring with non-sighting levels: The use of non-sighting levels to measure height difference had been discussed earlier. These devices can also be used for contouring. The straight edge level is used for contouring in the following way. Mark the point A, the beginning of contouring with a stake. Place one end of the straight edge up to point B. Find the next horizontal point C and mark it with a stake. Continue this process until the length of the contour line has been marked.

Mark the route of the contour line found by leaving a stake every 10 m. If the contour curves, more stakes may be needed. If the ground surface is rough (covered with lumps of the earth, stones or grasses), two bricks or wooden blocks of the same height can be used to support the ends of the straight edge while leveling. If the surface of the ground is covered with dense grasses, two stakes under the ends of the straight edge can be used to lift it above ground level. Be sure that both stakes are the same length and driven into the ground to the same level. The horizontal lines found can be transferred in this way. The horizontal, lines up with top level of the stakes, to ground level without error.

The line level is very efficient for contouring because it allows work progress quickly, even on rough grasses. It is reasonably accurate because the maximum error is less than 6 cm per 20 cm distance. Remember that three people are required to use the line level. The rear person places one-end staff on the marked starting point A and keeps the cord on the 1m graduations. The front person, also keeping the cord on the same graduation, moves the second end - staff up or down the slope until the center person signals that the mason's level is horizontal. The front person marks the point B where the staff touches the ground. The rear person walks to the marked point B while the other two people walk ahead until the cords are well stretched. The entire procedure is repeated and another point C of the contour line is marked. This process continues until the length of the contour line is marked.

The flexible tube water level can be used to contour quickly on rough ground. It gives very good accuracy with a maximum error of 1 cm per 10 m distances. Care must be taken not to loose water during the procedure. An assistant is required for this method. Bring two standpipes together to the starting point A of the contour line. Remove the stoppers and mark the height of the water levels on each measuring scale. These heights should be the same. Replace the stoppers in the tube ends.

Place a measuring scale at the starting point A of the contour line. Let the assistant walk ahead until the end of the hose is reached. Remove the stoppers and the assistant moves the scale up or down the slope until the water level is at the marked height. Ensure that the water level is at the marked height at your end. When it is, signal to the assistant to mark location B of that scale with a stake. Replace both stoppers. Move forward to the point B, marked with the stake. Let the assistant walk ahead until the end of the hose is reached. Repeat the procedure and continue in the same way to end of the contour line.

Contouring with sighting level: The bamboo sighting level can be used for contouring. It requires an assistant. Contouring with this level can be done as follows: Place the bamboo sighting level next to a leveling staff and read the height on the scale by sighting through the tube. Mark this height on the scale. Paint can be used or tie a piece of cord, or a colored rag at that height. Attach the target of a target levelling staff at that height. Place the bamboo level in a vertical position at A, the beginning of the contour line to be plotted.

Let the assistant hold the levelling staff, walk 15 to 20 m ahead a long an appropriate horizontal line and place the staff vertically. The assistant moves it up or down the slope until the mark is lined up with the sighting line seen through the bamboo tube. Turn the bamboo level from left to right to see the mark on the measuring scale. Check frequently to make sure that the bamboo tube remains horizontal. When the mark is sighted, the assistant marks the position B of the leveling staff with a stake. Walk up to this stake B and place the bamboo level in a vertical position. The assistant walks another 15 to 20 m ahead with the leveling staff. Repeat this process until the entire length of the contour is marked.

A contour line, a line along which the slope gradient equals zero can be surveyed quickly with the hand level. However, the results are not very accurate. The method used with the hand level is the same as that of the bamboo level, except that the mark on the leveling staff is made at the height of the surveying line. The sighting line height will either be at your eye level, or at the height of the pole supporting the hand level, which is used to improve its accuracy.

A surveyor's level or a theodolite and a precisely graduated leveling staff can be used to quickly and accurately determine contour lines. Since the reading on the telescope is several hundred meters, reduce the number of stations. Like the semi circular water level, survey several points from a single station. In open areas, it is possible to use this method for long distances. In areas with forests, there may be need to measure short distances and clear sighting lines.

The slope measuring devices can also be used for contouring. When contouring is done with slope measuring as the cross-shaped device described earlier. If such a staff is used, the target should be tightly fixed at eye level. The height of the assistant can be used in the absence of a leveling staff as a reference level.

The assistant holds the leveling staff vertically; standing 10 to 15 m away from the starting point A of the contour line to be plotted. Form the starting point use its target lines up with the zero graduation of the clinometer. Let the assistant mark this ground point B and repeat the same procedure form it. If a clisimeter is to be used, remember to use the left scale and make the sight of the leveling staff line up with its zero line.

Graded lines of slope: Graded lines of slope are often used in fish farms to assist gravity in running water. Water supply canals and pipelines, as well as drainage canals, are built with a graded slope. Fishponds should be built with an adequate bottom slope so that the pond can be drained completely. The ability to set graded lines of slope is therefore important in building a fish farm. Graded lines of slope can be set in several ways, using three series of methods with the devices described earlier.

Any of the slope measuring devices can be used to set graded lines of slope. The clisimeter is particularly commonly used for this purpose, but any other clinometers can be used instead. It is best to use a target leveling staff. Its target should be tightly attached at the eye level. Remember that the height of the assistant can be used as a reference level. From the starting point A of the line of slope, sight the target leveling staff. The graduation of the clinometers should correspond to the slope chosen. Signal the assistant to move the levelling staff up or down the slope until the sighting line of the Clinometer lines up with the reference mark on the leveling staff. Mark the grand point B with a leveling staff. Mark the grand point B with a stake and repeat the procedure from that point.

Sighting levels can be used to set lines of slope. The surveyors level and the theodolite are example because their limited accuracy makes it difficult to lay slopes with gradients than less 1%. For smaller gradients, it is best to use non-sighting levels. Before using the sighting level, calculate the difference in height (H-meters) between two consecutive points according to their horizontal distance (D-meters) in order to find the desired slope gradient.

$$H = (S \times D)/100$$

Example:

- Read levels at 10 m intervals, horizontal distance
- The slope set equals 1% or 1 m per 100 m
- The necessary height difference H for a 10 m horizontal distance equal 1/100×10 = 0.10 m

On the highest point A of the slope set, station the levelling device and measure the height of its sighting line (H^1) above the ground. Add this value to H to obtain the height to be read (R) at the next point on the levelling staff as:

$$R = H + H^1$$

Measure a horizontal distance of 10 m from the starting point, following the contour line as closely as possible. Place a leveling staff vertically at that point. For this part of the procedure, use:

- A graduated leveling staff, the calculated height (R) is clearly marked
- A target leveling staff, the target tightly attached at the calculated height (R)

Sight the leveling devices, at the leveling staff. Signal the assistant to move the staff up or down the slope until the sighting line, lines up with the mark (R) on the staff. At this point, let the assistant drive a marking stake into the ground. Point B will be 10 cm lower than point A. Station the levelling device on this marked point, B. The assistant walks ahead another 10 m with the levelling staff. Repeat the procedure.Non-sighing levels are much more accurate than simple sighting levels for setting lines of slopes with gradients smaller than one percent. Generally, non-sighting levels can be used to set lines of slope with gradients as small as 0.3%. The flexible tube water level is reliable for slopes as small as 0.1%. To set lines of slope with a different gradient (S%), use the same procedure described for contouring. The only difference is that the forward end of the leveling device should be kept above the ground at the height H for fixed horizontal distance D-meters, as in;

$$H = (S \times D)/100$$

Distance D varies with the type of leveling device used. It is best to level going down hill. If going down hill must be leveled, make the rare end of the leveling device higher by H-meters. The best way to do this is to prepare a piece of wood with a thickness equal to H. During leveling place a piece of wood under the forward end of the level if down hill is being leveled (FAO, 1980).

Example:

If S = 0.5% and downhill is being leveled

- Using an A-frame level for setting the line slope; D = 4 m; H = 2 cm
- Using an H-frame level D = 2.5 m; H = 1.25 cm
- Using a straight edge level; D = 3 m; H = 1.5 cm
- Using a flexible tube water level D = 10 m; H = 5 cm

When using the line level, add the height H to the cord height, which will be maintained by the front person, instead of placing a piece of wood under the forward measuring staff.

Example:

If S = 0.5% and downhill is being leveled with a line level: D = 2 0 m and H = 10 cm. Keep the forward end of the cord at a height 10 cm higher than the rear end of the cord.

CONCLUSION

Integrated farming; using pumps; how to plan your fish farm considering its size and complexity; laying out ponds according to their use; laying out the access roads on your farm; laying out the canals on your farm; level differences on your fish farm; if you are building a barrage pond; a pump might be necessary and living on your fish farm are important considerable in fish farm planning. Height measurement, measurement of differences in height, methods for measurement of height differences, calculating differences in height, the line level, the flexible tube water level, the T bone level, the improved T-bone, the bamboo sighting level, the hand level, contouring Mason's level, the A-frame level, the a frame and plumb line level, contouring with non-sighting levels, contouring with sighting level and graded lines of slope are important topography measurement that enable the fish culturists know basic principles to design and build fishponds, reservoirs and small dams and use existing topographical maps.

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