Agricultural Water Management Project

Guidebook for Extension Training in Agricultural Water Management

Module No. 4

How to help farmers when deciding to improve their water distribution system within one single plot (precision levelling)

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1. Introduction

The guidebook, of which this module is an essential part, is interested in sustainably improving advisory services by Egyptian government agencies and their field personnel. This shall lead to finally helping farmers in Egypt's Old Lands to cope with decreasing allocation of irrigation water. Such an approach necessitates the provision of economic options to farmers as well as seeking to determine the social aspects that affect farmers' attitudes towards innovations and government interventions. Towards this end, it is essential that extension workers and irrigation advisors know the main sources of information and the key elements that encourage farmers to identify the right strategy and possibly adopt new techniques and practices – without recurring to any financial support from the government or from foreign donor projects.

This module deals with the viability of improving the field levelling for optimizing surface irrigation (gravitary) systems.

The creation of small basins is the traditional way of coping with uneven field surface, but this technique needs much labour to prepare the land and to direct the water. Spreading the water in furrows in contrary needs a more precise levelling operation in order to give the field a certain slope. Using furrow irrigation needs a minimum size of irrigated plots in order to obtain a reasonable "run-length" for the water. Water application then demands less labour, but the longer the furrows are, the more skills of the irrigation operator are needed ("cut back flow"). Feeding furrows with the help of syphons is a quite unusual technique in Egypt, because of abundance of cheap labour and relatively small plots sizes.

If the irrigation water is delivered at the field turn-out in a slightly pressurized pipe (as will be the case in certain areas of the Egyptian Irrigation Improvement Project, IIP), furrow irrigation can be combined with using so-called gated pipes for feeding the furrows. But in most cases in Egypt, the feeding of furrows – if those are used at all - will be done by simple perpendicular earthen field ditches running on the highest side of the plot, which are opened at the head of each furrow by a hoe.

If the water is delivered by a medium pressurized system at the field turn-out (hydrant or valve), one can think about using a fully pressurized irrigation system, like drip irrigation or different forms of sprinkler irrigation (according to the pressure available and according to many other conditions of suitability). Pressurized irrigation systems - beyond the simple gated-pipe technique - are not dealt with in this module, but will be presented in a separate course to those extension workers and farmers in New Lands areas with sandy soils, where high value crops (often exportable crops with a high Gross Margin) are grown and the nature of soils needs frequent irrigation applications.

2. Options for Land Levelling

2.1 Definition

The irregularity of the surface of agricultural land - as in any agriculture depending on surface irrigation - is one of the major problems in the Egyptian irrigated agriculture. It leads to a non-uniform distribution of water in the farming plots which causes a number of problems.

First, crops in plots receiving too little water may experience water stress, which leads to yield reductions, and, from insufficient downward movement of water, leads to salinization of the root zone of the soil.

Secondly, those low spots of a field plot receiving too much water may cause the groundwater table to rise, which makes plant roots rot for lack of aeration, and yields are lowered because of water logging. In case of sandy soils with high permeability and low storage capacity for water, fertilizers may be leached into the groundwater.

Farmers depending on a rotational water allocation tend to over-irrigate, if they are not convinced that the water is reaching their farm turn-out in regular intervals, diminishing the risk of their crops getting stressed from under-irrigation.

Besides providing a secure and dependable water supply, this problem can be greatly diminished by giving a field one even level. To ease the water distribution within the field plot, levelling can be done either without slope ("zero slope") or with a predetermined slope depending on the size of the plot, the nature of the soil, and the water discharge available at the farm turn-out, be it from an open channel or from a pressurized pipe. In the latter case, water distribution can be further improved through investing in a lightly pressurized irrigation system, like gated pipes delivering the water directly into (long) furrows. Where soils are of a sandy nature, with the water storage capacity being extremely low – as is the case in Egypt's New Land areas – a pressurized drip irrigation or sprinkler system might be needed in order to allow for frequent (up to daily) water application. On one hand, pressurized systems require very high initial investments, and because of the energy needed to maintain a certain pressure in the system, these techniques also have high operational costs. But on the other hand, pressurized systems can be operated on uneven land, thus saving on investments in land levelling.

This module however deals with investments meant to improve gravity surface irrigation systems as they are the dominant irrigation system in Egypt's Old Lands. Using piped low pressure field canals for conveying water from the source to the field outlet do not change the need for levelling to obtain a good water distribution within the field.

2.2 Land levelling practices in Egypt

The historic efforts of Egyptian farmers to improve the water distribution within their cultivated plots certainly started in pharaonic times. Even if no precise information is available to us, it can be assumed that farmers started to retain the flood water of the Nile as long as possible by manually building small ditches. And probably they tried to get the flooded land as evenly covered by the water as possible. The recent history of land levelling in Egypt started with using draft animals. Farmers were using a wooden bar equipped with two arms to allow the farmer to modify the position of the bar scraping the soil, and equipped with two rings serving to attach one or two draft animals. Later-on, this wooden leveler was then equipped with a metal edge to better cut land from high spots and to pull it to low spots. Since they are extremely hard to work when dry, the heavy clay soils in Egypt's Old Lands need to be ploughed before the levelling operation, or to be wetted by one water application. In this latter case, the preferred draft animals were and still are water buffaloes because of their good ability to work in muddy conditions.

The levelling work itself was usually executed by some specially skilled farmers in the village who had a good eye and the experience to adjust the edge of the levelling bar in such a way that the needed degree of precision was obtained and water was spread evenly within the plot. Until the end of the 70s this was the most common mode for land levelling, and it is still used by farmers cultivating very small farms with even smaller plots of a few kiraat (one kiraat is 1/24 of a feddan, which is approximately equivalent to an acre) only.

2.2.1 Special case: Puddling of soil for Rice Planting

Levelling rice plots before pre-irrigation is important, particularly if direct seeding is envisaged. However, seeding rice is not a very common practice in Egypt, since the transplanting method is preferred: it allows to save one month of field occupation and it gives higher yields, the additional labour required with this method not being an important cost factor in Egypt's rural areas. After a general levelling of the plots when dry, rice growing requires a pre-irrigation to soak the soil with water and to allow for a special pass of land preparation, which is called "puddling". Puddling can be defined as the process of breaking soil aggregates into uniform mud, accomplished by applying mechanical force to the soil at high moisture content. To a farmer, puddling is mixing soil with water to make it soft for transplanting the seedlings on one hand, and to create a more or less impervious layer below the root zone to prevent the irrigation water to seep into the ground water table. In the case of Egypt, rice puddling is not a substitute for levelling, but it helps in maintaining a level field surface, the water surface being a natural and perfect indicator for the level of the soil. Flooding of paddy fields entails a significant water requirement. This is the main reason for the high water requirements of rice growing when compared to other crops which are sown into dry land. Logically, there is a need to carefully examine the costs and benefits of puddling, and to seek ways (a) to minimize water requirement for pre-irrigation and puddling, and (b) to minimize percolation losses during paddy growth while creating an optimal root environment suited to the specific physiology of the plant, and this for different types of soils.

2.2.2 Mechanization

Towards the end of the 70s, the usage of draft animals was gradually replaced by using tractors which became common in the Egyptian agriculture. The Russian and Romanian imported tractors in that time were the most popular due to their simplicity; they only had a simple pulling bar, no hydraulically operated attachment holder. Farmers used these 60-70 hp tractors to which they attached the conventional wooden leveler. To fit it to the higher power of the tractors, compared to draft animals, they modified the wooden leveler accordingly. Wetting the soil by a pre-irrigation was not anymore useful, since the tractors could not work in muddy conditions, and also the need for ploughing the soil before doing the levelling work could be avoided, if the levelling was done directly after the last harvest, when soils had not yet dried-up completely and had not yet become stone-hard.

With this technique, still a second worker had to follow the tractor to manually adjust the levelling bar. Due to the higher power of tractors, it became then possible to increase the width of the leveller, and to use heavier metal blades instead of wooden ones.

The described technique is slowly being improved, thanks to two innovations: Firstly the availability of tractors being equipped with a hydraulically operated “three point” attachment, and secondly the possibility of replacing the specialists’ eye by an electronic device giving the desired level by means of a laser beam and a receiver which is then automatically adjusting the levelling implement.

This development gives farmers now several options when deciding to do levelling of their fields.

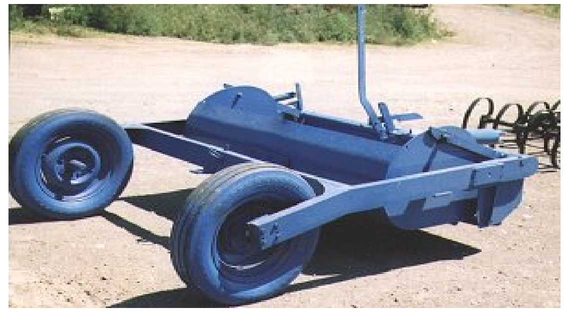
2.2.3 Special case: Using a hitched grading blade for punctual corrective operations

Since tractors equipped with the hydraulically operated three points attachment became common in the early 1980’s, they were also used to attach steel blades for doing land grading operations. In order to compensate the ups and downs of the tractor rolling over uneven land, the position of any implement directly attached to the tractor, logically, needs to be constantly adjusted. This is usually done by the tractor operator himself or by a second worker sitting on the tractor via the hydraulically operated system acting on the three points attachment. Where available, this type of grading blade is occasionally used to do field work, but because of its lack of precision, it is mostly used to do rough grading operations like smoothening agricultural roads or filling a field ditch which is not anymore needed. The accuracy of this operation is relatively low, and a fine adjustment is difficult, since the blade is mounted very closely to the rear axle of the tractor and tends to immediately follow the movements of the rear wheels: where the rear wheels of the tractor roll over a high spot, the blade is lifted in the air and does not cut the soil, if no corrective adjustment is done. In contrary, when the tractor goes down into a low spot, the blade is cutting deep into the soil, cutting a hole, if not lifted accordingly.

Since this adjustment is very difficult to do, the levelling precision with this technique, if it should in an exceptional case be used to do the levelling of field plots, is assumed to be very low. We assume the efficiency of such a levelling job to be 60% of what could be obtained by so-called precision levelling equipment, using modern equipment described in chapter 2.5 under option 3 below.

Despite its lack of precision, levelling a field with a directly mounted grading blade is very time consuming (3-5 hours), since several passes are needed. This technique is not a real alternative to the levelling options described below, but it is an occasional complement, especially after heavy earthworks like digging a drain have been executed.

2.3 Option 1: Using a manually operated leveler mounted on 2 wheels



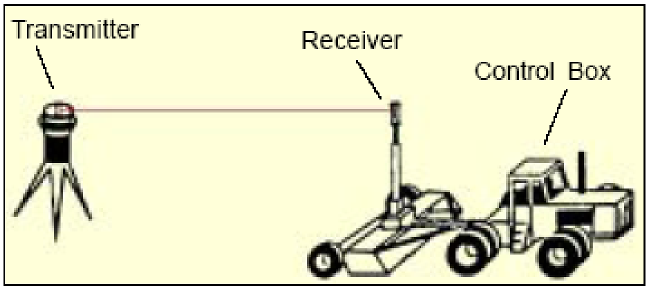
Between 1982-1983 a new type of levelling instrument became available. The leveler is mounted on two wheels. The position of these wheels behind the shield ensures a relaively high distance to the rear axle of the tractor. This design avoids that the blade follows immediately the ups and downs of the tractor when rolling over high spots or going down into low spots. The shield itself is a so-called "turn buckle" or "bucket" instead of a simple blade. This buckle is manually adjusted by means of a handle allowing to control the depth of cutting high spots, keeping the soil in the buckle, and depositing it over the next low spot. According to the power of the tractor used, the width of the bucket may range from 1.8 to 4 m. The efficiency with this technical option is assumed to be about 80% of what could be obtained with a better equipment.

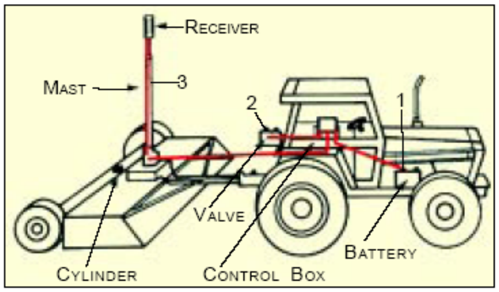
2.4 Option 2: Using a hydraulically operated leveler mounted on 2 wheels

The availability of tractors equipped with a hydraulic command system in the 1980's made it possible to use hydraulically operated implements. Unlike the grading buckle described before, this type of leveler is attached to a tractor by means of a long dragbar. The leveler is equipped with a hydraulic piston to adjust the position of the shield or buckle. It is equally possible to tilt the shield or buckle. This option overcomes the inconvenience of the manual and time-consuming operation coupled with a lack of accuracy of option1, all other characteristics being similar: The distance between the leveler and the tractor is equally relatively long. According to the power of the tractor used, the width of the bucket may range from 1.8 to 4 m. The accuracy is generally better than with option 1.

2.5 Option 3: Using a hydraulically operated automatic leveler mounted on 2 wheels and adjusted by a laser beamFehler! Textmarke nicht definiert.

The LASER (Light Amplification of Simulated Emission of Radiation) consists of a transmitter which sends a laser beam to a receiver mounted on the leveler and linked to a control box of the hydraulic system of the tractor. The beam commands a valve of the hydraulic system which in turn constantly adjusts the levelling buckle.





The laser levelling process starts with a field survey for determining the level or slope of the plot as well as surveying the high and low spots in the field. For successful automated operation, the difference between the high and low spots should not be greater than 15 cm for one pass. Otherwise the transmitter must be set twice and a second pass would be needed.

The transmitter can serve 2 to 5 tractors at a time, making it economically efficient. The larger the area, the less time per feddan is required to level the land. The advisable area

to be served by the laser unit is 5 feddans or more. The levelling unit can be attached to a tractor with 70 hp or more and the working width can be as with option 1 and 2. The expensive laser technique makes the tractor hour cost about LE 60, which is about three times as expensive as the options described above, if no subsidy is provided. If well executed, and care is taken when doing the regular soil tilling operations, this process does not need to be repeated every year.

The problem for Egypt's small-scale farmers to use this option is twofold: Firstly, the field plots are mostly too small to justify the use of such equipment, let alone of several tractors at a time, and secondly, there are only few laser levelling units available either at the government owned and operated machinery stations, or in the private sector. A third obstacle resides in the fact of the operators being government staff who are not paid according to their performance. They tend, as is the case with any such economic model in any country of the world, to seek for their individual interest instead of serving the client. Experience of farmers in Egypt testifies frequent cases of very poor performance of levelling operations with laser guided equipment. It seems that sometimes the operators do the job without proper adjustment of the laser transmitter, or they even don't switch on the transmitter, and work upon their visual judgement, but charge the farmer for a laser guided operation. Such practices need to be prevented by highly skilled irrigation extension staff who would then act as controllers and as farmers' advocates against the state-owned operators. To do so, extension staff and irrigation engineers need to have insight knowledge on this technology, and they should be able to do adjustments of the transmitter by themselves.

After a successful levelling operation however, an additional benefit can be obtained, if the farmer opts for distributing the water through long furrows instead of the traditional small basins, the latter being an ancestral technique of coping with uneven plots. If the water supply is not by open field channel, but by a pressurized pipeline, as will be the case in some areas of the national "Irrigation Improvement Project" IIP, the use of gated pipes combined with long furrows seems to present the maximum technology package for obtaining an optimum field water distribution uniformity.

3. How to estimate the "cost-benefit" for the different alternatives of precision land levelling

The financial Cost Benefit Analysis is a good approach when the primary basis for making decisions is the monetary cost vs. monetary benefit of the alternative long-term investments. When it comes to decide whether or not to apply a certain technique which needs to be repeated each season, each year or each few years, as is the case for precision land levelling, the farmer may use a simplified method of the CBA. This is then called a simple Gross Margin estimate.

The 9 steps of proceeding to make a CBA – in a simplified way – may also be followed for the estimation of the Gross Margin increase which can be expected from investing into better land levelling:

Step 1. Define the problem: Low water uniformity in the field because of a non-accurate level of the field surface.

Step 2. Establish the objective: To improve/ optimize on-farm water distribution and to increase yields and Gross Margin of a crop.

Step 3: Determine the constraints

- Gross margin which can be obtained from an average smallholder farm in the Old Land that determines the costs a farmer can incur.
- The time frame necessary to apply certain improvements is limited to the short intervals between the summer and winter cropping seasons, if the farmer can not afford to leave-out one cropping period.
- Problems with coordination and cooperation among farmers concerning the cropping pattern (e.g. no cotton in rice area, or no rice in cotton area) and cropping calendar in view of agreeing on a period for the execution of maintenance work when the land is free.
- The availability of liquidity for technology implementation. This could be through savings, and/ or borrowing from family members and neighbours, making a "gamaiya" monthly rotational collection of money, where each member receives the amount on his turn, or having access to credit from banks on village level.

Step 4. Specify the assumptions

In order to make costs and benefits of different technical options somehow comparable, it is necessary to formulate assumptions. These make it possible to analyze a single factor which is then modified, all other factors being held constant. Based on such an ideal situation the extension worker can then judge the relative advantage of one option against the other options and advise the farmer accordingly. The general assumptions are presented below:

- The use of the same tractor with same horse power (70 hp), although we know that the tractors at the governorate have generally higher performance and that usually two tractors are dispatched, which decreases the time required.
- The width of the blade or buckle is 2 m.
- This job is done on 1 feddan that is considered for economic calculations, acknowledging that in the case of using wider blades and laser levelling equipment the minimum size of plot required to obtain economies of scale is about 5 feddan.
- Existing workload and operating costs will remain constant during the comparison period. The time for irrigation application for one feddan per year is estimated to be 50 hours.
- The pumping cost per hour per feddan is assumed to be LE 4.50, i.e. the total pumping cost per feddan per year is then LE 225.00.
- The cost of irrigation labour is assumed to be LE 95/ feddan/ year. Alternatives 1 and 2 will are assumed to save 15%, while alternative 3 is assumed to save 20% of the labour costs for irrigation.
- The gross margin per feddan is set to be LE 4,000/ year. For alternative 1 and 2 an increase by 10%, and 20% for laser land levelling are assumed. The yield increase per feddan is a result of the better water uniformity and better crop distribution in the field (or allowing long furrows instead of basins), which results in increases of the gross margin.
- Based on interviews with experts and field researchers the levelling operation needs to be repeated every year, if option 1 and 2 are used, while precision levelling is assumed to be repeated only after 3 years or 6 cropping cycles.

Step 5. Identify the alternatives

Assuming that there are mainly four alternatives for precision land levelling in the Old Lands in Egypt, these are:

1. Tractor with land leveler mounted on 2 wheels, equipped with manual adjustment lever (we take this option as our Base Case/ Status Quo)[1]
2. Tractor with land leveler mounted on 2 wheels and equipped with hydraulic piston operated from the tractor
3. Tractor with laser guided land levelling unit mounted on 2 wheels.

Assumptions of alternative 1: land leveler mounted on 2 wheels and equipped with manual adjustment lever
• Precision levelling takes 3 hours/ fed • Operating cost of the tractor for land levelling is assessed at LE 25/ hour. • Land levelling is done every year • Pumping cost is diminished by 15% (easy and faster water flow)
Assumptions of alternative 2: land leveler mounted on 2 wheels and equipped with hydraulic piston operated from the tractor
• Precision levelling done in 2.5 hours/ fed • Operating cost of the tractor for land levelling is LE 25/ hour. • Land levelling is done every year • Pumping cost is diminished by 15%
Assumptions of alternative 3: laser land levelling unit mounted on 2 wheels
• Precision levelling done in 2.5 hours/ fed • Operating cost of land levelling is assumed to be LE 60/ hour (market price) • Field levelling is done every 4th year only • Pumping cost is diminished by 20%

Step 6. Calculation of Costs and Benefits

a. Identification of Costs and Benefits

[1] [1] In this module the status quo is not considered to be “no leveling at all” as this is unrealistic. Research inputs have shown that the tractor with land leveller mounted on 2 wheels, equipped with manual adjuster is the widely used by farmers. Therefore it is used here as the Status Quo.

This module is to focus on the financial costs and benefits that can be converted into money. The consideration of the non-financial costs and benefits is beyond the scope of this module, because these are subjective and its valuation differs from one individual farmer to the other. However, they can have an impact when evaluating the alternatives, if two options generate a similar amount of benefits and require the same costs. In such case the farmer will include the non-financial costs and benefits in choosing the most suitable alternative.

	Costs	Benefits
Alternative 1	Rent cost/ hour x 3 hours	Yield increase by 10% Saved pumping cost by 15% Saved irrigation labour cost by 15%
Alternative 2	Rent cost/ hour x 2.5 hours	Yield increase by 10% Saved pumping cost by 15% Saved irrigation labour cost by 15%
Alternative 3	Rent cost/ hour x 2.5 hours	Yield increase by 20% Saved pumping cost by 20% Saved irrigation labour cost by 20%

b. Quantification of Costs and Benefits

In the present analysis only actual payments are considered. Therefore, no depreciation charges or interest charges are added or deducted. Moreover, market values associated with land levelling process are used instead of financial ones. They reflect the real costs that an economy bears. If in agriculture a subsidy is paid to increase the use of a production factor, then the cost of the item in economic analysis is the price plus the subsidy, whereas the farmer himself would only consider the subsidized price. All input prices considered in our analysis reflect the market prices of such inputs without subsidies.

The data is collected from mixed sources; staff experiences of the German support team to the project “Agricultural Water Management” (AWMP), survey of current system costs, special studies, and analyst judgment.

Table 1: Cost-Benefit Data of Land Levelling Alternatives/ feddan/ year in LE

Item	Alternative 1	Alternative 2	Alternative 3
I. Costs			
Tractor operating Cost for land levelling (LE 25, 25, 60/fed) x (hours, 3, 2.5, 2.5 required)	75	62.5	150
II. Benefits(LE/ fed)			

Projected increase in gross margin: yield increase by 10%, 10%, and 20% of LE 4,000	400	400	800
Saved pumping costs: 15%, 15%, and 20% of LE 225	34	34	45
Saved cost of irrigation labour: 15%, 15%, and 20% of LE 95	14	14	19
Total benefits (LE/fed)	448	448	864

The table summarizes changes of the costs associated with changes of expected benefits. Applying land levelling using hydraulic leveler (alternative 2) is the cheapest alternative among the 3 alternatives (LE 62.5/ fed). Yet, the total benefits (LE 448 /fed) gained by this alternative rank second after alternative 3 with total benefits of LE 864/ fed and alternative 1 ranks last.

In the previous table the costs and benefits are presented without discounting[2], i.e. without considering the time value of money (see Module 2 for details), as they only consider one year.

Step 7. Evaluate the risk/ perform sensitivity analysis

The sensitivity analysis in this module seeks to subject the results of the CBA to more pessimistic estimates of benefits and costs. The intention is to identify those input parameters that have the greatest influence on the outcome, whether the costs or the benefits. In order to test the sensitivity of the alternatives to changes in benefits and costs, three possible scenarios (increase cost by 10%, decrease benefits by 10%, increase cost and decrease benefits by 10%) can be developed and analyzed.

Step 8. Evaluate the alternatives Fehler! Textmarke nicht definiert.

The following part shows to what extent land levelling is economically feasible for Egyptian farmers. Since we deal here with an innovation that represents one item of variable costs of production while all other items remain constant, then a comparison between the incremental changes of the cost due to this innovation versus its incremental benefit would be the best way to check directly the economic feasibility of such an innovation. This comparision is done with the help of a Gross Margin Calculation.

Calculating gross margins reveal how much the farmer earns, taking into consideration the costs that he incurs. In other words, gross margin is equal to gross income divided by total revenue, and is expressed as a percentage. The gross margin is a good indication of how profitable an investment is at the most fundamental level. Investments with higher gross margins will leave over more money to be spend on other activities. To calculate gross margin, the used formula is the following: Net Profit/Total Revenue X 100

[2] Present Value = Future Cash Flow / (1 + Discount Rate)$^{\text{Number of Years You Have To Wait For The Cash Flow}}$

Table 7: The calculation of the Gross Margin for the 3 Alternatives

	Alternative 1	Alternative 2	Alternative 3
Total Revenue (benefits) in LE	448	448	864
Total Costs in LE	75	62.5	150
Net Profit[3] in LE	373	385.5	714
Gross Margin (%)	83.2%	86%	82.6%

The table shows that – under the assumptions made above - laser levelling with a gross margin of 82.6%, despite the highest nominal net profit (over three years!), ranks last. Alternative 2 ranks first with a gross margin of 86% and alternative 1 ranks second with 83.2%. The result shows that it is more profitable to conduct precision land levelling through yearly using a hydraulically operated leveler.

Step 9. Make recommendations and take a decision

Investing in improving or optimizing on-farm water distribution by farmers through the 3 precision land levelling alternatives has proved to be financially justified. In all cases, the net benefits are positive over the whole life cycle of the investment.

The Gross Margin calculation shows that laser land levelling has a gross margin of 82.6% which is less than the other two alternatives, whereas alternative 2 ranks first with a gross margin of 86% and alternative 1 ranks second with 83.2%. The result is that it is more profitable using alternative 2: land leveller mounted on 2 wheels and equipped with a hydraulic piston.

It is worth mentioning that in addition to the financial aspects in selecting between the alternatives, the social dimensions also play a role in making one of the alternatives more favourable than the other. These social dimensions are to be discussed in the following section.

4. Social Acceptability of Precision Land Levelling

The Participatory Rural Appraisal conducted by the Agricultural Water Management Project (AWMP) in June 2004, and two social assessment studies conducted in 2005 have discerned a number of aspects with regard to farmers' perception of the application of precision levelling.

It was established that farmers get their information on laser levelling from varies sources. The Village Extension Workers (VEW) from the Ministry of Agriculture and Land Reclamation (MALR) provide information during gatherings and ask farmers to compare between a field that has been levelled by laser (demonstration plots) and another that was not. Others have seen the laser unit operating in the governmental Sakha Research Station in Kafr El-Sheikh and/ or in the fields of big land holders. In addition to seeing the laser unit, its operation and its benefits from the TV through an episode of the "Secret of the Land" program.

[3] The net profit equals the total revenue minus total costs

4.1 Benefits perceived by farmers

Farmers are found to be aware of the general benefits of laser levelling such as having to level the land every 3 years only, saving irrigation water, increasing yield, and reducing work load. For example they know that the regular tractor only presses the land, where the high and low levels in the field remain unchanged, while laser levelling makes the field be like a palm, i.e. no high and low land levels for three years. Consequently reducing the required irrigation time and having in turn impact on the required pumping time and on the amount of water used. Thus, decreasing irrigation costs as well as saving water. Farmers added: “We prefer to use the laser unit over the regular scraper because it presses the land effecting that the land does not need much water”. Precisely leveled fields also enable farmers to employ the combine for harvesting row crops such as rice and wheat.

The equal distribution of water –achieved through laser levelling- prevents seeds from spoiling due to over water application in low land levels or drying due to low water application in high land levels. The uniform application of water in the field allows the use of less seeds and the rapid germination of plants. In consequence, the yield increases, farmers income as well as land prices. Laser levelling also decreases the growth of weed in the field, hence reducing the time and effort that farmers have to spend in weeding. It also allows the dry transplantation of rice that reduces the number of labour needed as well as the waste in rice transplants.

The benefit of reducing the working load in the field -through the use of laser units- is valued a lot by farmers for a number of reasons. Less work means less labour cost for levelling, weeding and harvesting. The rapidly changing family pattern in rural areas from farmers having many children helping them in the field to farmers’ children going to school and having limited experience of working in fields. Hence, households are currently forced to hire labour that is increasing in cost. Using the laser leveler every three year would reduce the number of labour to be hired and the annual cost that the farmer has to incur. In addition, farmers mentioned that they can use the gained time for raising cattle which is an income generating activity. A farmer in Daqalt canal said: “Now with less work load in the field I can help my wife in raising the cattle that used to be her responsibility”.

The above shows the acceptance of farmers and their willingness to adopt the innovation, because they are convinced of its benefits through the information they have acquired from the extension worker, their neighbours, and the TV. Still, it is important to inform farmers about how to maximize the benefits of using the laser leveler through its complementation with other innovations such as, long furrows, gated pipes, etc. This requires the development of unified packages for the extension workers and advisory staff. The aim is to formulate, provide accessible and detailed information to enable farmers to take their own investment decisions. Therefore, the extension handbook is to be formulated allowing farmers to choose what is suitable to their individual conditions.

Necessary is also to provide practical training to advisory staff on laser levelling as well as to the laser units’ operators. Some farmers in the northern Delta Besintway Canal area have complained that drivers are not well trained. In addition to providing training to farmers showing them how to receive the land after being leveled with the laser tractor.

In spite of the acknowledgement of the benefits of laser levelling by the majority of farmers there are a number of constraints that hinder the wide application of laser levelling the Old Land in the Delta. These are to be discussed in detail below.

4.2 Constraints perceived by farmers that hinder the access to Laser Units

Farmers declared that the constraints preventing them from having access to the laser units consist of infrastructural, laser units scarcity, the laser application pre-requisites, and the gender constraints.

The laser unit is a big and heavy tractor that requires wide roads to reach its destination. The narrow roads hinder the passing through of the tractor, which is the case in some areas in Besintway canal/ Beheira. In areas where the water table is high or the drain is leaking the usage of the laser tractor is also hampered**.** Farmers in Qahwagy canal assert: “We do not use the laser tractor because of the leaking drainage, the high water table can cause the sinking of the heavy laser tractor”. In addition, the dominant feature of the Hammamy canal is the cultivation of citrus and guava trees, with land pockets cultivated with other crops, making it difficult to consolidate the land for laser levelling.

In general, there is high demand on laser units, especially before the cultivation of rice and wheat. The limited number of such units in Kafr El-Sheikh governorate results in a demand fulfilment percentage of only 25%. The Kafr El-Sheikh governorate has only 3 governorate owned laser units. In contrast, in Beheira governorate, in addition to the government owned units, there are three private sector operated units. Yet, this did not increase the supply of laser units available to small-scale farmers in this governorate because the private entrepreneurs prefer to work in the newly reclaimed desert land within this governorate, where plots are larger and profitability with commercial farmers is higher. The equipment serves at least 5 feddan at once or works a minimum of 10 hours.

The access to laser units is sometimes constrained by the high cost compared to regular levelling, LE60/ hour and LE25-30/ hour respectively. Therefore farmers are often using the regular leveler first in order reduce the required time and cost for the laser. The predominant feature of land holdings in Egyptian rural areas is their small size of less than 1 feddan. This small size is due to the inheritance processes and the limitation of land allocation within the Agrarian Reform Cooperatives. Smallholder farmers complain that only rich farmers have access to the service, while the poor are neglected.

Although the difficulty in reaching an agreement among a group of farmers to consolidate the land to meet the critical size for using a laser unit was raised by farmers. Farmers in Besintway have stated that they use to consolidate their small plots before the cultivation of rice, which facilitates the levelling operation. This would help to make sure that irrigating the high water consuming rice crop does not harm neighbouring plots through spilling over the limits of the rice fields.

Farmers have specified different official sources for providing them with laser units in the project area: The mechanization association, the agricultural department on district level, the land improvement office, the cooperative. But the most frequent way of hiring levelling services is through contacting someone they know, and who is often an extension worker. A farmer in Hammamy canal said: “We contact the person we know, because he is our relative and is thus more inclined to help us”. By depending on their relatives farmers seek to bypass the extensive bureaucratic procedures that leads to the loss of time, money and energy.

Laser units are also made available for free during seasonal campaigns (summer/ winter) and are used on so-called demonstration plots. Extension workers apply certain criteria for the selection of demonstration plots, such as that land has to be located on the main road to allow others to see the demonstration. Then the land should not be rented but be cultivated by its owner, and the farmer has to be known to the extension worker. Consequently, small farmers complain that only bigger landholders have access to the free campaign laser units. It is worth mentioning that during campaigns the laser units are not made available to farmers on commercial terms.

Finally, it is worth mentioning that women-headed farming households do not have easy access to the laser units. A woman in Qahwagy canal said: “I managed to have it on my land because my family owns the land next to mine and they asked the tractor driver to level my land as well. I know that this is the only reason for a woman like me to be able to obtain the machine”.

Summary of findings:

As a result of the previously mentioned constraints there are still many farmers who prefer the use of the regular tractor with a manually operated shield over hiring a laser levellling unit because it is more practical when having to do small plots. The possibility for land consolidation in order to make the use of the laser units and other mechanical equipment more economic has not yet been sufficiently used. Encouraging private investment in laser units may facilitate the access to this technology, since it is expected that the terms of operation applied by the private sector are more flexible than those of the governorate, even if the latter are subsidized. The preparation of WUA to use its annual savings or a collective loan to buy a laser tractor for its member farmers as well as for renting to neighbouring WUAs seems to be worth studying.

It is obvious that channels known to farmers by which they can get access to laser levelling units are not clear. Many governmental agencies are involved, yet neither the steps nor the financial conditions for hiring the laser units are clear to the farmers which we have questioned. Therefore most farmers prefer to resort to informal structures like their relatives and friends to assist them in hiring a laser unit. The danger of corruptive practices is inherent to this type of procedure.

The actually practiced criteria for the selection of demonstration plots favour rich farmers over poor ones, although they are the least in need for any kind of subsidy. It is important to note that all these constraints mainly affect smallholder farmers and women and prevent their easy access to laser units.