Participatory Farm Planning

A Guide to Tree Based Farming Systems Analysis

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1. Introduction

Farm Planning is a process which is undertaken constantly by farmers, extension workers and researchers in developing and industrialized countries alike. It is carried out by means of various methods and tools according to available knowledge and resources. Simple rules of thumb estimates as well as sophisticated computer models are part of farm planning. The use of more sophisticated methods usually goes beyond the capabilities of farmers, especially the small farmers in developing countries. The application of such tools requires the involvement of specialists and consultants, which bares the danger of separating the planning process from the needs and desires of the implementor. This may result in unrealistic, theoretical plans which do not take into account real constraints and options.

This manual emphasizes on a participatory approach in farm planning. Participation in planning means to do away with the old paradigm of a standardized decision maker with a known utility function. The major message of this book is that the optimal farm plan is not simply the result of the planner's calculations but can only be identified by means of an interactive "back and forth" process between the planner and the implementor. The significant advantage of this method is that the farmer is allowed to adjust and at the same time to quantify his goals as he is being confronted with the results of the consequences of alternative farm plans. The way quantitative results of planning calculations are being communicated is crucial. In any case the "horrible formats", which sophisticated computer programmes use to "spit out" must be avoided. Therefore, the communication model which we emphasize here is a pictorial approach. The existing farm as well as alternative plans must be displayed in simple farm maps. These are believed to stimulate the famer's imagination as regards the consequences of future farm development. We think that pictures not only complement numbers, but are also less of a barrier in communication, especially between parties with different level of formal education. We hope that keeping these new concepts in mind this manual may help planners, extension workers and farmers to make farm planning a more lifely and fruitful affair.

2. Objectives of the Handbook

This handbook aims an approach of farm planning, developed by Waibel and Wesseler (Wesseler and Waibel, 1995; Waibel, 1991) within the context of the farming systems philosophy. The approach was developed for tree based farming systems. It thus contains two main parts. First, the concept of participatory farm analysis and secondly, a problem-oriented review of quantitative methods of farm economics, which are believed to be the core element of farm planning. The review concentrates on methods relevant for decision making problems regarding fruit trees, say perennial crops.

2.1. Farm planning and the farming systems philosophy

Farm planning is one of the tools of farming systems research and extension (FSRE). This concept is based on the growing recognition of scientists and development workers about the complexity of systems with which resource poor farmers deal with. FSRE is no more than a rediscovery of the importance for a holistic and problem-oriented view of the family farm, which has to precede any intervention into the development process, and which is combined now with new concepts in general systems theory as well as modern tools of farm planning. Among the various components of FSRE, emphasis in this manual is given to the use of participatory monitoring and evaluation methods as applicable to the conditions of the farmers in Kenya.

The first and most important step in FSRE is the diagnosis of the existing farm. The diagnostic phase involves the collection and compilation of information in order to design proposals and plans for interventions. In general, diagnostic activities may include the review of standardized data from secondary sources, the use of research information and the discussion with local officials. There is, however, no substitute for direct farm observation and formal surveys. As regards the latter, the question is in which way formal surveys are to be conducted. Until know, the most common approach is to formally interview farmers. This approach however is increasingly found to be unsuitable for farm planning, mainly because farmers are often forced into a passive role, which is detrimental to the realistic outcome of the planning process. In this manual, it is understood that farm planning is based on the involvement of the farmer from the very beginning. This type of approach is meanwhile known in development activities and has been applied in the field of aquaculture. It is called “participatory monitoring and evaluation“

and tries to make use of visual aids, which allow the farmer to present his farm instead of being interviewed. Actually, farmers are asked to draw pictures, which are maps of their farm, suitable to demonstrate the major interrelationships among the various subsystems. In this way, the view of the farmer is presented rather than the often misled perception of the planner or the researcher. In the case of fruit tree production, by following this method it is made sure that the planning process is reduced to fruit tree technologies but takes into account the whole farm. At the same time, maps and pictures serve as a guide for the quantification of the most important subsystems and their interactions. These maps can be further used to plan and demonstrate possible improvements. It is of utmost importance that not only drawings are made of the farm but that the farmer is given the chance to explain the elements of the drawing. By following this procedure, farm planning is expected to become a more lifely undertaking, which reduces the barrier of introducing necessary concepts of quantitative economic thinking.

2.2. Problem-oriented introduction of quantitative economics methods

Farm organizations change as a result of changing conditions such as prices, quality and quantity of available resources as well as the available technology. Before the existing farm organization will be changed, it is useful to compare various alternatives by preparing quantitative estimates. In order to avoid wrong conclusions and for the ease of calculations, appropriate methods must be used. This is of particular relevance if decisions are to be taken which bear long-term consequences. Going into fruit trees requires investment decisions. This ultimately means that the farmer's degree of patience will play a major role in this decisions, because as the saying goes "time is money" and a thousand Pesos earned after only a couple of years is quite different from a thousand Pesos earned today. Secondly, fruit trees are often a risky business. Once they are established there is little the farmer can do to influence the actual production level. Furthermore investments in fruit trees require cash outlays thus stressing the farmer's financial capacity. Hence rentability calculations may be meaningless if the liquidity position of the farm family is insufficient.

These examples show that cost and return calculations must be adjusted to the actual decision problem. Therefore, the quantitative methods which can be taken from any standard text book in economics are best presented by means of examples. This approach is taken in this manual

and it is hoped that this will make the methodology more digestible for planners and extension workers not so familiar with the “inert matters“ of farm management economics.

3. Participatory Farm Analysis

This chapter introduces a participatory approch to farm planning. This and the other chapters follow the phases of farm data gathering in chronological order.

3.1. Preparation for the farm visit

Before we start a farm visit it is useful to do some preparations. First of all we have to simply ask ourselves: Why do we want to see the farmer? There are many purposes to see the farmer, such as a regular farm visit to monitor his fruit trees and to discuss fruit tree problems, to check on farm trials, to invite the farmer to join a meeting, etc.

For the handbook we are concerned with the development possibilities of farming systems. Therefore, we will assume that it is the first time that we meet the farmer to discuss **development possibilities** (Maybe, we met the farmer before to discuss other subjects.). A further assumption is that we have already identified the farm we would like to see.

If we know the purpose of our visit, we can identify the information needed. This leads us to the next paragraph.

3.1.1. Identifying information needs

Considering our purpose, the identification of farming-systems development options, we have to identify the information needed. Based on the farming systems approach, there are three main areas of consideration, which influence the activities of the farm-household (see also figure 1):

- socio-cultural environment,
- physical environment,
- policy/institutional environment.

For every area we have to identify the kind of information needed. We have to remind ourselves that our focal point is the farm and that we want to come up with development options. Therefore, the first step is to get an overview of the existing farming system including some quantitative information for the farm-income-analysis.

The overview of the farming system allows us together with the farmer to identify areas of possible changes and the production systems affected by those changes. Once the production systems are known, quantitative data are required. Recalling the crop-budget sheets, we can identify the necessary variables, like fertilizer, pesticides, transportation costs etc.

If there is some additional information needed (like access to additional land for fruit tree growing, availability of labor, main labor tasks etc.) they also have to be identified. The next step then is to analyze what kind of information is already available.

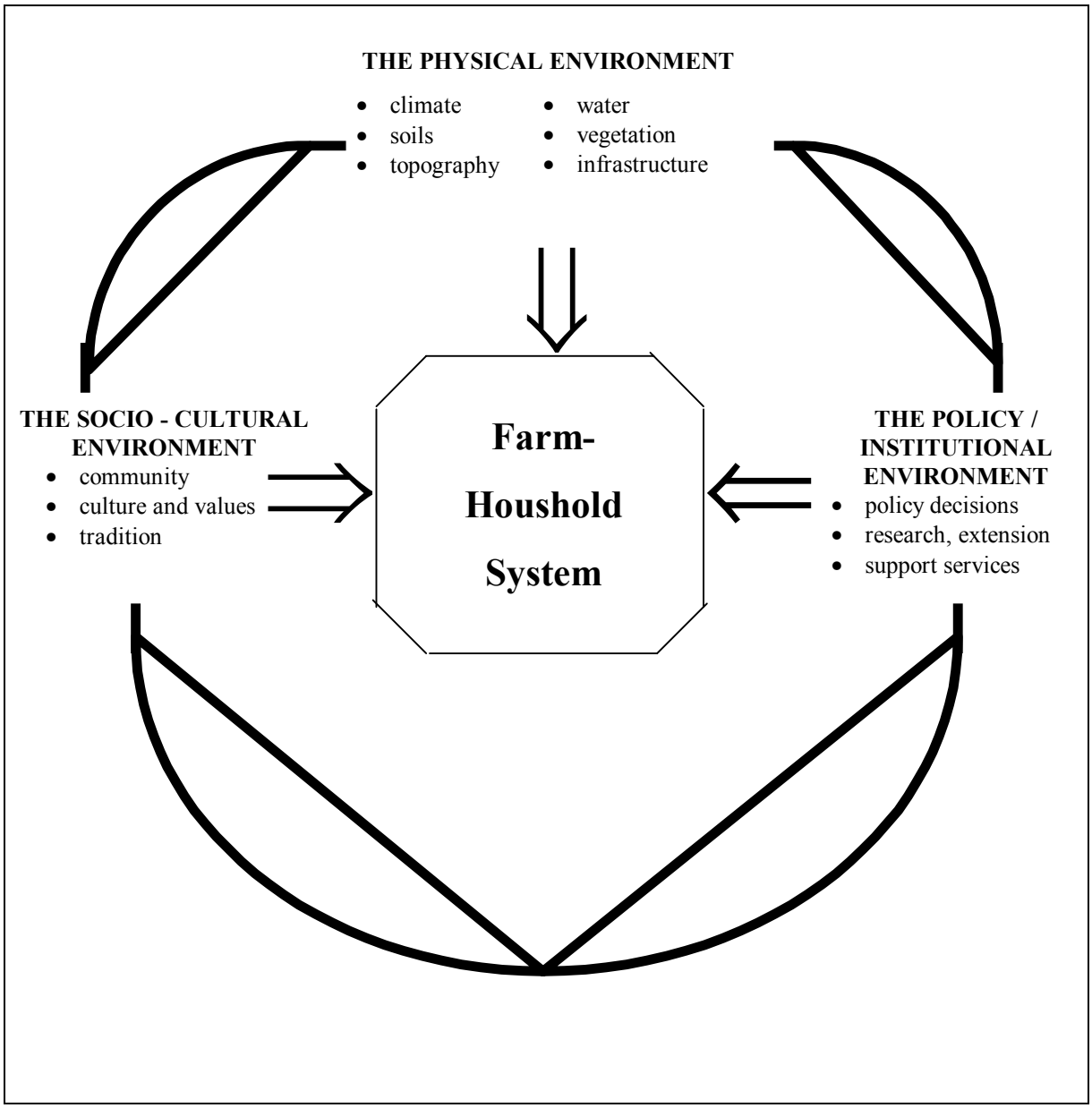


Figure 1: The farm-household system and its environments

3.1.2. Checking of available data

In many cases information is already available. We can find specific information regarding the different cropping systems and their inputs and outputs in publications of the Department of Agriculture or in studies conducted by Universities. Information on fruit trees might be available from fruit tree projects. We can check the databases of such a project for information on the farm we plan to visit. It is useful to prepare crop budgets for the known main crops to see where we will have difficulties in getting information.

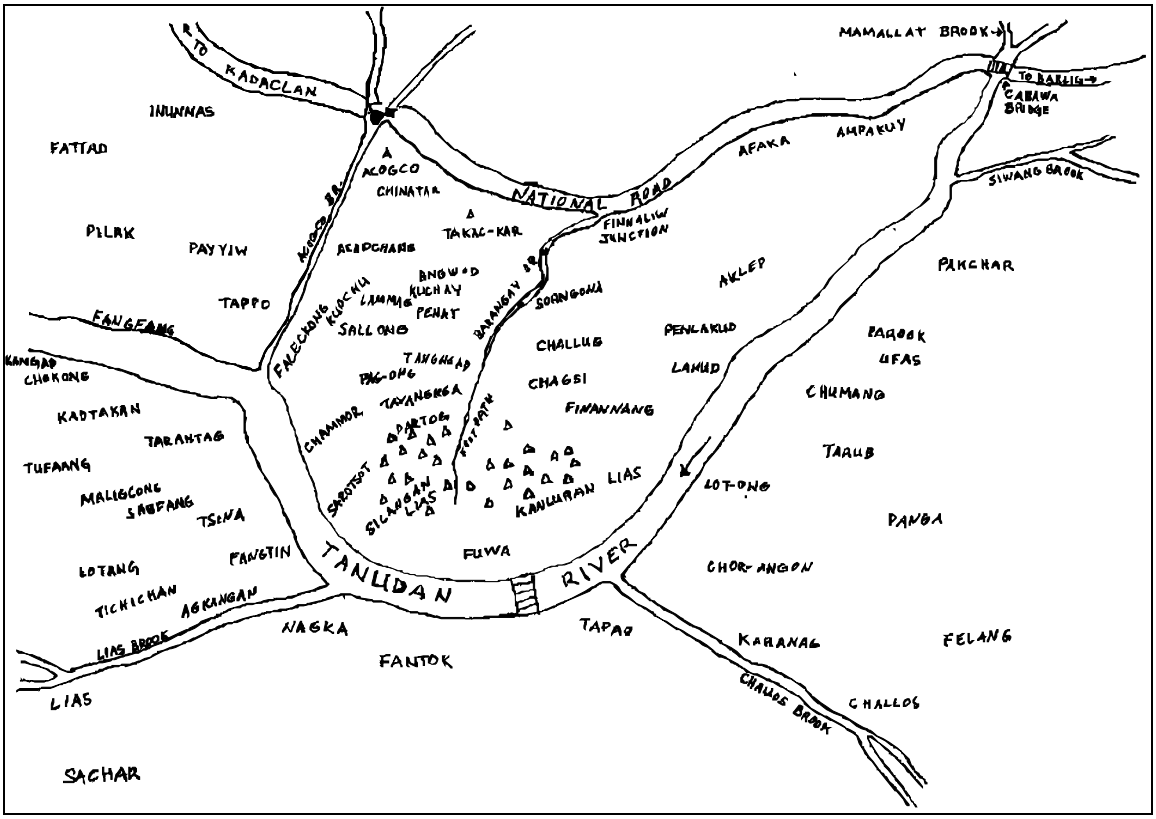


Figure 2: Example of a Town Map (Wesseler and Waibel, 1994)

If the area-based extensionist and researcher are not part of the team, we have to contact them. If we are not aware of the cultural settings and the land tenure situation, we have to contact resource persons, like staff of local research centers (e.g. the Cordillera Study Center).

Having identified the necessary information and compared it with the available secondary data, we know now the topics we would like to discuss with the farmer. It is also useful to have a

map of the location as shown in figure 2 which can be used during the discussion with the farmer to identify the different lots. The town map should include landmarks like roads or rivers and local names of specifc places.

3.1.3. Discussion guidelines

When visiting the farm, we have to make sure to bring the necessary equipment, like:

- pencil,
- eraser,
- pencil sharpener,
- ball pen,
- paper and writing board,
- check list of information needs,
- measure tape.

Even more important, the farm-family should be informed about our visit. It is easier if the **family is already aware** of the project and shows the willingness to cooperate for the analysis of their farming system.

We also have to consider the right timing. The most appropriate time seems to be **in the morning after breakfast**. We can use the colder time of the day to do the farm walk; when it gets warm, we can do the discussion. The afternoon is left to prepare the farm-income-analysis and to identify additional information needed.

In our farming-systems team, we should ensure a proper attire and try to have a local mediator as a team member. For the visit we have to delineate our responsibilities:

- who will do the introduction,
- who will take notes during the farm walk,
- who will take notes during the drawing of the farm map,
- who will start drawing the farm map,
- who will talk to other household members,

It is helpful if the person doing the discussion with the farmer is different from the one who takes notes. When we have decided upon the responsibilities, the next step is to prepare our

introduction. We should not forget to introduce ourselves and the project we are affiliated with. One member of the group should explain the purpose of our visit (the farmer should already be aware of this), the activities we would like to do (farm walk and discussion) and ask him about his expectations regarding our visit. The local mediator of our group is the best person to do the introduction.

Tips for dealing with negative responses

It is most important that the farmer knows you heard his negative comments. You do not need to sympathize with him/her, but do confirm that you heard him, i.e., you are listening to him. Then...

1. Try to direct the conversation back to the point where you want it to be.

2. Another alternative is to turn the negative comment into a positive one yourself by coming up with own suggestions.

3. Finally, try to get the farmer to turn his own comment around by asking him what he would like to change to make things better.

Example: When discussing the prospect of fruit tree growing, the farmer says to us "Why should I bother with irrigating a tree? It takes as least five years before I can harvest anything. During that time I have to water it and nothing happens for so long? I may not even be here in five years."

Then we can respond in the following manner:

1. I can imagine that it is frustrating for you to wait so long to see the benefits of your efforts. What would need to change to make you willing to irrigate the tree?

2. I can imagine that it is frustrating for you to wait so long to see the benefits of your efforts. Since you cannot improve the situation by making the tree grow faster we could work together to improve the chances that the tree will bear fruit in five years. We should try to make sure that you will have enough water so that the tree won't die during the dry season.

3. I can imagine that it is frustrating for you to wait so long to see the benefits of your efforts. Since you cannot improve the situation by making the tree grow faster we could work together to improve the chances that the tree would have fruit in five years. What

do you think we could do to insure this?

Tips for eliciting proper responses

1. Ask clearly and directly worded questions.
2. Repeat the farmer's answer in your own words to check whether you have understood him correctly.
3. Be prepared to rephrase your questions if the farmer doesn't understand it.

Tips for handling talkative interviewees

It is important for the farmer to know that we are interested in what he has to say. If he is very talkative with respect to relevant topics, it may be fruitful to let him express himself for a while. We can direct the conversation by politely asking questions in between. However, if the farmer talks about non-relevant things, it is still important to let him talk for a while as we may get some valuable information which we did not expect or would not have learned if we strictly asked our questions. We can try to guide the conversation back to relevant topics by asking direct questions, or we can ask him directly to only talk about the farm now and at the end or on another date we can take up the other topics. Of course, it will then be necessary to follow through.

Use of vernacular

We will use the local language i.e., dialect of the people during your interviews and farm walks. This is important so that the interviewees will clearly understand the questions we are asking them.

Separate male/female interviews

A separate interview will enable the interviewee to answer more freely. Gender issues should become transparent and the information gained should be more complete.

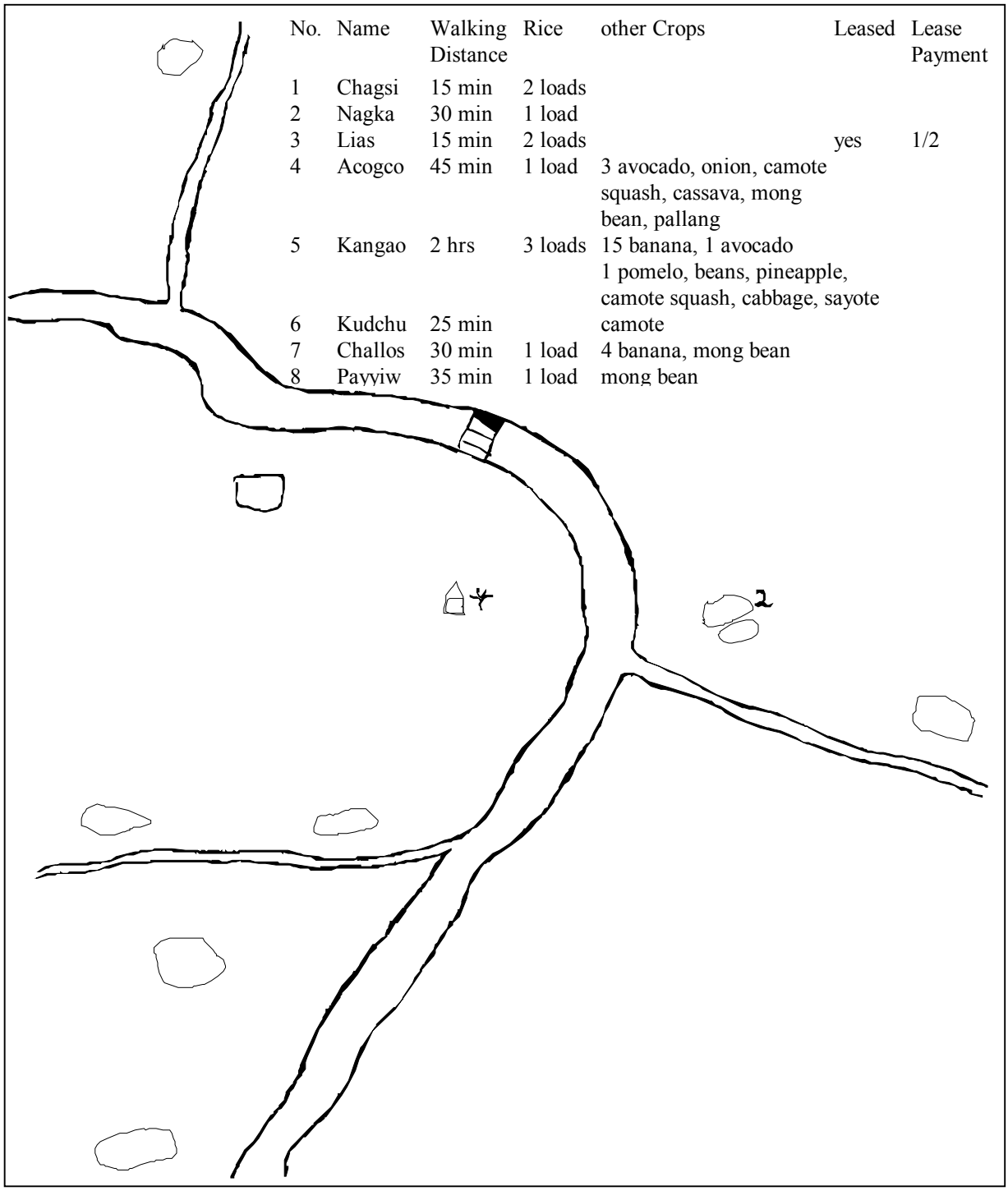
3.2. Farm Visit

Having made all the necessary preparations, we can start our farm visit. After breakfast, we arrive at the farm and introduce ourselves, the purpose of the visit and the planned activities. The first step will be to ask the farmer about the main farm activities and the locations of his farms or fields. We can expect that the family has several farms in different locations (vegetable and maize fields, an orchard, etc.). If there is more than one location, we will start by drawing a scetch of the farmhouse and the locations of the different lots. One of our group will do the drawing (the one we have decided upon). It is best to start with the house of the farmer and to draw two landmarks to identify the direction of the map. Next we will locate with the farmer the different lots, the planted crops, source of irrigation, if any, owner of the lot, heritage, if bought, buying price, the walking distance to the house, access to the road for transportation. We must not forget to ask about land rented out to others and the tenure arrangements. The one drawing the map can write down the information regarding the lots at the bottom of the map as shown in figure 3. Table 1 shows a list of items to be included in the general farm map.

Table 1: List of items to include in the general map

1. Farmhouse
2. Landmarks to identify the direction
3. Different farms or fields
4. Planted crops
5. Source of irrigation
6. Owner of the different fields, heritage, if bought the price
7. Walking distance to the house
8. Access to the road

After the initial discussion, we will ask the farmer to show us the farm, especially the areas for further possible developments. We do not necessarily have to see all the locations; it depends on the distance to the farm house and the importance of the location to the farmer. We **have to** see the areas which the farmer would like to develop in the future.



No.	Name	Walking Distance	Rice	other Crops	Leased	Lease Payment
1	Chagsi	15 min	2 loads			
2	Nagka	30 min	1 load			
3	Lias	15 min	2 loads		yes	1/2
4	Acogco	45 min	1 load	3 avocado, onion, camote squash, cassava, mong bean, pallang		
5	Kangao	2 hrs	3 loads	15 banana, 1 avocado 1 pomelo, beans, pineapple, camote squash, cabbage, sayote		
6	Kudchu	25 min		camote		
7	Challos	30 min	1 load	4 banana, mong bean		
8	Payyiw	35 min	1 load	mong bean		

Figure 3: Farm Map with Identified Locations

3.2.1. Farm walk

During the walk to those lots which are not adjacent to the house we have the chance to talk about farming problems and we get familiarized with the farm, the farmer, the actual situation and the existing problems. It is important that one person takes notes. When we reach the lot, we let the farmer explain the area, the situation of the planted crops, the inputs used (check for fertilizer and pesticides and the system of pest control), previous and expected harvests, as well as selling prices. If livestock is incorporated in the system, we ask for feeds used (commercial and farm feeds) and animal productivity, like piglets per year or weight and price for slaughtered hogs.[I]

3.2.2. Drawing a farm map

When we return from the farm walk, we continue with our map. Now we can add a drawing of the locations we have visited. One person will do the drawing and identify the resource flows at that location and the connections to the other subsystems like piggery and other crops. Another person will take notes. It is important to quantify the resource flows. Based on the information gathered during the farm walk the person taking notes has to check if some data are still missing.

The main task of drawing the farm map is to **motivate the farmer** to present his/her farm and to **actively incorporate** him in the drawing of the map. Preferably the farmer takes over and continues the drawing. Figure 4 shows the farm map of a farmer from Kericho.

3.2.3. Initial discussion of possible farm developments

After the farm map has been finished, we can discuss development possibilities. It is the farmer, who has to come up with suggestions, because he knows the farm best. We will incorporate the new developments into the farm map and show their linkages in the system. Depending on the actual farm map, we may be able to use the existing one or it may be necessary to draw a new one. We have to take notes during the discussion of development possibilities about

[I] The appendix shows a standard list of information needs.

additional land requirements, labor, capital and water requirements if it comes to fruit trees. We must not forget that some activities necessarily require reduction of others; for example increasing the area of avocadoes might require a decrease in the area of maize.

Entreprises:.

	Area
1. Maize	2,5 acres
2. Potaoes	1,00 acres
3. Beans	0,5 acres
4. Vegetables	0,5 acres
5. Citrus/Loquarts/Quavas	0,75 acres
6. Homestead &farms structures	0,5 acres
7. PAstures + Fodder crops	2,25 acres

	8,00 acres

Sketch Map

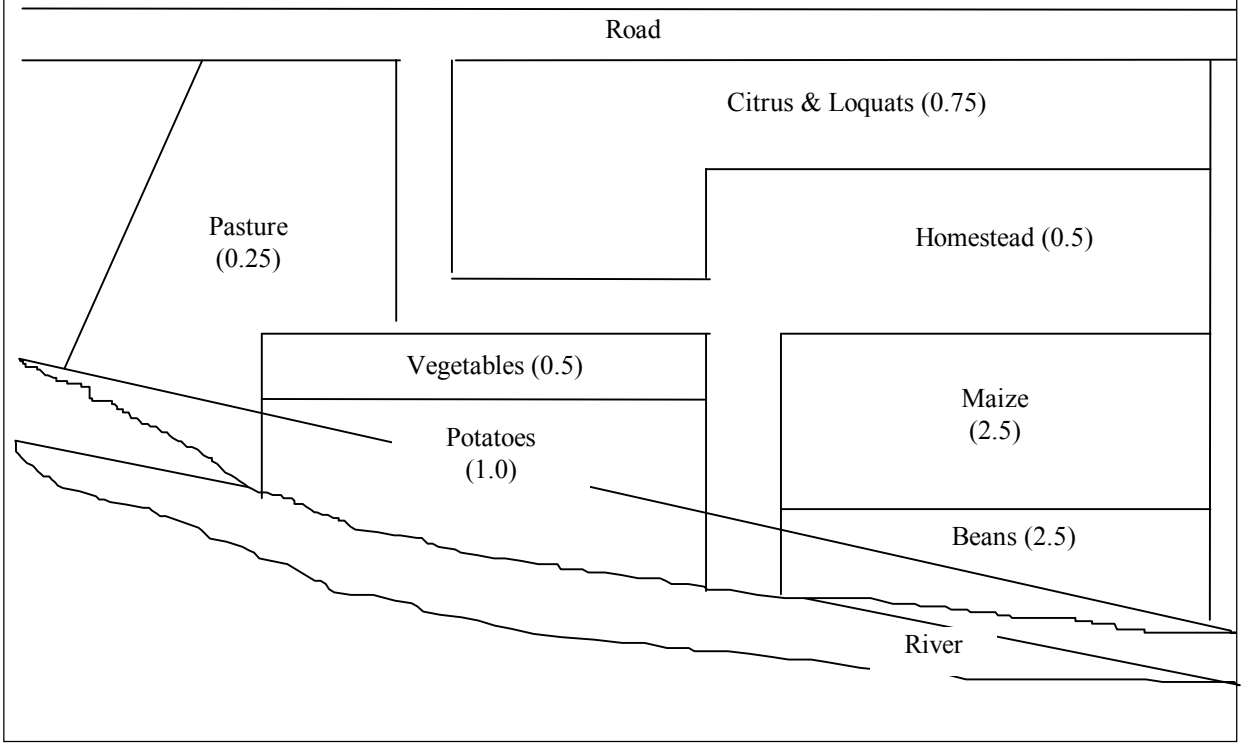


Figure 4: Farm map of a fruit tree farmer from Chepseon location, Kipkelion Division of Kericho

3.2.4. Additional farm data gathering

Now that we know the farmer's ideas for further developments, we can identify the additional information needed. This will regard the marketing of the new products and the sources of investment capital (do they get cash gifts from relatives abroad, do they have off-farm income, can they get a credit from local sources like rural bank or neighbors etc.).

Having obtained all the necessary information, we will express our gratefulness about the farmer's participation. An appointment will be set for the next day, if some additional information is needed. Another appointment will be fixed for at most one month from now to discuss the proposed farm plan. If possible, we should invite the farmer **to attend a meeting** with a **farmers' group,** where we will discuss farm development options in general.

3.3. Gathering of additional non farm data

After leaving the farm we have to review our information and see whether we need additional data. In most cases, this will be for marketing possibilities of products and purchases of inputs. At the next market place, we can check if needed inputs are available and how much they cost, and if the farm products are traded and what there prices are.

We also have to start to prepare the farm budgets to see if we have all the information we need. Otherwise we have to send one person of our group back to the farmer the next day. (we already made an appointment!) to gather the additional information. Even if we have all our data, we will inform him.

Having all the necessary information, we can start the farming systems analysis. This will be part of the next chapter.

4. Quantitative Methods of Farming Systems Analysis

The farmers who produce fruits face several problems in decision making, which are different to problems related to annual crops like maize. Reasons are e.g. a time frame of more than one year, changes in yield and inputs over time. In this chapter tools are applied which can be used to assist the farmer to solve the decision problem.

Also government agencies are faced with the problem to estimate the value of an orchard, either to calculate the contribution to the overall household income for policy analysis or to decide the payments for indemnification in the case of projects like roads or water dams.

The decision problems can be grouped into three areas:

1. Is an investment into fruit trees profitable?
2. Continue or replant an orchard?
3. How much do fruit trees contribute to household income?

Answering the question the problems of optimal life-span, age-yield relationships, the value of an orchard and the comparison between investments into annual and perennial crops have to be discussed. We will also include aspects of uncertainty.

The different questions will be addressed by using the example of a Kenyan avocado farmer who has to decide whether to continue his existing orchard or to replant it with either avocados or papaya.

Before we start with the example a narrative on discounting will be given as discounting is one of the basic principles in evaluating decisions affecting more than one year.

4.1. Discourse: A Narrative on Discounting

The procedure of discounting is related to the problem of comparing payments that occur at different points in time. For example, what if we have to choose between receiving Ksh 1000 today or receiving Ksh 1000 in one year. Almost all of us would prefer to receive the Ksh 1000 today. Why? One reason is that we are not sure whether we will receive the Ksh 1000 in one year if we give up the Ksh 1000 today. Even if the person or agency who promised the

payment might not pay and even if we can trust them, we may die during the next year. There is almost always risk involved regarding future events, like receiving KSH 1000 in one year.

The second point is, that if we receive the KSH 1000 today, we can invest them or at least put them in a savings account and receive more than KSH 1000 in one year. This are the opportunity costs for waiting.

Discounting is a procedure that allows to compare payments that occur at different points in time. This can be illustrated by the following example. Suppose, a friend borrowed money from you last year. Your arrangement was that he will pay back Ksh 1000 after two years, which is one year from now. You both meet and he asks you how much you would like to receive if he pays his debt today. The problem for you is to decide how much money today has the same value as Ksh 1000 in one year. Most people will demand an amount that is less than Ksh 1000. We will suppose that you decided to accept the offer of your friend to pay you Ksh 950 now. In other words, you are indifferent between Ksh 950 today or Ksh 1000 in one year. In your opinion, the discounted value of Ksh 1000 one year from now is Ksh 950 today. What is the discount rate that you used?

To calculate the discount rate, we have to equalise Ksh 950 with Ksh 1000. We will do that by multiplying Ksh 950 with a factor q. The mathematical equation is:

Ksh 950 * q = Ksh 1000

If we solve for q, we get:

q = Ksh 1000/Ksh 950 = 1.053

If we calculate q-1, we get 0.053. This is called the discount rate in a decimal value, which is equivalent to a discount rate of 5.3%. In our example, your personal discount rate was 5.3%. We can use the discount rate to decide what kind of payments we should prefer. Suppose that we have to decide between receiving Ksh 5786 today or Ksh 6336 next year and our discount rate is 5.3%. What should we prefer? We can solve this problem by calculating the present value of Ksh 6336 and comparing it with the Ksh 5786. If the present value of Ksh 6336 is higher than Ksh 5786, we should prefer the payment in one year. We get the present value of Ksh 6336 by dividing it by q (q=1.053):

Ksh 6336 / 1.053 = 6017.094

The present value of Ksh 6336 is more than Ksh 6017 and that is higher than Ksh 5786. Therefore, we should prefer the payment of Ksh 6336 in one year.

We can also apply this method to a multi-period analysis. Suppose the government offers us a savings scheme. We should deposit Ksh 5000 today and then we will receive Ksh 2650 next year and Ksh 2700 in two years. Should we do that?

We will assume that we will get 5.3% interest per year from a savings account. This will increase our capital to Ksh 5544 after two years considering compound interest. The mathematics are:

Ksh 5000 * 1.053 = Ksh 5265 (after one year)

Ksh 5265 * 1.053 = Ksh 5544 (after two years, 5265 were reinvested)

This is equivalent to: Ksh 5000 * $(1.053)^2$ = Ksh 5544

On the other hand, if we use the savings scheme of the government, we will have Ksh 5490 after two years. We can deposit the first payment of Ksh 2650 in our savings account with 5.3% interest for one year. At the end of the second year we will receive our second payment of Ksh 2700 plus the deposit on the savings account. The mathematics are:

2650 (paid back after one year and then deposited on the savings account)

Ksh 2650 * 1.053 + Ksh 2700 = Ksh 5490 (after two years)

In this case it would be better to deposit our money at 5.3% per year in a savings account than using the payment scheme of the government.

In general, to calculate the increase of an amount of money K_0 received today over a number of years *n* can be calculated by the following equation 1.

Equation 1: Calculation of terminal value

$K_n = K_0 * q^n$; where, K_0: capital in year 0,

K_n: capital after n years,

q: 1 + i (interest rate),

n: number of years.

To calculate the unknown original amount of money that led to a known amount of money after n years. Equation 1 can be transformed as shown below in equation 2.

Equation 2: Calculation of present value

$$K_0 = K_n * q^{-n} \qquad \text{or} \qquad K_0 = K_n / q^n$$

Equation 2 can be reformulated to calculate the interest rate *i* and the number of years *n*.

Equation 3 and 4: Calculation of interest rate and number of years.

$$K_0 = K_n / q^n$$

$$\Rightarrow \quad q^n = K_n / K_0$$

$$\Rightarrow \quad q = \sqrt[n]{K_n/K_0} \qquad n * \ln q = \ln (K_n / K_0)$$

$$\Rightarrow \quad i = \sqrt[n]{K_n/K_0} - 1 \qquad n = \ln (K_n / K_0)/\ln q$$

It is also possible to calculate the annuity out of a present value. Let us assume we were employed by the government and joined the government insurance system. Now we are at the point of retirement and get the payment of the insurance system. The government offers us two payment schemes:

A) We get Ksh 50000 immediately.

B) We get Ksh 6000 per year for the next 10 years, paid out at the end of the year.

Which payment scheme should we choose?

Payment scheme B offers the sum of Ksh 60000, what is Ksh 10000 more than under A but spread over 10 years. On the other hand, we can deposit the Ksh 50000 on our savings account for 10% interest per year; and withdraw every year an equal amount while the remaining deposit earns interest. How can we make a decision?

We have to decide, if the present value of Ksh 6000 received every year over 10 years is higher than Ksh 50000 or what is the average annual payment we can get if we deposit Ksh 50000 for 10 years on a bank account?

We know that it will be more than Ksh 5000 per year as we earn interest. But, is it more than Ksh 6000?

To solve this problem, we can make use of the capital recovery factor (CRF). The CRF converts a constant stream of income into its present value, if the interest rate and the number of years are known. The formula is displayed in equation 5.

Equation 5: Present value of an annuity.

$$a = K_0 * CRF_{i,n}$$

$$K_0 = a / CRF_{i,n}$$

with: a = annuity

CRF = capital recovery factor

$$= \frac{(q-1)q^n}{q^n - 1}$$

If we apply equation 5 to our example, we first have to calculate the CRF for 10% interest rate and a 10 years time frame. The $CRF_{10;10}$ is 0.1627454. If we use this CRF, we get the following result:

A) Ksh **50000** or Ksh 50000 * 0.1627454 = Ksh **8137**.

B) Ksh 6000 / 0.1627454 = Ksh **36867** or Ksh **6000**.

The present value of an annual payment of Ksh 6000, paid over 10 years assuming a discount rate of 10% is almost 36867. This is less than the Ksh 50000 under alternative A. Therefore, we should decide to choose alternative A. If we do so, we can get an annual payment of almost Ksh 8137 for the next ten years, if the interest rate is 10%.

The principal of discounting can be applied to the multi period-analysis of fruit trees. The net-return per year is equivalent to the received payments in our savings-example. If the sum of all payments per year is positive, then the returns are higher than the costs and we earn money with the fruit trees. Because the payments occur at different point of time they have to be discounted. The annuity of the NPV can be compared with the gross margin of annual crops.

End of discourse.

4.2. Multi-Period-Analysis of Fruit Trees

As said before, the decision problems regarding fruit trees can be ordered into three main groups. In this subchapter we analyse the first group of problems. As data source a case study from Embu area will be used (Wesseler et al.).

The problem we like to solve is if an investment into fruit trees is profitable. Therefore, we have to estimate the returns and costs of an orchard over the life-span, calculate the annual cash-flow, discount and summarise it to get the NPV. If the NPV is positive, an investment into the fruit trees is profitable.

Table 2 shows the example of an investment into avocado trees. The calculation was made for 15 years. As we can see the costs for the avocado enterprise increase during the first years and reach their peak in year eight. From year eight on the total costs decrease. The avocado trees start to bear marketable fruits in year four. The yield increases until year 8. From year eight on the yield decreases as disease problems increase.

In this case the decline in yields was due to the increase in with phytophtora affected trees. This also caused the decline in costs, as the maintenance costs as well as the marketing costs decrease with less productive trees and yield.

The gross annual flow during the first four years is negative. The initial investment was almost Ksh 300,000. Year 5 is the first year where the income from the trees are higher than the costs during the year. The cumulative present value increases continuously and becomes positive in year seven, which is equivalent to the pay-back period. This indicates that an investment into avocado trees will be profitable as from year seven on the NPV is positive.

To compare the investment in avocados with an annual crop, we have to calculate the annuity. The annuity can be compared with the gross margin of the annual crops. As we can see from table 2, the annuity changes with the life-span of the orchard, e.g. the annuity in year 11 is higher than in year 10 but less than in year 15.

Which annuity shall we use for comparison with the annual crop? Obviously, the annuity of the life-span that gives the highest income to the farmer. The life-span with the maximum annuity is the optimal life-span, as the farmer can not increase his income by using the existing orchard by one or more years. For the calculation of the annuity, the costs of replanting and the salvage values of the equipment have to be included. In this example, fixed equipment are assumed to be overhead costs and the costs for replanting are included under the items *land preparation* and *hole digging and planting*.

In this example the farmer reaches his average maximum income after 13 years. The average income is almost Ksh 191000. He would be better of by replanting his existing orchard after 13 years with new avocado trees than using his trees for one more year. However, we have to note that the differences between a life-span of 12, 13 or 14 years is quite small.

Table 2: Investment analysis of 15 acres of avocado trees (750 trees)

Item	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Variable costs																
Land preparation	112500															
Hole digging and planting	15000															
Seedlings	52500															
Manure and fertilizer	58200															
Chemicals	40500															
Tools and Equipment	11480															
Spraying costs																
Weeding		28800	28800	28800	28800	25000	24300	20000	19000	21000	19200	10000	5000	5000	5000	5000
Pruning						500	700	1000	1500	1900	2880	1500	1300	1100	900	700
Fuel and oil				500	1500	3000	3700	4500	5000	6300	5940	2500				
Harvesting					2400	15000	45000	75000	97500	60000	45000	30000	15000	13000	11000	9000
Transportation on inputs	8000			300	1200	3500	4600	5000	5700	7500	6000	4000	2500	2400	2300	2200
Transportation of outputs					18000	25000	70000	83000	90000	80000	75000	60000	45000	40000	35000	30000
Market cess					1200	3000	6000	7500	8000	7000	6000	4000	2000	2000	2000	2000
Spraying equipment and maintenance					500	9300	11000	12500	14500	19000	15000	14000	10000	8000	6000	4000
Labour (watering)		124800														
Fertilization and manuring	3750		160		3200		3200		3200		3200					
Topdressing and applicat. (CAN)			3080		5160		36000		15000		36000		36000		36000	
Total costs	301930	153600	32040	29600	61960	84300	204500	208500	259400	202700	214220	126000	116800	71500	98200	52900
Gross output in ksh					30000	187500	562500	937500	1218750	750000	562500	468750	421875	300000	200000	100000
GAF	-301930	-153600	-32040	-29600	-31960	103200	358000	729000	959350	547300	348280	342750	305075	228500	101800	47100
Present Value	-301930	-142222	-27469	-23497	-23492	70236	225601	425364	518307	273786	161321	147000	121149	84019	34659	14848
Cum.PV	-301930	-444152	-471621	-495119	-518610	-448374	-222773	202591	720898	994684	1156005	1303005	1424154	1508173	1542832	1557680
Net Present Value	1508173															
Annuity		-479684	-264471	-192123	-156579	-112298	-48189	38912	125447	159229	172279	182520	188978	190817	187141	181983
Annuity per acre		-31979	-17631	-12808	-10439	-7487	-3213	2594	8363	10615	11485	12168	12599	12721	12476	12132
Annuity per tree		-640	-353	-256	-209	-150	-64	52	167	212	230	243	252	254	250	243
Interest Rate	0.08															
Life Span	13															
IRR	30%															

As said before, the positive NPV indicates that an investment into the fruit trees will be profitable. This results holds only for the assumed prices, yields, etc. An important information to the farmer is what happens if prices drops and costs increase.

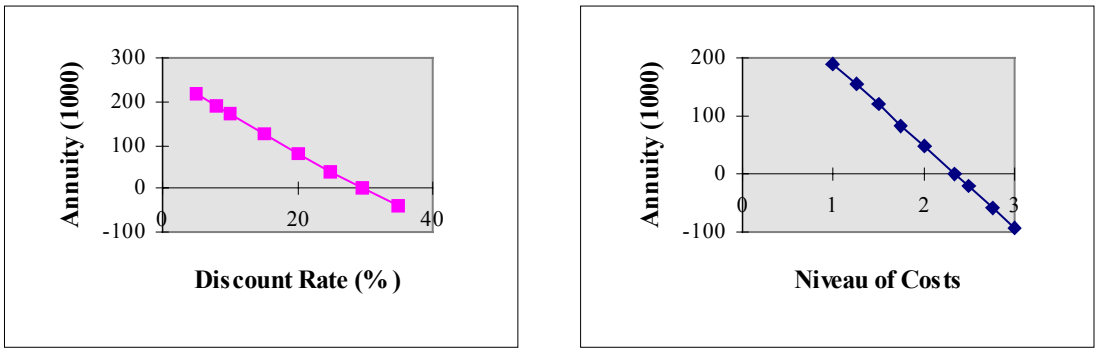
In the following we will answer this question by conducting a sensitivity analysis. We will decrease the price for avocados and observe what happens to the NPV. Of course, we can already say that the NPV will decrease. Important to know is by how much prices can drop and the investment is still profitable. Meaning to say, what is the minimum price the farmer should get for his avocado fruits. This minimum price is also called the switching value of the fruit price.

Practically we can do this by calculating the NPV for different prices. This is an easy exercise, with the use of a spreadsheet programme like Excel or Lotus-1,2,3. Table 3 shows the NPV and the annuity for different price niveaus of avocado fruits. The results show that under the current situation the price can drop by almost 53% until the NPV or annuity becomes negative.

Table 3: NPV and annuity for different price niveaus

Price niveau	NPV	Annuity
1.000	1508173	190817
0.900	1225751	155084
0.800	943330	119352
0.700	660908	83619
0.600	378486	47887
0.500	96064	12154
0.466	0	0
0.400	-186358	-23578

The same analysis can be done for other variables like discount rate and labour or total costs. The result is shown in figure 5.



a **b**

Figure 5: The Impact of Discount Rate (a) and Costs on Annuity (b)

4.3. The replacement decision.

So far, we are able to calculate the NPV and the annuity of an investment into fruit trees considering the optimal life-span. This allows us to decide if an investment into fruit trees is profitable and to compare the result with an investment into annual crops or other fruit trees.

We assumed that the farmer has an area available and wants to decide what kind of crop to grow. In reality, the situation is more like that farmers own an orchard and have to decide whether to continue with the existing crop or to replant it with the same or a different crop.

For our next exercise we will assume that the avocado farmer has an 12 year old orchard. He likes to know if it is better to continue for one more year or to replant the orchard with pawpaw or a new stand of avocados. All in all the farmer has three options:

- to continue for one more year and than to decide again;
- to replant today with pawpaw;
- to replant today with avocados.

If the farmer wants to maximise his profit, he should choose the option which promises the highest returns. To get this information, he has simply to compare the annuity of pawpaw, avocados and the expected income from the existing orchard for the next year.

We will at first calculate the expected income from the existing 12 year old orchard for the next year. We use the information from our example of chapter 4.2 as the basis for the calculation. The results of the calculation are demonstrated in table 4.

Table 4: Expected income from 12 years old avocados (15 acre) for the coming year.*

Item	1
Variable cost	
Weeding	5000
Pruning	1100
Harvesting	13000
Transportation of inputs	2400
Transportation of outputs	40000
Market cess	2000
Spraying equipment and maintenance	8000
Topdressing and application (CAN)	0
Total costs	71500
Gross output in ksh	300000
GAF	228500
Present Value	211574
Interest Rate	0.08

* Numbers used are from table 2.

It can be seen that the expected income is almost Ksh 212000. To this amount the expected income of a new stand of avocados and pawpaw respectively delayed by one year and discounted to the present value have to be added and compared with the immediate investment into replanting.

For the calculation of the new stand we have to assume an infinite investment chain.[II] The present value of an infinite investment chain can be calculated out of the

[II]This can easily be explained, when we consider that pawpaws have a lifespan of 4 years, whereas Avocadoes have one of about 13 years. When avocadoes are 13 years old, we could have replanted pawpaws thrice and have a one year old pawpaw stand and so forth.

annuity.[III] The results of the calculation for the three options of the farmer are presented in table 5.

[III]The annuity can be interpreted as an average income until infinity out of an infnite investment chain. The present value of an infinite annuity is: $NPV = a/i$. The prove can be found in standard books of investment theory (e.g. Weston and Brigham, 1981)

Table 5: Expected present income for different alternatives of replanting.

Option 1: Continuing for one more year and replanting with avocados:		
Expected income from current accedes:		211574
Expected income from new avocados one year from now:		
annuity of avocados:	190817	
NPV of infinite annuity:	2385213	
discounted NPV of infinite annuity:		2208530
Total expected income (in present value)		**2420104**
Option 2: Continuing for one more year and replanting with pawpaws:		
Expected income from current accedes:		211574
Expected income from new avocados one year from now:		
annuity of avocados:	319821	
NPV of infinite annuity:	3997769	
discounted NPV of infinite annuity:		3701638
Total expected income (in present value)		**3913212**
Option 3: Replanting immediately with new avocados:		
Expected income from new avocados:		**2385213**
Option 4: Replanting immediately with new pawpaws:		
Expected income from new pawpaws:		**3997769**

The results from table 5 show that option 4 promises the highest returns. The expected present income from an immediate replanting with pawpaws of almost Ksh 4,000,000 is higher than the returns of almost Ksh 3,900,000 from postponing the decision by one year. It is worthwhile to note that a replanting with avocados should be delayed as

the returns of a delay with almost Ksh 2,420,000 are higher than the returns of almost Ksh 2,390,000of an immediate replanting.[IV]

After the calculation, we would discuss this result with the farmer. We should be careful in recommending to switch from avocados to pawpaw. For the analysis we assumed that there are no additional costs for the farmer to switch from avocados to pawpaw immediately. In reality the farmer has already established marketing channels for the avocados but not for pawpaw. Therefore, we can not expect that the farmer will realise the assumed gross return for pawpaw. During the discussion with the farmer at the workshop, he decided to continue with the avocados. He valued the marketing risk for pawpaw higher than the calculated additional gains compared to avocado.[V]

4.4. Calculating the annual income from fruit trees.

For the impact analysis of projects, for agriculture policy, etc. it is important to know the contribution of different farm enterprises to the overall household income. Normally, this will be calculated on a yearly basis. With fruit trees we face the problem to calculate the contribution to the annual income. Besides the costs and returns during the respective year the depreciation of equipment used for the fruit trees and the change in value of the orchard have to be included.

Again, we will use the example of our avocado farmer and calculate the income he made in one year from his fruits as the trees were 12 years old. Therefore, we can use the results from table 4 for the income calculation. As there are no depreciation costs for equipment[VI], only the change in value of the orchard has to be added.

In general, we would use the market price for a 11 years and 12 years old orchard, calculate the difference and use the result as an estimation for the change in value. In reality, we hardly find a market for orchards of avocados at different age levels. Hence,

[IV] Of course, we expecxted that result. We know from our previous analysis that the optimal life-span of an orchard is almost 13 years.

[V] If the annual returns from pawpaw drop by 10% only, option 1 becomes the one with the highest expected income.

we have to calculate the value of orchards at different age levels. To do so, we have to ask ourselves, what is the value of a 11 year old and 12 year old orchard?

Obviously, this is the expected income for the coming years in present value. The expected income can be calculated by using the numbers of table 3 and 4. For the calculation we have, as before, to consider the optimal life-span and an infinite investment chain. Table 6 demonstrates the calculation. The value of the 11 year old orchard is the sum of the expected income during year 12, year 13 and the NPV of an infinite investment chain into avocados from the end of year 13 on, all discounted. The value of the 12 year old orchard is the expected income from year 13 plus the NPV of the infinite investment chain, also discounted The difference out of the two calculated numbers is the change in value of the orchard. Table 6 shows this is almost Ksh 103000. As the number is negative the value of the orchard decreased by that amount.

Table 6: Value change of the avocado orchard

Value of a 11 years old orchard:		
GAF in year 12 (end of the year):	305075	282477
GAF in year 13 (end of the year):	228500	195902
NPV of infinite investment chain:	2385213	2044936
Total:		**2523315**
Value of a 12 years old orchard:		
GAF in year 13 (end of the year):	228500	211574
NPV of infinite investment chain:	2385213	2208531
Total:		**2420105**
Change in value:		**- 103210**

[VI] In this example it is assumed that there is no equipment used **only** for the avocado trees that lasts more than one year. Meaning to say, that the other equipment, like vehicles has to be included under overhead costs.

Using the calculations made, it can be concluded that the overall contribution to the household income from the avocados was Ksh 305075 - Ksh 103210 = Ksh 201865, the annual income of year 12 plus the change in value. The income in cash was Ksh 305075, whereas the income in kind was - Ksh 103210.

5. Summary

The handbook explains the rationale of a participatory approach to analyse tree based farming systems. But, the aim is not stop there but to demonstrate an approach that can easily be applied in the field. The approach consists of two main parts: the farm walk and drawing of the farm map. They are elaborated in detail in chapter three.

The approach also recognises that collecting of information and analysing of information has to go hand in hand. Therefore, chapter 4 demonstrates economic tools to analyse tree based farming systems. As there is an amount of literature available, that discusses the analysis of annual crops in the farming systems context, the tools are related to perennial crops. The on-farm decision problems are discussed and ways to solve them shown. To demonstrate the usefulness of the tools actual farm data of an avocado farmer from Embu have been used.

All in all, this handbook can be seen as a useful guide to those who are involved in farm planning. Especially those, who are interested in the role of tree crops in Kenyan farming systems.

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Table A1: Investment Analysis of 15 acres Paw Paw (9900 trees)

Item	0	1	2	3	4	5
Land preparation	112500					
Layout of holes	7200					
Digging holes	79200					
Manure costs	475200			237600	237600	
Manure application	26400			13200	13200	
Fertilizer cost and transport	59340					
Fertilizer application	640					
Seedlings cost and transport	99000					
Planting	39600					
Weeding		28800	28800	28800	28800	14400
CAN top dress			16500	24750	24750	
Spraying, chemicals			28500	28500	28500	
Spraying, labour			14400	14400	28500	
Harvesting and handling			267300	554400	792000	633600
Transport of output						
Irrigating costs, 4 perm.labourers		120000	120000	120000	120000	120000
2 knappsack-sprayers	20000					
Total Costs	919080	148800	475500	1021650	1273350	768000
Output			801900	1663200	2326000	1900800
Gross Annual Flow (GAF)	-919080	-148800	326400	641550	1052650	1132800
Present Value	-919080	-137778	279835.4	509283.1	773729.2	770964.6
Cum.PV	-919080	-1056858	-777022	-267739	505989.9	1276955
Annuity	319821					

Annuity per acre	21321
Interest Rate	0.08