Case studies on the application of Drip Irrigation in Horticultural Crops Production in Ukambani, Kenya

Luvanda A. M\textsuperscript{1} and E. A. Indai\textsuperscript{2*}

\textsuperscript{1}Kenya Forestry Research Institute, Dryland Eco Region Research Programme, P.O. Box 892-90200, KITUI-KENYA

\textsuperscript{2}South Eastern Kenya University, P.O. Box 170-90200, KITUI-KENYA.

\*Corresponding Author

ABSTRACT

Case studies targeted 2 groups and 8 individual farmers involved in the production of horticultural crops for enhanced income and environmental conservation. The horticultural crops produced included: tomatoes, onions, kales, baby corn, french beans, eggplant, hot/sweet pepper, cabbage, squash and spinach. The study was conducted among selected farmers between 2003 and 2006 in four phases in a period of one year. The objectives of the study were to assess the farmers’ income, employment opportunities, marketing system and profitability of horticultural crops. Pre-tested questionnaire, data sheets and observations were used in capturing data. Collected data was analysed using excel and Statistical Package for Social Sciences (SPSS). The direct benefit to farmers were a monthly income of Ksh.4,750, consistent food supply, employment and farming skills improvement. The project was implemented on cost sharing basis ensuring the programme’s future sustainability. The major challenges included inadequate technical support, poor farming skills, inadequate skills in soil and water conservation, pests and diseases attack, marketing of farm produce and the economic viability of the various enterprise/crops. The output can be enhanced through awareness creation and education, adoption of group approach to marketing, timely provision of high quality inputs and improvement in the credit facility to farmers.

Key: Socio-economics, horticulture, drip irrigation, employment and income.

I. INTRODUCTION

Kenya’s agricultural development has continued to rely heavily on rain fed agriculture. Rainfall distribution in semi-arid areas ranges between 400 to 900 mm per annum (Moresmau and Hanne, 2004). Furthermore the rainfall is inadequate, erratic and unreliable forcing the country to continue experiencing food deficits resulting into critical importation of agricultural commodities like maize and yet demand for water for different sectors has been growing continuously (Saleth, 1996; Vaidyanathan, 1999). Research shows that there is a large potential for poverty reduction through increased and improved irrigation in small-scale agriculture (e.g. Postel et al., 2001). Drip irrigation is a water conserving technology that is aimed at reducing water wastage. The system delivers water through small holes made on pipes. The system uses ensures frequent supply of water to the plant (Dasberg and Or, 1999). According to Sijali (2001), the system has many advantages which include:

a. High crop yields. High yields are realised as a result of regular water supply to the plant
b. Water conservation and efficient water usage. Since the system delivers water to the roots of the plant, it ensures that water is conserved thus ensuring that there is no wastage.
c. Low chemical and fertilizer application costs. Since the chemicals and fertilizers are applied together with the water, it saves on labour and costs.

Drip irrigation can result to increased income among poor farmers apart from improving food supply to householders who are poor (IDE, 2004). Drip irrigation frees farmers from dependence on rain fed agriculture. In Zimbabwe drip irrigation production increased by 300% over rain-fed agriculture (Chitsiko and Mudima, 2002). Irrigation is therefore critical to the development of agriculture in Kenya. Drip irrigation is thus one of the methods that has an advantage of applying water where it is needed (Asher and Phene, 1993). Drip lines allow an irrigation system to water the root zone that lies directly under the grown crops, efficiently watering each crop thus minimizing water wastage (Naika et al., 2005). The horticulture industry is currently the third most important foreign exchange earner after tea and tourism. Small holder production constitutes 80% of all the produce. Approximately 60% of the horticultural crops are exported. In the year 2000, the production of horticultural crops stood at 3.1 million tonnes, which was valued at Ksh. 45.8 billion (RoK, 2000). According to De Lange (1994), small scale drip irrigation can be dived into:

a. Independent farmers: These farmers grow their crops on land that does not belong to any scheme.
b. Scheme farmers: Grow and irrigate crops on a scheme where the farmers share the same water source.
c. Vegetable garden: Usually found in small gardens and small parcels of land and share the same water source.
d. Backyard farmers: this system is almost the same as vegetable garden only that farmers are not grouped together.

The Integrated Natural Resources Management in Ukambani (INRMU) project started its operation in January 2002 as a follow up to a three-year pilot phase on District Forestry Development Programme (DFDP). The project aimed at increasing the income of the Ukambani population based on the understanding that poverty alleviation contributes to the well-being of the people. The project contributed to the goal of environmental conservation using the supper efficient drip-irrigation and a soil conditioner that absorbs water and releases it slowly to the soil around the roots of planted crops.

Research has show that an increase in leaching for drip irrigation results to an increase in crop yield in vegetables (Hoffman et al. 1979; Hoffman and Jobes, 1983; Jobes, Hoffman and Wood 1981). Other researcher found similar findings for drip irrigated processing tomatoes in San Joaquin Valley (Hanson and May, 2004; Hanson, Hutmacher and May 2006). Drip irrigation is an appropriate irrigation technology which significantly reduces the drudgery of lifting water faced by smallholders and can address water management problems (Kay, 2001), it fills an important technology gap for the rural poor by offering a low-cost entry into irrigated agriculture. The farmers adopting drip irrigation had ventured into horticultural production as a means of realising the poverty alleviation goal. Research shows that water use efficiency increases up to 100% in a properly designed and managed drip irrigation system in India (INCID, 1994; Sivanappan, 1994). The target crops were: tomatoes, onions, kale, baby corn, french beans, eggplant, sweet pepper, cabbage, squash and spinach. Community Action Plans (CAP) was drawn between the project and farmers to operationalise the project activities.

Farmers reaped both social and economic benefits accruing from this project. The direct benefits to farmers include the quantities of produce that are marketed and consumed. The farmers involved in these activities benefited through training and cost sharing programme on inputs. It was anticipated that the farmers would be self-dependant once the project came to an end. The major challenges were inadequate of technical advice to farmers, quality and safety, farmers’ capacity, soil fertility management, un-availability and high prices of farm inputs, poor agricultural practices, absence of rural
micro-credit providers leading to low incomes and high levels of un-employment, water management, and application of pesticides, market for farm produce and economic viability of the various enterprise/crops.

**HYPOTHESIS**

1. Benefit-cost ratio is greater than one;
2. Employment is created through the horticultural crop production;
3. Neighbouring farmers adopt introduced practices.
4. Each farmer individually markets his horticultural produce;
5. 

**OBJECTIVES**

1. To determine the farmers income from the horticultural crop production.
2. To assess the employment opportunities and other impacts created by the horticultural crops production.
3. To assess the marketing system and asses the profitability of horticultural crops.

**II. RESEARCH METHODS**

This study was carried out in Ukambani Counties of Machakos, Makueni and Kitui. These counties are part of the thirteen counties that constituted former Eastern province. In 2002, these counties registered a population of 954,084, 839,155 and 550,678 respectively. The youth formed a big proportion of the population of 56.3%, 47% and 59.4% of the total population respectively. Poverty was rampant among the local community and was estimated at 66.2%, 58.59% and 66% in Machakos, Makueni and Kitui respectively. Agriculture was the main source of income in the three counties contributing over 70% 60% and 75% for Machakos Makueni and Kitui respectively (RoK, 2002a; RoK, 2002c).

There were a total of 17 groups and 29 individuals involved in the horticultural production in the whole of Ukambani. Case, involving a randomly selected sample of 2 groups and 8 individual farmers involved in horticultural crop production, was conducted. Four phases of interviews with the same farmer were carried out in a period of one year. The sampled farmers were distributed as follows: 2 farmers in Kitui (Martha Willy and Muema Kiilu), 5 farmers in Machakos (Simon Mutuku, Benson Kaindi, Kithito/Kibauni group, Petronila Ndanu and Shadrack Wambua) and 3 farmers in Makueni (Kwata Vinya group, Christopher Muiya and Willy Mwololo Tithu). Structured questionnaires and data sheets on yield and sales were pre-tested and adopted for this study. The data sheets were used to generate the quantitative data on yields and sales. Observations were made to supplement the above data sources. Collected data was analysed using Ms excel and Statistical Package for Social Sciences (SPSS).

**III. RESULTS AND DISCUSSIONS**

**Socio-economic characteristics of horticulture producing farmers**

**Land ownership and use**

Land holding was estimated at four acres per household. It was divided into homestead (0.2 acres), cropland (2.0 acres) and horticultural land (0.3 acres), grazing land (0.5 acres), woodland (2.0 acres) and the fruit orchard (negligible). The soils were characteristically sandy and loamy. An acre of land was selling at approximately Ksh. 50,000 on the market or lease value of Ksh. 2,000 per season. The land was generally flat as reported by (20%) of the respondents or gentle sloping as reported by (80 %)of the respondents.

Each household had four housing structures on the compound with at least three of them being iron roofed with a brick wall. One house was grass roofed with either mud or timber wall. Half of the
farmers’ houses had a concrete floor. Each household was composed of eight members of equal gender. On the average, one member was on salaried employment and never resided on the farm. Four members were above twenty years of age with the potential to provide labour for on-farm development activities. Two groups with an average membership of ten were studied. None of the members were on salaried employment.

Farming
Traditionally, farming in Ukambani depends on rain fed agricultural system. Due to the prevailing weather conditions, not all crops perform well. The major crops grown in this area included vegetables, cereals and fruits. Experience showed that farmers had comparative advantage in the growing of these drought resistant crops such as maize, beans, green grams, cowpeas, kales, mangoes and oranges. Information on crops and estimated yields is contained in table 1. The vegetables, which consisted mainly of kale, provided the potential highest potential -income at the household level.

<table>
<thead>
<tr>
<th>Crop</th>
<th>Yield/acre – bags</th>
<th>Unit price/kg – Ksh</th>
<th>Value – Ksh</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vegetables</td>
<td>300</td>
<td>10</td>
<td>150,000</td>
</tr>
<tr>
<td>Oranges</td>
<td>10</td>
<td>10</td>
<td>9,000</td>
</tr>
<tr>
<td>Mangoes</td>
<td>10</td>
<td>5</td>
<td>5,000</td>
</tr>
<tr>
<td>Maize</td>
<td>10</td>
<td>5</td>
<td>4,500</td>
</tr>
<tr>
<td>Beans</td>
<td>2.75</td>
<td>12.5</td>
<td>3,100</td>
</tr>
<tr>
<td>Ground nuts</td>
<td>2</td>
<td>11.25</td>
<td>2,025</td>
</tr>
</tbody>
</table>

Production of horticultural crops
Most of the farmers had been in the horticultural crop production for a period of one and half years. The motive of the farmers joining the project was to generate income. A few farmers (20%) were also producing for subsistence purposes. The drip irrigation is intensive in terms of human resource, material inputs and machinery. The operations involved in the drip irrigation include terracing, initial land preparation and/or cleaning, levelling, trenching, fertiliser/manure application and planting, weeding (three times per crop per season), watering and pesticides application, top dressing, harvesting, grading and final marketing. Four types of labour were identified and included family labour, hired labour (depended on the amount and nature of work being done), permanent casual (worked throughout the season) and group labour. The project ensured that farmers were well facilitated. The project was implemented on a cost sharing arrangements. Where the farmer made an initial payment to the project before any activity could be undertaken on his/her farm.

The priority horticultural crops were tomato (90%), kales (90%), baby corn (70%), onions (60%), french beans (50%), cabbage (20%), spinach (20%), water melon (10%), squash (10%) and eggplant (10%). The seeds for these crops were found on the markets under different brand names depending on the company producing them. The challenge facing the farmers was the capacity to raise enough quantity of produce to guarantee market supply and income. The drip irrigation farmers were few and scattered making marketing logistical arrangement a big problem. Given that this study was focusing on the benefits, no efforts were made to establish the seed varieties or the manufacturers.

a) Tomato
Tomato had an average rotation age of four months. The nursery phase usually took three weeks, two months in the farm before harvesting begun and a harvest period of one month. Tomato is vulnerable to attack by pests and must be properly managed by providing support and applying pesticides when necessary. The average yield per square metre was estimated at 3 kg and is valued at Ksh. 54

b) Baby corn

Baby corn was characterised by low management costs, no nursery phase and short rotation period. The only disadvantage was lack of local market. The crop had a rotation of two and half month. It takes one and half month on the farm before harvesting begins. Harvesting takes a period of three weeks at most. The highest yield was obtained during the first harvest, which drastically declines thereafter. The timing of harvesting period was very important. The average yield per square metre was estimated at 0.5 kg and was valued at Ksh. 10. The yields were on the lower side as the data was attributed to a few farmers.

c) Onions

Onions have been planted by farmers for a long time and have few pests and disease problems. The onions have a rotational period of five months though harvesting can be done at any time after the fourth month. Onions have a nursery phase of one month to one and half months. The average yield per square metre was estimated at 1 kg and was valued at Ksh. 20.

d) Cabbage

Cabbage was among the least planted horticultural crop despite the presence of local and urban centre market. Cabbages have a nursery phase of three weeks with further two-months in the farm before
harvesting begins. It could stay in the farm up to four months. The average yield per square metre was estimated at 3 kg and was valued at Ksh. 20.

e) Kales

Kale seed can be bought on the market in different varieties, produced by different companies. We have short to long lasting varieties. Kale was one of the priority crops, which took three weeks in the nursery; one month before harvesting begin, three months of harvest phase. Kale variety (ies) studied had a rotation of four months. The average yield per square metre was estimated at 1.7 kg and was valued at Ksh. 15.

f) Spinach

Spinach was grown on one farm with a rotation of four months. The nursery phase took three weeks and one and half month in the farm before harvesting commences. Harvesting usually continues for a period of one and half month. The average yield per square metre is estimated at 2 kg and was valued at Ksh. 20.

g) French beans

French beans were one of the main export crops though its consumption was gaining popularity locally. Harvesting usually commenced when the crop was almost one and half month and may continue for a period of one month. The crop was very susceptible to pests attack and the farmer incurred expenditure on agro-chemicals. Ninety per cent of the losses in french beans were attributed to pests and diseases. The average yield per square metre was estimated at 0.7 kg and was valued at Ksh. 10.

h) Eggplant

Eggplant had a rotation age of four months from the time it was sown and was gaining popularity on the local market. The crops took one month in the nursery, two months before harvesting started and another
two months of harvesting phase. The average yield per square metre was estimated at 1.65 kg valued at Ksh. 15.

i) Squash

Squash with a rotation age of four month was least planted though gaining popularity with local people for its sweetness. Squash had no nursery phase; it took one and half month before harvesting begun. It took two and half month for harvesting to be complete. The average yield per square metre was estimated at 0.3 kg and was valued at Ksh. 1.

Technical information and credit

Technical support

The project staff (100%) mainly drawn from the Forest Department (60%), and KEFRI (10%) provided technical advice to farmers. All the farmers acknowledge the support from the project in terms of pests and disease control (100%), crop management (90%), soil and water conservation (80%), use of compost manure (10%), drip lines maintenance (90%), marketing (60%), credit management (100%) and woodlot management (20%). The farmers were visited at least three times in a month. Further to providing technical support, the project staff visited the farmers as a routine (60%), to collect produce (20%), loan repayment (20%) and oversee well construction (10%).

Main issues the farmers wished the project to consider were transportation of produce (90%) and marketing (80%). The crops, which required the assistance of the project in marketing, included baby corn (60%), french beans (60%) and tomato (10%). The farmers also requested the project to pay cash on collection of produce and facilitate timely delivery of inputs.

Credit facility

Credit facility was one aspect that made this project unique from many other projects. The farmers had to make an initial payment (Ksh. 26,000 on the average), which signified his/her commitment and capacity to repay the loan in addition to making the programme sustainable. Among all the farmers studied, they acknowledged receipt of loan amounting to Ksh. 70,000 on the average. At the time of winding up this study, the farmers had repaid up to 39% of the loan on the average.

Marketing of horticultural produce

Twenty per cent of farmers sold packaged produce while thirty per cent of the farmers sold both packaged and unpackaged produce whereas fifty per cent of the farmers sold unpackaged produced. The produce was usually packaged in polythene bags especially for customers who came from far. Packaging increased the sell value of the product and kept it in a hygienic condition. The average farm gate prices for various produce are provided in table 2. The highly priced produce include french beans, onions and sweet pepper. Prices may not be the best indicator for the farmers to select on the crops to produce.
Table 2: Unit prices of various crops in Ksh/kg

<table>
<thead>
<tr>
<th>Produce</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>French beans</td>
<td>30</td>
</tr>
<tr>
<td>Onions</td>
<td>30</td>
</tr>
<tr>
<td>Sweet pepper</td>
<td>30</td>
</tr>
<tr>
<td>Tomato</td>
<td>20</td>
</tr>
<tr>
<td>Squash</td>
<td>20</td>
</tr>
<tr>
<td>Baby corn</td>
<td>20</td>
</tr>
<tr>
<td>Egg plant</td>
<td>10</td>
</tr>
<tr>
<td>Kales</td>
<td>10</td>
</tr>
<tr>
<td>Cabbage</td>
<td>10</td>
</tr>
<tr>
<td>Spinach</td>
<td>10</td>
</tr>
</tbody>
</table>

Price among the various horticultural crops was assessed and French beans showed superior price compared to the other crops throughout the year. French beans and baby corn showed the best price in May and this could be attributed to export market. With the exception of cabbage, all the other crops were fetching good prices in December probably due the various festivities in the month. Figure 1 gives details on the price variation over the year.

![Figure 1: Annual Price variation with a year for various crops](image)

**Market chain**

Four market channels in the order of priority are recognised as producer-consumer, producer-retailer-consumer, producer-middleman-consumer and producer-middleman-retailer-producer (Figure 2).

![Figure 2: Market Chain for horticultural crops](image)
The outlets for the horticultural crops include neighbours (100%), local market centres (80%), INRMU project (60%), growing urban centre (40%) and big towns ((30%) in the order of priority. The farmers either individually or as groups should strive to market their produce where prices are good. Under the current arrangement, the produce is mainly sold at the farm gate. This sale point leaves the farmer vulnerable to exploitation.

Group approach to marketing (80%) was seen as a way of ensuring that horticultural produce got ready markets, reduced costs and maximised profits. Fifty per cent of the farmers were in the process of forming a cluster. Priority crops were baby corn (10%), mangoes (10%), eggplant (10%), tomato (20%) and french beans (10%). These crops were highly perishable and either had no local market or supply overrides demand. This project was being implemented in an environment weak co-operative movement in Ukambani and therefore the need to strengthen the initiative.

Factors influencing output

Results of a regression analysis showed that cropland, horticulture land, number of seminars the farmers had attended, amount of loan repaid, soil type and the period the farmer had been in the production of horticultural crops could explain 78% of the independent variables. None of the independent variables was significant at 90% confidence interval. Full results are contained in Table 3.

<table>
<thead>
<tr>
<th>Model</th>
<th>Sum of Squares</th>
<th>Df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regression</td>
<td>6.280</td>
<td>6</td>
<td>1.047</td>
<td>1.760</td>
<td>0.344</td>
</tr>
<tr>
<td>Residual</td>
<td>1.784</td>
<td>3</td>
<td>0.595</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>8.064</td>
<td>9</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a - Predictors: (Constant), period, repaid1, cland, stype, hland, seminars
b - Dependent Variable: Output1

\[ r = 0.882 \quad r^2 = 0.779 \]

Quality standards

Quality standards (90%) were very important in horticultural crops production. The following factors were considered in the assessment of quality characteristics: size of produce (50%), colour (20%), healthy status (60%) and variety (10%). The crops where standards were considered were kale (10%), tomato (90%) and french beans (20%). High quality standards gave the produce an advantage to compete in the market and fetch good prices. Crops destined for export were expected to meet very high standards and no traces of banned chemicals were supposed to be found in the produce. In an effort to meet the expected standards, the horticultural farmers were in the process of improving their quality measures. The farmers were planning to construct a disposal pit, grading shade, toilet and store.

Social and economic impacts assessment

Direct benefits

Income

The results of a gross margin analysis showed that the drip irrigation farmers earned an average of Ksh 57,000 annually in the range of Ksh. 5,000 to Ksh. 121,000 or Ksh. 4,750 in the range of Ksh. 420 to Ksh. 10,083 per month. We can define the amount earned as the cost of entrepreneurship. The drip irrigation farmers were using proceeds from horticultural crops on paying fees (40%), loan repayment (40%), re-invest (60%), purchasing food (40%), buying clothing (20%), investing in dairy project (20%) and as payment to members as dividends (20%). The priorities vary from individual to individual, area to area and group to group. The benefit-cost ratio was used to assess the project worth. This ratio was calculated when the present worth of the benefit stream was divided by the present worthy of the cost stream. The formula for calculating the benefit-cost ratio is given as:
Benefit-cost ratio (Australian Government, 2007) is given as:

\[
\frac{\sum_{t=1}^{n} B_t}{\sum_{t=1}^{n} C_t} = \frac{1}{BCR}\left(1 + i\right)^t
\]

Where \(B_t\) is the benefit in time \(t\), \(C_t\) is the cost in time \(t\), \(i\) is the interest rate and \(t\) is the period in years.

The results of a benefit-cost analysis show that all the farmers were operating above the benefit-cost ratio of one. This implies that the present worth of the costs are less than the present worth of benefits and farmers are better off continuing with the project. For our case, the average ratio stood at 1.98 ranging from 1.15 to 3. The ratio was computed at 14% interest. The variation in the benefit-cost ratio could be attributed to type of crop, seed source and variety, land preparation technique, tending frequency, level of inputs, pre and damages, pests and diseases and availability of markets.

**Employment**

All the farmers agreed that drip irrigation had created employment opportunities among the local communities. Family labour provided one person on full time bases while five others worked on part-time in the drip irrigation project. An average of three casuals and one security person made earnings from the drip irrigation. On the other hand, casual labourers received Ksh. 100 per day or Ksh 1,200 per month. At least six people found employment in the market chain of the drip irrigation.

**Indirect impacts**

All the farmers agreed that there were indirect benefits associated with drip irrigation project. Eight per cent of the farmers said that local market of the horticultural crops demand had been met. At least two neighbours had adapted the drip irrigation technology not in its totality (60%) and manual irrigation (30%). Other farmers had adopted the mango orchard (30%) and seedlings production (60%) technologies. At least six farmers had made inquiries on the drip irrigation technology. Further, other farmers had adopted the woodlot (60%) technology. Ninety per cent of the farmers said that directly or indirectly they were involved in the farmer to farmer extension where at least six individuals and/or group had been trained on the drip irrigation. On the average the drip irrigation farmers had attended two seminars each. Members of one group had shown interest to start individual drip irrigation projects.

**Other Projects by drip irrigation farmers**

Drip irrigation has been used as an incentive towards the promotion of environment conservation. The horticultural crops producing farmers were involved in other projects such as seedlings production with an average capacity of 3,000 seedlings (90%), woodlot development with an average capacity of 550 trees per household (40%), mango orchard with a capacity of 110 stems (40%) and honey production with a capacity of 14 hives (10%). This is an overwhelming contribution to the environment and the poverty alleviation strategies holding all conditions favourably. One farmer was planning to expand his mango orchard.

**Constraints**

The main prioritised problems affecting the production and marketing of horticultural crops included transport, water supply, input quality and supply, pests and diseases management, poor markets and marketing strategies and crop failure. These constraints are hereby discussed below.

a) **Transport**
Horticultural crops being highly perishable especially with the prevailing weather conditions in Ukambani, timely transportation system must be availed. Currently, INRMU project partially provide transport and marketing services to farmers. The major problem with transport had been delays in the collection of the harvested produce. The crops that were highly affected were baby corn and tomato. Harvested produce especially tomato and french beans normally ended up rotting resulting into financial. This problem was cited by all farmers. It was important for the farmers to get involved in the marketing of their produce and this involved using public transport to get the produce to the market.

b) Water supply
Water was a very important input in drip irrigation project. Frequently, drip irrigation farmers experienced water supply problems. These problems were experienced by 90% of the farmers and included broken down and/or low capacity pump, clogging of irriganes and the rising cost of fuel. Due to prevailing problems, farmers resorted to a number of strategies, which included surface flooding and direct watering. There were other farmers who were sinking shallow wells and had planned to buy kerosene pumps. Farmers also manually cleaned and repaired the irriganes.

c) Input quality and supply
Poor means of communication (road and telephone) significantly contributed to delays in the delivery of inputs to farmers. Some of the inputs that farmers had problems in accessing included baby corn seed, irriganes, nipples, pipes, fertiliser and pesticides. Some of the agro chemical supplied such as hot sol and nitric acid had proved to be ineffective. Furthermore, farmers claimed that some pesticides were usually expensive and no instructions were provided. At times, little supply of pesticides was made. This problem was cited by 90% of the farmers. Timely delivery of high quality inputs such as certified seed may do the farmers a lot of good. Through the cost sharing arrangements, the farmer should purchase their own inputs from any authorised dealers.

d) Pests and Diseases
Horticultural crops were prone to pests and disease attack. In many instances, most diseases were due to excessive dampness such as rust. The pests that gave farmers a difficult time included whitefly, spider mite and caterpillar. Alternatively squirrels and birds contributed to crop losses especially if the area were bushy as cited by 80% of farmers. Some farmers (10%) experienced problems with termites; this problem was contained by destruction of nests and application of Termicides. The farmers who experienced pests and diseases may apply fungicides and/or pesticides on their crops depending on the problems. The project recommended pesticides/fungicides which included hydrogen peroxide ($H_2O_2$), Hot sol, Sulphur, copper, Bt among others. Due to one reason or another, farmers diverted to the use of more environmentally unfriendly agrochemicals such as Dimethane, Karate, Danadin, and Bestox. The above example may not be exhaustive since it’s only a few farmers that were surveyed.

e) Market
Most market problems have been experienced with export crops, which have no market at the local market level. The most affected crops included french beans, baby corn and eggplant. Unstable and/or poor prices coupled with selling of produce at credit significantly affected the profitability of the horticultural crops production as cited by 70% of the farmers. Entry into the local market and promotion of home consumption for produce that was not initially accepted as food was quite a welcome idea. Strategies for the market to accept all grades needed to be pursued by the farmers. Farmers could form clusters to market their produce. Farmers needed to work out strategies to deal with defaulting creditors.
f). Crop failure
Soil related problems and flooding are blamed for crop failure. The affected crops included baby corn, tomato, sweet pepper, kale, french beans and cabbage. This was reported by 70% of the farmers. Soil analysis and construction of terraces could be the only way to deal with the problems of soil and flooding. These actions were necessary so that further remedial action could be taken against confirmation or rejection as the cause of crop failure. Diversification of crops and rotation are some of the strategies the farmer could use to minimise on crop failure. In the event of total crop failure, it was important for the INRMU project to consider rescheduling or waiving loan owed by the affected farmer. The farmer could support the crops such as tomatoes.

Other problems include un-skilled labour (30%), expensive and limited supply of manure (20%) and land disputes (10%). Proper identification of the people who implemented the project must be considered for training. In most cases, the head of household was trained but the wife and children who implemented the project did it in ignorance. For the case of manure, the farmers were to produce their own manure rather than purchasing it at far away distance. Similarly, during the dry season the farmer could stick to the purchased fertilisers such as DAP and CAN. The farmers who were involved in land dispute had move to a different site and are progressing well with project activities. Further skills could be acquired through experience, technical advice, training and hard work.

IV. CONCLUSION AND RECOMMENDATION
Drip irrigation exploratory phase in Ukambani has been very successful. Farmers who implemented the project on full time basis realised an estimated annual income of Ksh 57,000. Further to the income, the local market and subsistence supply of horticultural crops guaranteed in addition to employment opportunities at the family and neighbourhood. The positive results were also justified by the benefit- cost analysis, which gave a ratio of above one by all the farmers involved in the horticultural crop production. Marketing of the horticultural produce faces challenges and there is need for a shift from the individual approach to the group approach. All the changes require time for the farmers to reorganise themselves while others adopt the technology. The other projects farmers are implementing include seedlings production, woodlot development and mango orchards development and honey production. These projects will ensure sustainable environment conservation and enhance income to the farmers. Therefore, it is recommended that drip irrigation can be enhanced through awareness creation, provision of information on access to micro credit, provision of market and marketing information and value addition. The details are herein discussed below:

Awareness creation: Create awareness on the activities and importance of the project to receive a wider public acceptance and recognition beyond the project farmers. This can be achieved through barazas and putting adverts in the electronic and print media. Provide information on selection, packaging and use on the various to keep our environment clean.

Micro credit facility: There is need to establish a revolving fund to take care of farmers who have already cleared repaying their loans and are ready to invest in other activities such as poultry, brick making, dairy cattle, expand drip plots, purchase high quality drip lines, purchase high capacity pumps, invest in water supply and storage among others.

Markets and market information: Markets and market information is necessary so as to ensure that drip irrigation farmers remain competitive. There is need to streamline information channels. Up to date information is necessary especially on which crops to plant at what time. The cluster or group approach in marketing needs to be strengthened among the drip irrigation farmers. Farmers should target the export market by ensuring high quality and standards for the export crops strictly adhered to

Value addition: This a long term strategy where farmers should be sensitised towards value adding processes especially small scale agro-industries which will make use of the horticultural produce such as mango and tomato. This initiative can best be achieved if the farmers worked in groups.
V. ACKNOWLEDGEMENTS

Contribution by the following individuals is highly appreciated: Mr. Jan (INRMU project coordinator, and other project staff: Mr. Waweru Racheal, Naomi and Daniel. The support given by KEFRI staff, Dr. James Kimondo, A. A. Atanas and Mr. Joseph Kalani, is highly appreciated. Lastly, the authors acknowledge the support from KFS staff: Ms. Remmy Manzi, Ms, Sella Kithila, Mr. Kavitsi, Mr. Manoah Oyioka, Mr. Muthuri, Mr. Kung’u and Mr. Makotsi.

BIBLIOGRAPHY

7. Indian National Committee on Irrigation and Drainage (INCID) (1994) Drip Irrigation in India, New Delhi