CZECH UNIVERSITY OF LIFE SCIENCES PRAGUE

Optimization of cooperative jointed herb farmers' production

in Georgia

Master's thesis

Prague 2016

Supervisor: Ing. Jana Mazancova; Ph.D. **Author:** Bc.Welcome Zimuto

Consultant: Ing. Roman Kvasnička, Ph.D.

Assignment

Declarations

I hereby declare that I have written my master thesis on the topic “Optimization of cooperative jointed farmers production in Imereti West ,Georgia” by myself with help of the listed literature references .

In Prague on 22 April 2016

Bc. Welcome Zimuto

Acknowledgements

I would like to express sincere gratitude to my supervisor Ing. Jana Mazancova Ph.D. for her invaluable comments, advice and recommendations on my research .The help she provided me in the past two years has made this thesis a success story.

Special gratitude goes to Ing. Roman Kvasnička, Ph.D. who gave me confidence and challenged me to improve my work in the series of discussions and meetings we had. I also extend gratitude to RNDr. Ing. Tomáš Ratinger, Ph.D. for giving me fruitful insights in the last days of my research work .Best wishes go to my Georgian friends ,Shalva and Shakro who supported me during the field survey. I will never forget the moments we spent together. To my classmates,it was such a great 2 years, full of academic exhuberance and learning experiences.

I would like to also thank my wife and daughter Shalom for giving me moral support during this work. The nights and days we talked over the phone as you encouraged me will go down my memory lane. Last but not least ,I thank the Czech University of Life Sciences, Tropical Agricsciences Faculty for moulding my academic career by imparing knowledge from various fields of learning on me.

Abstract

Agricultural cooperatives play an important role in supporting small agricultural producers and marginalized groups such as young people and women. They empower their members economically and socially and create sustainable rural employment through business models that are resilient to economic and environmental shocks. Agriculture optimization ensures that cooperatives achieve economic and farm household goals as efficiently as possible in the face of competing constraints of physical, environmental, legal or socio-cultural nature. In this study linear programming technique was used to model alternative profit maximization strategies for 2 cooperatives in Imereti while at the same time utilizing their resource capacities. Questionnaires were used to collect the variable data which were used to formulate scenarios for the model .The model scenario was determined by the crop allocation pattern and net profit returns for each scenario. Results show that Dovlati cooperative farmers can save up to 60,000 GEL, while Kvitiri cooperative can save up to 20,000 GEL if they follow the strategy highlighted in scenario 3 which in this study was taken as the model scenario. In our scenarios the model had its land bounds going to the upper level and this strongly illustrated that farmers have are using more resources on smaller land pieces . However our recommended model shows that optimal profit reduced as the model progressed from scenario 1 to 3. Kvitiri cooperative is best suited for immediate adoption and application of our model since farmers already cooperate on both production and marketing. The model presents Dovlati with an opportunity to maximize their profit margin if the farmers cooperate both on production and marketing .

Key words: Cooperative farmers, herb farming, linear optimization models, crop land allocation techniques, profit maximization.

Table of Contents

List of Figures

List of Tables

1. Introduction

Georgia is a country situated in the Caucasus on the boundary between Asia and Europe .The country experiences a diversified climate throughout the year ranging from tropical humid, temperate to mountain glacier. Water resources are abundant and these support irrigation systems in most farming systems in the country.

Agriculture accounts for about 21 % of the GDP, making it a major pivot of Georgia's economy. This share highlighted in the latter dropped from 30 % in the course of the past 6 years (FAO, 2016). The biggest challenge faced today by the agricultural sector in Georgia is that there has been poor utilization of resources during the past decade. However there are other factors which have contributed to this such as collapse of agriculture infrastructure and lack of modern support mechanisms to farmers especially small scale farmers.

This research was carried out in to model alternative strategies of maximizing net returns of small scale herb farmers in Imereti West in Georgia .The need to develop these strategies was driven by the need maximize farmers profit while efficiently utilizing limited resources. Results of the model furthermore provides herb farmers with a feasible crop planning alternative to apply in their crop management techniques.

Muncan (2009) argues that in agricultural production, efficiency of enterprises is mainly hinged on the maximum utilization of the resources capacities .Thus there is need to constantly enhance new strategies to optimize the potential of the available resources in farmingIn this model The researcher used a linear optimization tool referred to as General Algebraic Modelling System (GAMS) software .GAMS is modern modelling software tool which has gained prominence in the 21st millennium among economists and researchers in agriculture optimization because of its effective capacity in solving linear problems using algorithmic values .

2. Literature Review

This chapter is a review of work which was done by other academic scholars, international organisations, and government of Georgia on the herbs production globally and in Georgia .It is the reference chapter of our methodology and results and discussion.

2.1 Optimization in agriculture

Optimization is achieving the farm household goals as efficiently as possible in the face of competing constraints of physical, environmental, legal or socio-cultural nature .Optimization is classified into two categories which are local and global .Local level optimization involves a lower order subsystem while the global involves higher order agricultural system (FAO, 2013).

Optimization represents a form of farm planning which follows a systematic technique, determining the best available plan for the combination of farm enterprises so as to maximize net profit and resource utilization .The significant question in agriculture enterprise and decisions is on how to enhance the competitiveness and capacities of the factors of production. Optimization give a set of alternative strategies to follow in-order to achieve maximum net profit returns among farmers. Muncan (2011) argues that in agricultural production, efficiency of enterprises is mainly hinged on the maximum utilization of the resources capacities .Thus there is need to constantly enhance new strategies to optimize the potential of the available resources in farming .The assertions of Muncan (2011) were supported by Manos etal. (2013), who in his study achieved an increase of total gross margin and a decrease of labour and fertilizer costs within a range of cereal and vegetable farm enterprises.

Lu sha sha etal. (2013) developed an interval-probabilistic agricultural production structure optimization model to address various agricultural uncertainties such as food security, eco-social benefits ,employment stability among others .In this model he found out that the results of the study were beneficial to policy makers and small household farmers in identifying the desired agricultural production optimization strategy under uncertainty in future agricultural production levels. Levina (2013) further undertook a research to optimize the structure of production and distribute agricultural goods by suburban enterprises in the region of Odessa (Ukraine).She argues in her research that the significant challenging

question faced by agricultural enterprises in recent years has been the question on how to enhance the competitiveness and capacities of the factors of production.

Sanus and Sadiq (2015) validated the argument presented by Levina (2013) when he examined resource utilization among cotton farmers in Nigeria and his results show that famers over-utilized land and seed while they underutilized chemicals and water resources. According to Mugabe etal. (2014) small scale resettled farmers in Zimbabwe are constrained with regards to their land holdings ownership. All farmland is owned by the state and as such they cannot use the land as collateral security to access credit. This problem of inaccessibility has led to large pieces of productive land being underutilized by small scale farmers due to poor techniques in crop planning decisions.

2.2 Linear Programming Models in Agriculture

Linear programming is explicit in nature thus it is considered a normative research tool. The behavior of farming systems enables the use of linear programming in farm models. The use of linear programming in agriculture allows the projection of future trends and thus makes it easier to make future situational decision making plans in agriculture.

Linear programming (LP) technique is a relevant tool in optimization of resources in order to achieve efficiency in resource utilization while achieving maximum net profit returns. Thus linear programming is a key recipe in increasing agricultural productivity (Majeke, 2013; Sofi etal., 2015).The emphasis of the use of linear modelling tools is gaining global momentum especially in small scale agriculture. However its application to agricultural systems needs careful interpretation since the data can be misunderstood by an ordinary farmer. Yang (1995) suggests that linear programming represents a form of systematic farm planning which mathematically determines the optimum plan for the choice and combination of farm enterprises so as to maximize income while minimizing production costs within a given set of available resources. Mugabe etal. (2014) further validates the suggestion by using linear programming model to maximize net farm income with land, capital, and consumption rate as constraints.

Garg etal. (2005) conducted a multi –objective linear programming to model the resources constraint problem under a given set of uncertain conditions to optimize land use plan .A stochastic model was further incorporated to minimize uncertainty in conditions

which might occur in future trends .Conditions of uncertainty in agriculture can be market factors ,rainfall patterns or consumers behavior .To minimize risks associated with such uncertainties linear modelling provides us with a more realistic forecast of the probable agricultural trends in the short term future.

In previous studies linear programming has provided more superior results than the normal business as usual tools of farm management and decision making. Majeke etal. (2013) used linear optimization to maximize net income of small scale farmers in Bindura, Zimbabwe .The results he obtained indicated an increase in gross income of 44.65 %. In Nigeria linear programming optimization enabled reallocation of resources in the existing small holder farm plans. The model results highlighted the need for provision of optimization techniques in extension services to farmers. This helped in the problem of farm resources utilization as well as ensuring stable farm labour wage with hired manual labour force was the main source of farm labour (Onyenweaku etal., 2013).

Extension programmes are effective in educating farmers in efficient allocation of their resources and these programmes are pivots upon which agricultural development programmes should be built. It is important to note that the advent of technological advancements has led to the development of soft computing optimization technique which solve problems in crop selection, irrigation planning and water resource use. These soft computing programmes can be difficult for farmers to understand but with the help of trained agricultural extension agencies implementation of the linear models is simplified.

Small scale farmers alone can find it difficult to use such tools in modelling without the help of experts .This presents us with the need to in calculate collaboration between farmers and experts in optimization modelling for agricultural applications .In Kuzekstan Region in Iran , applied linear modelling was applied to optimize economic benefit among small scale cereals and the results indicated a significant net increase in the profit margin and yield by an average of $ 987 per hectare and 6.15 tons per hectare (Mansoufar, 2013).

2.3 Farmers' cooperatives and their role in rural development

International Cooperative Alliance (2015) defines a co-operative as an autonomous association of persons united voluntarily to meet their common economic, social and cultural

needs through a jointly-owned and democratically-controlled enterprise. Cooperatives are guided by seven key principles and these are voluntary and open membership, democratic member control, member economic participation, autonomy and independence, education, training and information sharing among co-operatives and concern for community.These principles enable the cooperatives to be distingiushed from other forms of business which exist. Farmers cooperatives are guided equally by these principles with the thrust mainly hinged of satistfying the household needs.

Pinto (2009) reiterates that these principles have been perverted in their application in many environments for decades. In many developing countries farmers were in the past obliged to join cooperatives. In most of these countries, cooperatives have functioned as extended arms of the state. At the same time, cooperatives gained many benefits, such as exclusivity in the distribution of foodstuffs and export of agricultural products, fiscal exemptions, credits, donations, etc.

Very often, even when the farmer was not obliged to join a cooperative, these associative enterprises were manipulated by government. This has been the case in many Latin American countries such as Guatemala, Honduras, Peru and Paraguay, as well as in Asian countries such as Sri Lanka, Iran and Iraq. Pinto (2009) posits that the fall of the Soviet system, the end of the one-party states in Africa and the partial globalization of world markets radically changed the environment where agricultural cooperatives acted and interacted. The state protectionism of cooperatives made them inefficient as enterprises and thus had very low capitalization from the members.

Cooperatives and particularly agricultural cooperatives do play a major role in production, primary processing and marketing of agricultural and livestock commodities. Gamba and Komo (2013) argue that the justification for farmers cooperatives arises from their potential in maximization of profits,harnessing various skills from members, enhancing advocacy and bargaining power, enhancing financial accessibility, boosting social capital, promoting investment, providing educational opportunities, improving market access and thus contributing to poverty reduction. Van der Walt (2008) asserts that reasons such as poor management, lack of training, conflict among members, lack of funds, and operations were the major drivers of failure of farmer cooperatives in Limpopo ,South Africa. Poor cooperative management was a result of failure by leadership to harness the different skills

of cooperative members and lack of education and training amongst members in a cooperative.

It is clear that due to lacking position of cooperatives in terms of management skills, member training alone is not sufficient for realisation of the benefits associated with farm cooperatives. Community farmers need a mentorship program which will be assisted with managing the cooperative until they reach a stage where they can take full responsibility. According to Van der Wault (2008) the omission of this phase might be a prominent contributing factor to the precarious failure of small farmers cooperative. Financial support during the initial stages is indispensable. A newly established cooperative is normally not solvent enough to obtain loan finance. The financial backlog of the emerging farmers makes it impossible to expect any support in terms of equity. An initiative like this can only succeed if local government and non-governmental organisations support them with financial resources during their infancy.

Agricultural cooperatives play an important role in supporting small agricultural producers and marginalized groups such as young people and women. They empower their members economically and socially and create sustainable rural employment through business models that are resilient to economic and environmental shocks. Cooperatives offer small agricultural producers opportunities and a wide range of services, including improved access to markets, natural resources, information, communications, technologies, credit, training and warehouses. They also facilitate smallholder producers' participation in decision-making at all levels, support them in securing land-use rights, and negotiate better terms for engagement in contract farming and lower prices for agricultural inputs such as seeds, fertilizer and equipment. Through this support, smallholder producers can secure their livelihoods and play a greater role in meeting the growing demand for food on local, national and international markets, thus contributing to poverty alleviation, food security and the eradication of hunger (FAO, 2015).

2.4 Small scale farming cooperatives in Georgia

Agricultural infrastructure collapsed post-soviet union in the 90s with the agricultural sector suffering from decapitalization .Most farmers were left vulnerable with little or no access to inputs such as fertilizers and seeds .The government of Georgia attempted

rehabilitation of these structures in the early 2000s with funding from World Bank but alas it did not bring about the much needed short term recovery.

Cooperative farming in Georgia started during the late 30s during Soviet era of collectivization and then it was referred to as “kolkhoz”. The Kolkhoz collectivization farming resembled a totalitarian system in a planned economy. The kolkhoz principles contradicted with the cooperative principles of autonomy, independence and democratization (Oxfam, 2015). Davlasheridze etal. (2014) posits that the Law of Georgia on Agricultural cooperatives explicitly states that the main principles of cooperatives deviates with the kolkhoz system of the Soviet era. Most small scale farmers can not draw the line between a “kolkoz” and a morden farm cooperative.This has created lack of trust among cooperative members since The kolkhoz system do not resemble a modern cooperative. In situations where small scale farmers lack trust amongst each other cooperation is difficult to foster in a cooperative .Most cooperatives in Georgia are charaterised by members who belong to the same family which shows that the trust is still a major issue among farm cooperative members.

Oxfam (2015) reiterates that challenges such as lack of inputs reduced productivity of small holder farm systems in Georgia .However Gelashvili etal. (2015) views diverge with those presented by Oxfam (2015) and rather points out that the mixing of agricultural policy strategies with social projects has been the panachea to low produticvity in small agricultural cooperatives . The logic behind cooperative farming is to enable small farmers to combine resources and effectively utilize inputs while bargaining for better market prices. In contrast to the views presented by Oxfam (2015) and Gelashvili etal. (2015), FAO (2012) posits that lack of knowledge on how to derive maximum benefits from limited resources is a major obstacle hindering productivity amongst the majority of small scale farmers in Georgia.

The major obstacle to infrastructure development was the shortage of financial resources, though this was accompanied by a significant reduction in the supply of irrigation water. Furthermore weak management and administration of water resources and the absence of a water market, which caused irrational water waste led to poor productivity. Equally the small scale herb farmers in Imereti were caught with other farmers in this tragedy.

There is need for introduction of agricultural consultancy services which help farmers in-cooperate new agricultural techniques and practices aimed at improving productivity (Shergelashvili and Tokmazishvili, 2012). In situations where farm resources are not backed with modern extension services farmers fail to derive maximum returns from their production systems. This is the challenge which also faces most small scale cooperative farmers in Georgia today.

The EU is presently supporting both agriculture and rural development across Georgia. In 2013, a Sector Policy Support Program for Agriculture and Rural Development (EUR 40 million) was initiated by European Union (EU, 2012). It supports the implementation of the Agriculture Strategy for Georgia, with a special focus on enhancing competitiveness, promoting the establishment of business-oriented farmer associations and supporting small farmers. The Sector Policy Support Program is funded to the tune of EUR19 million with a second programme (EUR30 million) earmarked to support agricultural and regional policy planning. However, if the progressive depopulation is to be halted and poverty of the rural areas is to be alleviated, sustained efforts are required for the modernization of agriculture. Moreover, to ensure the sustainable development of rural areas, it is also necessary to support knowledge transfer and innovation in agriculture, forestry and rural areas and competitiveness of all types of agriculture in all regions, from promoting innovative farm technologies, to the organisation of the food chain, including the processing and marketing of agricultural products and to the economic development of rural areas.

This entails the diversification of economic activity to include specialist manufacturing and services, the establishment of a modern social and technical infrastructure, and the provision of targeted vocational education and training. The focus will, therefore, be upon extending the support being provided to Agriculture and Regional Development by stimulating the diversification of the rural economy, or, in other words, by stimulating a comprehensive rural development approach. The objective is to reduce dependency upon primary agriculture as a source of household income and to promote social inclusion and poverty reduction in rural areas.

2.5 Herbs production in Georgia

Herbs are grown in different production systems ranging from open land to greenhouse or high tunnels .Greenhouse systems are the best suited to cultivate herbs and can be either in pots or open beds .The main reason for preference of greenhouse system in herb production is that, it enables the grower to have more control over the growth environment which includes the drip irrigation systems, fertilizer applications and micro climate conditions .Drip irrigation systems enable the root moisture level to be maintained to optimum levels while at the same time minimizing soil water splashes on leaves which can reduce the leaf quality of the herbs (Geneve etal., 2015).

The disadvantage associated with the greenhouse production systems in developing countries is normally poor cropping and management techniques .In the case of Georgia this has been execabated by the absence of a functional extension service to fully capacitate small scale farmers on efficient crop management and decison making techniques. Greenhouse herb farming in Georgia is pronounced in the western parts which are the Imereti and Adjara (Young Economists of Georgia, 2015). Herbs cultivation is well suited to the humid tropical climates such as the one occurring in western part of Georgia. Herb production amongst small holder systems in Imereti thrive between the period November- May which is the winter of Georgia.

In herb production, seeds can be directly seeded in the ground by machine drill or in beds then transplanted into the ground . Labour is mainly needed for seed sowing ,transplanting, harvesting and packaging. A single worker is capable of thinning or handweeding an acre of land area per day. Labour costs contribute to the most significant part of overall costs. Labour costs are mostly manual and efficiently utilizing the productivity is the key to achieving maximum net returns in herb farming. During harvesting herbs can be picked once or can be picked several times depending on the herb condition at different times of harvest(Mossler, 2014 ; Geneve, 2015).

In Imereti region, greenhouse herb farmers mainly rely on foreign seed suppliers for their seed inputs .Other inputs which they purchase from foreign markets are herbicides and fertilizers .The major suppliers of these inputs are Russian ,Ukrainian and European suppliers .Dill seeds are the most demanded on the market and mainly supplied by Zaden and Brakers

Brothers . However some local farmers use their own produce their own seeds (People in Need, 2014).

Various microfinance institutions in Georgia are offering credit line facilities to green house farmers in Georgia. The financial resources assist farmers in the building of greenhouses and to cover other factors of production (World Bank, 2012). This initiative is alleviating the problems of farm resource capacities amongst small farmers. Greenhouses construction costs contribute significant fixed cost which should be covered by the farmer when the farm enterprise becomes operational. However in Georgia most farmers use simple polythene plastics and wooden poles thus its relatrively cheap to construct the greenhouses.The idea of building greenhouses is beneficial in that farmers can grow herb crops throughout the year, thus there is a constant suppply of herb produce to both the domestic and foreign markets .

World Bank (2012) reported that greenhouse farmers in Georgia outsource labor during the peak of the season and in one case a farmer claimed that she hires about 5 women since the greenhouse production activities are more labor intensive during peak of the season. Genève (2015) agrees with World Bank (2012) and details that herbs are labor intensive crops with most of the labor required mainly during the transplanting, weeding and harvesting stages. Labor costs contribute the significant proportion of total costs in greenhouse herb production systems. It is of paramount to understand the dire capital constraint situation which most small scale farmers find themselves. Small scale farmers can be able to reduce such reduce cost constraints by venturing into cooperative farming thus reducing production costs such as labor, inputs, and market transactions costs .

The advent of farm cooperatives in Georgia has seen small scale farmers venturing into various agricultural enterprises such as vegetable greens and fresh herbs production . In July 2013, the Parliament of Georgia adopted the Law on Agricultural Cooperatives; defining the legal status and basic principles and rules regarding formation, membership and management of agricultural cooperatives (People in Need, 2014).

According to the new law, agricultural activity is defined as “all kind of farming activity on agricultural land or land-related property, and other related services that includes the production, processing, packing, packaging, storage, transportation and marketing of plant and animal products”. The farmer groups that receive the status of Agricultural

Cooperative may be subjected to several privileges as prescribed by the law that include tax concessions, preferential credits and grants, and participation in development projects and programs. Agricultural cooperative membership is voluntary and such an enterprise should comprise of 5 members at minimum (3 for mountainous regions).

The status of Agricultural Cooperatives can be obtained through application to the Agency for Development of Agricultural Cooperatives (ADAC), a governmental body under the Ministry of Agriculture of Georgia that was established to grant status and monitor compliance of registered agricultural cooperatives with the new law. The new law of cooperatives has seen many farmers taking on board the initiative to form cooperative farming enteprises .However the hindrance to effective cooperation among members is lack of trust .It is of paramount importance to stress that cooperatives can uplift the small farmers net profit returns while at the same time improving the countries agriculture sector which has struggled in the past years .The inititiative of cooperatives among farmers has helped many famers in dveloping economies and helped increase the agricultural GDP of these economies.

2.6 Herb yields and markets in Imereti Georgia

According to Affinitas Consulting (2012), Ukraine is the major importer of herbs produced by Georgian farmers since it has the neccessary certifications to further export to Russian and European markets .In Georgia, share of herbs represents 6.2 % of the total vegetable production which in 2013 reached 205 500 tons (Geostat, 2013).The major herb crops under production in Imereti are dill, coriander, parsley and green onion .These are produced generally throughout the year and they supply both the local markets and the export markets with yields ranging between 500 to 600 kilograms per hectare .

In 2011 the exports of herbs from Georgia stood at 5,349 tons and the main destination markets were Belarus ,Ukraine ,Azerbaijan, Lithuania, Latvia and Estonia (Affinitas Consulting, 2012).The greatest demand of herbs on the market occurs during the winter periods when other competitors at both domestic and international level can not supply the market. During tis time herb farmers acquire the best prices for their produce both on domestic and international market (Czech university of Life Sciences Tropical AgriSciences Faculty ,Young Economists of Georgia and People in Need, 2014).

In 2013 share of herbs totalled 6.2 % of the total vegetable production which translated 205 500 tons (Geostat, 2013).The major herb crops under production in Imereti are dill ,coriander,Parsley and green onion .These are produced generally throughout the year and they supply both the local markets and the export markets with yields ranging between 500 to 600 kilograms per hectare (Affinitas Consulting, 2012) . In 2011 the exports of herbs from Georgia stood at 5349 tons to the destianation markets of Belarus ,Ukraine ,Azerbaijan, Lithuania, Latvia and Estonia (Affinitas Consulting, 2012).

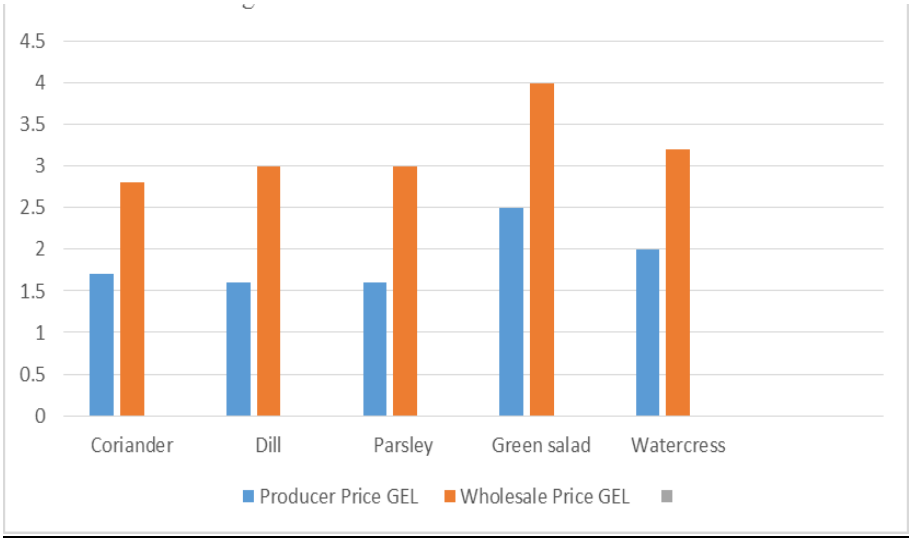

Figure 1:Herb market prices in 2014

Source : Young Economist in Georgia 2014

According to Young Economists of Georgia (2014) ,the prices of herbs in the capital city Tbilisi are relatively higher than in Imereti region .Retailers usually apply a 30smark up on the price of herbs making the final consumer prices rise to between 4 and 5 GEL per kilogram of herbs sold .

3. Objectives of the research and research question

The output of agriculture in Georgia has been declining continuously over the past two decades .The shift of the Georgian economy from a planned economy to a liberal market based economy posed a lot of challenges to the agriculture sector. This is coupled with the failure to provide technical and financial support to small holder agriculture resulting in low yield productivity in most of the agricultural regions of Georgia. The agricultural sector has over the years earned low revenues. One of the reasons is the Russian embargo on Georgian agricultural products which has led to farmers penetrating new markets in neighbouring countries and European Union alas under stiff market competition. This has seen some of the major crops fetching low revenues on the local markets due to a surge in supply and a shrinked market.

In Imereti, herb farming has gained prominence amongst various farm enterprise of small holder farmers .This has been a result of the increase in demand for fresh Georgian herbs by both local and foreign markets .Thus herb farming has become a lucrative farm enterprise especially in winter .However farmers are ill-equipped with skills and technical knowhow on efficient crop management techniques. Effective farm management techniques such as crop allocation strategies can enable farmers to realize maximal profits in their enterprises.

The aim of this research is to model an alternative profit maximization strategy Imereti cooperative herb farmers. To achieve this aim we use linear programming tools of farm optimization. There are many linear tools used in farm optimization applications and in our research we use General Algebraic Modelling System tool. Scenarios simulated for the model provides us with the maximum profit levels, crop planning combinations and the marginal benefits associated with each of these variables.

In simple terms decision variables in our model are profit margin levels and land allocation strategy for cooperative herb farmer. The decision variable is informed by outputs in our scenarios and the behaviour patterns they exhibit under various farm resource and market constraints. The optimization model recommends the range of land use by sub-area at the end of the planning period. The modelling results directly answer the question of ‘what to do?’(Chipunza etal., 2013).

4. Methodology

The research type used in this study was quantitative .The rational behind the choice of quantitative approach over qualitative was arrived at after careful consideration of the nature of variables under investigation .The variables in the questionnaire included but not limited to land area used for herbs cultivation ,average gross margin per cooperative ,average labour and input costs accrued per cooperative and the herb crops under cultivation in both summer and winter seasons.

Variables colleted were used to generate model scenarios for both cooperatives . Van Notten (2006) defines a scenario as consistent and coherent description of an alternative hypothetical future which mirrors the past ,present and future developments that is used a yardstick for action. The methodology was staggered into three phases as shown in fig 2.

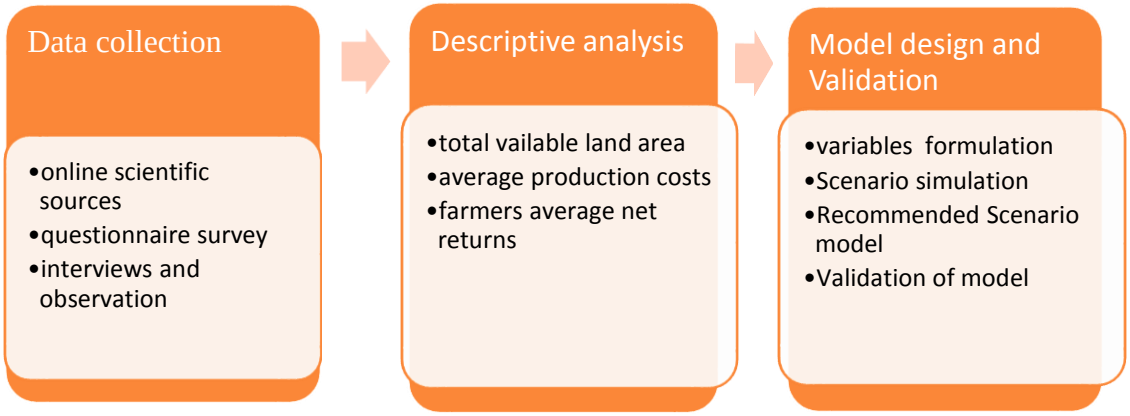

Figure 2: Methodology flow chart

4.1 Description of target groups

The target groups of this research were mainly small scale cooperative herb farmers .However other groups such as retail and wholesale markets in the nearby markets were the second target group of this research survey .Two markets were selected for identification of would be participants in our survey and these were Nikea and Chavchavdze vegetable

markets These markets have a close proximity advantage to the farmers cooperatives.These markets have a high trade interaction with herb farmers in Tskaltubo our targeted area .

4.1.1 Cooperative "Dovlati"

Cooperative "Dovlati" was founded in September 2010 in a village Maglaki of Tskaltubo municipality with a purpose to provide production, storage and marketing support services to its members. The "Dovlati" founders and members are small farmers who cultivate "regular" fruits and vegetables during the warmer seasons of the year and grow offseason greens in their small greenhouses during the colder seasons. Some farmers also grow limited amounts of offseason vegetables for consumption in their households and sale. Each farmer runs from one to five 500 square meters of greenhouses that are made of wood frames and polyethylene sheets as a cover (People in Need, 2014). The greenhouses are equipped with simple handmade irrigation systems. Most of the facilities do not use any heating equipment.

Dovlati cooperative farm members pay cooperative fees of about 50 GELs .The farmers in winter major in cultivating herbs such as fennel, parsley and coriander. Dovlati farmers sell part of their yield share of herbs through the cooperative while some is indivudually marketed through middlemen to foreign markets and local markets. Through People in Need and Czech Development agency the cooperative managed to establish storage facilities for greens .Dovlati cooperative offers free service for the storage of members herb produce . The storage house has a capacity of 100 tonnes for all the produce yield by members .This has enabled the famers to

4.1.2 Cooperative "Kvitiri"

In contrast to Dovlati, Kvitiri cooperative farmers cooperate from the production side ,postharvest and handling up to the marketing side of the herbs .Kvitiri has been in existence since 2014. Farmers in Kvitiri cooperative sell their herb output yield via the cooperative and generally share the labour force .Cooperative members pay an equal contribution towards production and marketing costs involved in herbs production .The herbs under cultivation in Kvitiri cooperative are fennel ,coriander and parsley.

4.2 Wholesalers and retailers of herbs

Another target group involved in the research were wholesalers and retailers at Kutaisi local markets near the target location. These herb retailers and wholesalers were interviewed after the farmers interviews as a cross checking measure to cross check the prices farmers receive on the market for two selected markets in Kutaisi .A total of 10 wholesalers and 10 retailers were randomly selected at the market place .All of the wholesalers and retailers interviewed did not hesitate to supply information to the researchers on price of herbs per kilogram.

It should be noted that the major difference between these two groups was that retailers mostly purchased herbs from wholesalers and repackage in smaller units of quantities while wholesalers purchased herbs either through middlemen or directly from farmers. However quantities of how much both traders traded between each other and also with farmers could not be ascertained. In some instances farmers were encountered at the market place marketing their own produce were interviewed by the researcher .These farmers were marketing some of their produce at the Imereti markets without the help of middlemen .The collected data was captured in excel and grouped in accordance to the variables under investigation.

4.3 Secondary Data Collection

Scientific articles and journals mainly from online web sources such as science Direct and Research gate constituted the main secondary sources of data collection. Other secondary data sources also included but not limited to reports of Government agencies such as USAID and international agencies such as EU and Enpard, .The key words which were used in the search were mainly optimization, Imereti, Georgia agriculture,, herbs and cooperatives and linear modelling

4.4 Primary Data Collection

Primary data collection took place between July and August 2015 .To select the cooperatives in Tsklatubo we used multi stage sampling which involved purposive and convinient sampling method . This sampling procedure involved first stage of purposive sampling followed by convinient sampling .This helped to minimize sampling errors while ensuring a more reliable and representative sample (Niragira, 2011). Farm households were regrouped into homogenous categories. Purposive sampling method was used to identify the cooperatives which specialised in producing herbs and these were identified as Dovlati and Kvitiri small farmers cooperatives. To select the farmers who could participate in the research we used convinient sampling. Convinient sampling allowed to select farmers who were willing to participate in the research. Two cooperatives were selected and these were Dovlati and Kvitiri. Kvitiri cooperative lies on lattitude 42 ° 13.832 ' North and 42° 33.140 ' East while Dovlati cooperative lies on 42 ° 37.786 ' North and 42 ° 14.485 ' East . Both cooperatives are found in Tskaltubo district of Imereti West ,Georgia .

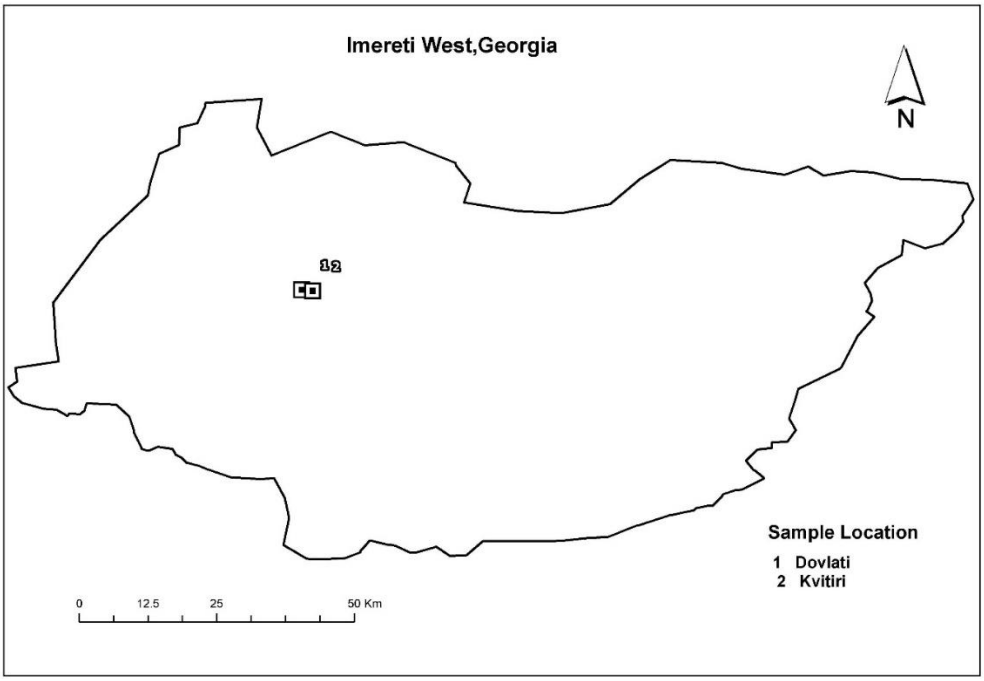

Figure 3: Target location, Imereti West Georgia

The target area was selected based on four factors as highlighted by the bulletins below;

- The dominance of small scale herb cultivation activities in the location
- Proximity to Akaki Tsereteli University where the researcher outsourced interpreters well versed with Georgian Script language and also English .
- Uniformity of farming systems in the region
- Tskaltubo is also located near Kutaisi City where the largets market of herbs is located and this enabled cross checking of primary data such as herb prices with wholesalers and retailers.

4.5 Data collection tools and variables

The author combined questionnaires, and observations in collecting primary data in the target community.The selection of the questionnaire variables was premised on the numeric nature of the variables under study. The questionnnaire survey was the best tool in this survey in gathering factual and authentic data about the target group. Two students were outsourced from Akaki Tsereteli University to assist in translations and communication between the author and the farmers during the survey. Prior to the field work both student translators were taken through a two day familiarisation group discussion on purpose of the research survey. The questionnaire was translated from English to Georgian script for easy understanding between farmers and the translators during data collection .

The questionnaire was pilot tested on the first day of the interviews using five randomly selected farmers from Dovlati cooperative. Interviews and questionnaires were combined together to close loopholes associated with misrepresantation of factual information which could potentially arise in the event of the farmers filling out information on their own. Responses which had outliers were investigated and verified by cross checking with the normal distribution trend of other farmers responses . The objectives of the research informed the process of selection of variables which were used in developing scenarios.

Table 1: Questionnaire Variables

Section	Description	Variables
	Basic Information about Farmer	1. Name of Farmer 2. Cooperative name
	Demography characteristics	1. Age 2. Education 3. Main economic household activity
	Objective of the farmer	1. Subsistence oriented 2. Market oriented
	Characteristics of cooperative farms	1. Area of greenhouse 2. Number of greenhouses per farm 3. Distance to market from farm
	Variable Inputs	1. Chemicals 2. Fertilizers 3. Irrigation sources
	Fixed Inputs	1. Number of workers per farmer 2. Labour wage per farmer
	Output	1. Seasonal yield of herbs 2. Sale of herbs 3. Herb market prices 4. Types of markets for herbs

However it should be higlighted that variables such as net margin per acre ,yield per hectare and production costs per cooperative were calculated using the following fomulas as defined in the equations [1] and [2].

$P\,M = (T\,S - A\,V\,C\,) \div (T\,L\,A\,)$…….[1]

Where ;

- PM is the profit margin for each crop
- TS is the total sales for each crop
- AVC is the average variable cost per crop
- T L A is the total land area cultivated for each herb crop in hectares

Average variable costs for each crop were estimated in accordance with equation [2]

$A\;C\; = T\,V\; \div T\,Y\,O$ ……...[2]

Where;

- A C is the average costs per unit hectare of each herb crop cultivated,
- T V is the total input and fixed costs of incurred per crop
- T Y O is the total yield output per herb crop

4.6 Model design and validation

Modelling is simply a way of integrating information in a rational way and as such can include a variety of methodologies. Our model assumed a hybridization approach with site specific parameters which allowed identification of data gaps while focusing on research priorities. The variables under investigation were grouped into three categories of sets, scalars and parameters. Sets represented the herb crops under investigation and these were mainly coriander, fennel and parsley. Scalars represented the constraints and in our model these were land and costs of production. Scalars were indicated by the right hand side of our linear equation. Parameters represented the costs of production incurred for each acre of herb crop .The costs of labour per herb crop could not be ascertained and thus it was estimated by allocating equal costs based on available cash.

Table 2: Positive Variables

Variable	Model Indicator	Description
Profit	Goal	objective
Land	Scalar	Constraint
Cash	Scalar	Constraint
Market	Scalar	Constraint
Crops	Sets	activity

Positive variables and equations were defined in each scenario as illustrated below in table 3 and 4. The equations in were defined in accordance with the General Algebraic Modelling system guidelines and the table 4 shows how the algebraic definition for each particular equation .Note that the equations do not follow the usual patterns as is the case with other modelling softwares.This is because of the algebraic nature of the GAMS software as per the manual of operation.

Table 3: Scenarios equation sets

Left hand side expression	Relation	Right hand side expression
sum(C,GM(C)*ACT(C))	=	profit margin
sum(C,Fland(C)*ACT(C))	≤	land constraint
sum(C,Fcash(C)*ACT(C))	≤	cash constraint
sum(C,Fcash(C)*ACT(C))	≤	market constraint;

Table 4 Key

- GM (C) denotes the gross margin per herb crop
- ACT (C) denotes the activity level per herb crop
- F cash (C) denotes the cash costs per herb crop per hectare
- F land (C) denotes the land area planted per herb crop per hectare
- F market (C) denotes the market capacity to absorb yield at a given price

4.7 Data Processing

To determine the costs of production incurred by the whole cooperative for each particular herb crop per unit area, we averaged costs incurred by each farmer and then summed them to come up with whole cooperative production costs. The total costs were taken as the cash resource constraint .To determine the average costs incurred per herb crop we used the Centre For Land Use Guide for Herbs production (2010). The costs of seed ,herbicides and fertilizers slightly differed for each herb crop and thus was negligible. Gross margin for each herb crop was determined for each herb crop by calculating the difference between the revenues and estimated costs incurred per herb crop.

Scenarios were simulated for each cooperative using the variable data collected . A scenario is a coherent, internally consistent, and plausible description of a possible future state of a system or environment. Scenarios commonly are required in adaptation and vulnerability assessments to provide alternative views of future conditions considered likely to influence a given system or activity.

The simulation of scenarios was based on the fundamental principle of subjecting an objective goal function to constraints.Manos etal. (2013) modelled an agricultural production plan by combining various criteria to an objective goal function and subjecting them to a set constraints in the form of labour, capital and irrigation water. We applied the simplex linear programming method to simulate scenarios .The software tool used for the linear program was General Algebraic Modelling System (GAMS) software.This software was developed by a group of world bank mathematicians in 1985 to solve complex linear and non problems in various economic and industrial sectors across the globe (Brooke etal., 2010). Profit maximization was taken as the objective function in all the scenarios .Three trial scenarios were simulated for each cooperative .The constraints were taken as the land ,costs of production.Market constraints were excluded in two of the scenarios for each cooperative .In one of the scenarios for each cooperative the market constraint was introduced.This was done to solve the problems of allocation observed in scenario one and two.

In each of the scenarios the level indicate the minimal at which a variable starts to attain the optimal profit .The upper level denotes the maximum attainable limit for a given variable under the given constraint .The marginal indicates the shadow prices associated with each variable .The marginals represent the shadow prices associated with each variable in the data output.The scenarios were developed in such a way that scenario two was a development of scenario one for each cooperative while scenario three was a development of both scenario 1 and 2 .This strategy was also used by Ruben etal. (2005) in the simulation of optimization scenarios for less favoured areas in subsaharan Africa

5.Results and Discussion

The results of each variable under investigation show variations patterns taken by scenarios between the two cooperatives. The results presented in this section provide an insight into the discussion on factors which caused the patterns followed by our models and the descriptive data as illustrated in the succeeding sections.

5.1 Cooperative farm typology

Dovlati farmers' cooperative is a market oriented cooperative with less cooperation on the production side of the herbs. Dovalti farmers have been in herb production from year 2012 up to date. The land area and yields of Dovlati farmers vary from one farmer to the other with some farmers harvesting very high yields while others record very low yields as indicated by figure 5. However all farmers use the greenhouse method of herb production and also they focus mainly on two herbs i.e. fennel and parsley. It is important to note that Dovlati cooperative farmers grow herbs only in winter and in summer they grow vegetables and other greens such as Bulgarian pepper and green salad which are the more profitable in summer season than herbs.

Kvitiri cooperative has a lower number of farmers compared to Dovlati cooperative. Farmers in Kvitiri cooperate both on production and marketing side. They also share proceeds from herbs equally amongst themselves .The cooperative is in its infancy and they started just in year 2014. Kvitiri cooperative farmers grow herbs in both summer and winter seasons. Besides growing of herbs they also grow other vegetables such as green salad, watercress and Bulgarian pepper in both seasons .Kvitiri cooperative farmers have a great potential to adopt to the ideal cooperative principles unlike in comparison to their Dovlati counterparts.

5.2 Production costs

The most significant costs incurred by farmers in Dovlati and Kvitiri cooperatives arise mainly from labor cost than they do from variable input costs. The reason why labor costs in herbs production are higher than other variable inputs is that herbs production under greenhouse systems are labor intensive with much of the labor requirements increasing as the herbs grow to their leafing stages (Clark, 1991). However it was found that there are two

categories of workers' wages in Dovlati and Kvitiri cooperatives and these are 90 GEL per week wage denoted as category A as illustrated in and the 120 GEL per week wage denoted as category B in table 6. In category A workers earn as much as 1,080 GEL per season and this is below category B where workers earn 1,440 GEL per season. In our model we chose weekly wage per worker of 90 GEL which falls under category A. The reason for our choice was premised on the assumption that the majority of farm workers who participated in our research survey pay 90 GEL per worker per week in the winter herb growing season. The following table [6] below summarizes these costs.

Table 4: Labor wage categories

Category	**Weekly wage (G**EL**)**	**Total weeks per season**	**Total Seasonal wage per worker (G**EL**)**
A	90	12	1,080
B	120	12	1,440

Tables 4, 5, 6 and 7 generalize all the variable costs which are incurred by one farmer in both Cooperatives .The costs of water and greenhouse maintenance were not included in the tables .One of the reasons why they were not included is that they could not be ascertained since the famers do not keep records of how much water they use per each season to grow herbs .Secondly all farmers' water costs are paid together with the household water and to minimize the effect of distorting our model, we decided to model what was related to the scale of our problem. In total Dovlati cooperative has 26 farmers while Kvitiri has 5 farmers and the costs which are incurred by the cooperative are summarized in table 6 and 7.

Table 5: Dovlati Variable input costs

Input	Cost(GEL/kg)	Quantity(kg)	Total Cost(GEL)
Seed	30	26	720
Pesticide	20	26	520
Herbicide	50	26	1300
Manure	3.3	2,600	8,580
Total			11,120

Herbicides have the higher cost compared to other inputs as illustrated in production costs tables 6, 7 and 8. The reason attributed to this is that the chemicals are imported from countries such as German, Netherlands and Belarus (USAID, 2012). However when cooperatives buy them they are given a discount by the suppliers and this one of the major advantages of cooperatives in Georgia.

Table 6: Kvitiri Variable Input Costs

Input	Cost (GEL/ kg)	Quantity (Kg)	Total Cost (GEL)
Seed	30.0	5	150
Pesticides	20.0	5	100
Herbicides	50.0	5	250
Manure	3.3	500	1,650
Total			**2,150**

To come up with the total costs incurred by Dovlati and Kvitiri cooperatives we summed up the total input costs and the total labor cost for our model scenarios. The resultant total cost amounted to 94,360 GEL and 18,350 GEL for Dovlati and Kvitiri respectively. The

total costs for all the farmers in the cooperative Dovlati represent the estimated cash to cover the costs incurred during the whole season. It is also the cash constraint variable in our scenarios. Clark etal., (1991) recorded all labor hours committed in growing herbs under greenhouse system and the resultant labor costs showed that the cost of labor were significantly higher than other costs of production .

Table 7: Total Labour costs

Cooperative Name	Number of workers	Wage (GEL/Week/Worker)	Labor (Weeks /season)	Total Cost (GEL)
Dovalti	78	90	12	84,240
Kvitiri	15	90	12	16,200

5.3 Market price trends

In 2013 the price of fennel was higher than the price of parsley and was pegged at 1.5 GEL per kilogram and 2.5 GEL per kilogram, respectively. In 2014 the price of parsley rose to 3.0 GEL per kilogram while that of fennel rose to 5.0 GEL per kilogram. In 2015 the prices of both herbs fell down to the 2013 prices .According to Vardiashvili (2015) the increase in demand for culinary herbs from Georgia by new market niches in Bulgaria, Ukraine, Belarus, Azerbaijan, Latvia and Moldova necessitated this sudden increase in herb prices and fennel was under high demand than parsley .This was also due to the higher price which fennel fetched on the market and this price increase was by the 2014. The new market niches opened an opportunity for the cooperative to further diversify their production activities so as to satisfy the demand created in the neighboring countries markets.

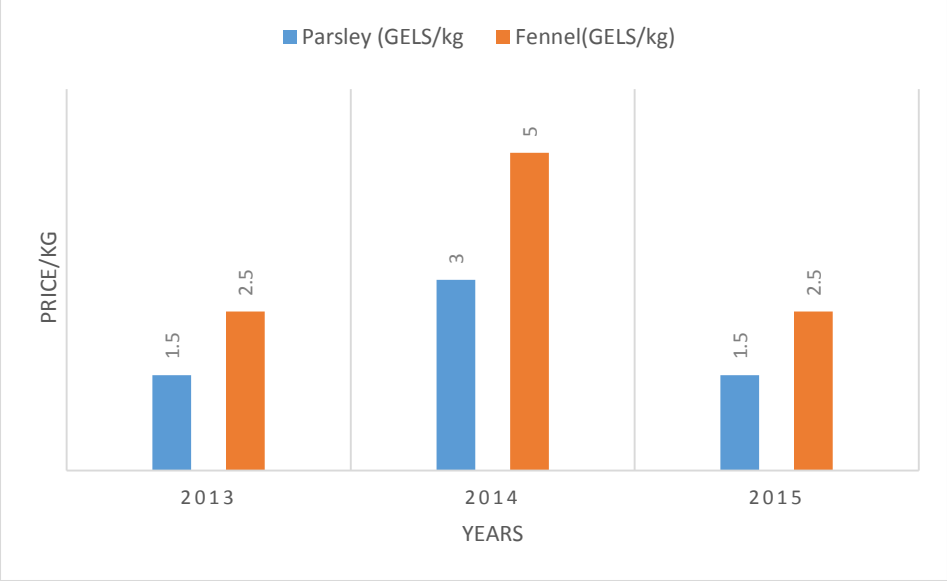

Figure 4: herb market prices from 2013 to 2015

5.4 Herb yields

Herb yields in Dovlati vary unevenly from one farmer to the other. Dovlati farmers' harvests range from as low as 1.5 tons per hectare to a high of 22.0 tons per hectare per farmer .However the majority of the farmers harvest is below 5.0 tons per hectare of herbs in the 2015 season. Farmers in Dovlati cooperative, cooperate in marketing of their produce and very little in the production process.

Determinants of low yields amongst farmers in small farming systems is usually associated with poor resource management. Farmers tend to allocate more labor and input resources to already fertile landscapes instead of allocating to areas which have low fertility.

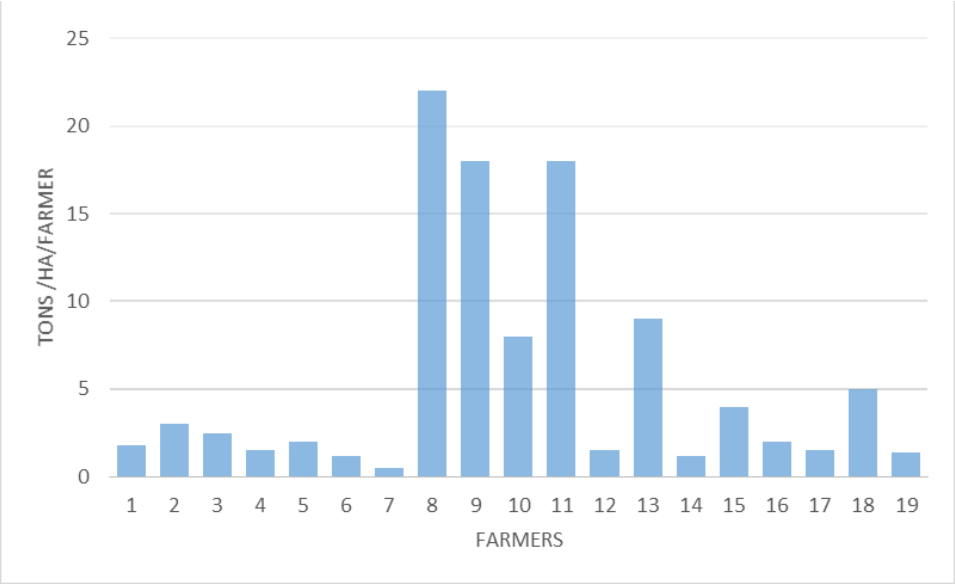

Figure 5: Dovlati Herb Yields

Kvitiri farmers' yields are also higher in winter than in summer. The yield increase in summer is necessitated by the increase in demand of herbs over other vegetable crops during winter and mostly by the local and foreign market traders .Thus farmers preferred to increase their greenhouse herb production capacity to full during winter season. Figure 5 illustrates the variations in yield in the cooperative. Farmers' yields in summer range from between 1.0 ton per hectare to about 2.4 tons per hectare per farmer .In contrast the winter herb yields are higher and range from 3.0 tons per hectare per farmer to about 4.5 tons per hectare per farmer.

It is important to note that Kvitiri farmers cooperate in both production and marketing and share equally the proceeds from their herb harvest. However cooperation alone might not be sufficient to improve farmers net profit returns. Koladea and Harpham (2014) suggest that small scale farming intervention programs which focus more attention on innovations and better linking social capital with extension agencies, banks, markets, and agricultural value chains can strengthen the expand the cooperatives productivity and net profit levels .

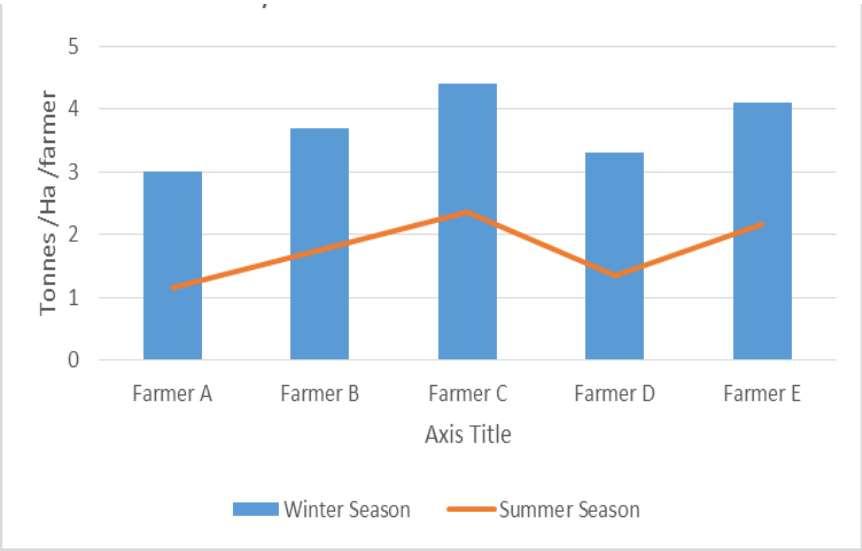

Figure 6: kvitiri herb yields

5.5 Model Scenarios

The scenarios in table 8 and table 9 illustrate the three scenarios which were used in arriving at the models for both cooperatives under this study. The Scenario 1 for each cooperative was simulated with cash constraint as the total costs. For all production activities in a range of alternative, the variables are specified with different combinations of land, labour and inputs (Ruben et al., 2005). Scenario 2 is a development of scenario 1 for each cooperative while scenario 3 is the model scenario whose output results sets evens out the biased patterns of scenario 1 and 2. This strategy was also used by Ruben et al. (2005) in the simulation of optimization scenarios for less favored areas in sub-Saharan Africa. He further posits that simulation of succeeding scenario based on preceding scenario allows to track the patterns which are followed by sceanrios and can inform coreectictive action on simulation strategies from one scenario to the next. The difference in scenario 1 and 2 is that we used the lower bound of the cash bounds as the upper bound (available cash). Scenario 3 is a development of both scenario 1 and 2 and it attempts to evenly allocate land to all herb crops.

In Scenario 1, Dovlati has an upper bound of 95,000 GEL while scenario 1 for Kvitiri has 25,000 GEL . However for scenario 1 for both cooperatives , optimum profit starts to be attained at 32,000 GEL for Dovlati. Kvitiri ttains its profit at 4,000 GEL cash as indicated by lower bound is 32,000 GEL and 4,000 GEL for Dovalti and Kvitiri respectively. The amount

of money which cooperatives save if we use scenario 2 as our optimization strategy is about 63,000 GEL for Dovlati and 21,000 GEL for Kvitiri.

Cash marginals associated with cash resources in scenarios 2 and 3 are 0.9 and 0.6 GEL/hectare espectively. These cash marginals (cash bounds) indicates to us that there is no profit gain per unit land area increase as indicated in table 8 and 9. This observation clearly shows that all land has been fully utilized the cash resources at our disposal. Scenario 1 and 2 do not have market constraint thus there are no results for market bounds and market marginals .Scenario 1 and 2 allocates land to only one crop for both cooperatives and this is a dangerous and risky situation in agriculture production since there are risks of markets, weather and pests and diseases which lead to loss in farm sales revenue. Scenario 3 is a simulation which attempts to correct the crop allocation problem exhibited in results of scenario 1 and 2. In this scenario the market factor was introduced and the results are illustrated in table 9 and 10.

The elimination of market factor in scenario 1 and scenario 2 simulation was based on the assumption that the market capacity to absorb herb produce is unsaturated. In contrast to scenario 1 and scenario 2, scenario 3 has market cost constraint of 2,000 GEL/ton of parsley and 500 GEL /ton of parsley for Dovlati and Kvitiri cooperatives respectively .The results recorded in these scenarios show that the model allocates land area to both crops which is not the case in scenarios 1 and 2 .This means that scenario 3 suits the objectives set in our study of oiptimizing while at the same time allocating both crops a portion of land area to reduce monocropping risks.

Market constraint indicates the capacity of the market to absorb farmers' herb produce without lowering the price. Beyond 2,000 tons the market becomes saturated and there is oversupply of herbs and this consequently reduce the herb prices and reduce the profits associated with the herbs. The point presented by the results of scenario 3 is that it allocates land for both herb crops. The results in scenario 3 for both cooperatives indicated a land margin of zero, meaning that land area is enough given the available cash resources. The general trend in profit attained shows us that there is a reduction in profit when we introduce the market constraint in the third scenarios. This is in contradiction with Ogundari (2006) who found that an average of about 60 % of potential maximum profit was gained

due to production efficiency in his model trials amongst small famers in Northen Nigeria. The contradiction can be attributed to resources distribution which does not fit our model. Furthermore he attributes his gain to both technical and allocatively efficiencies .

Crop diversification was the key strategy which we used to arrive at both of our proposed models which are scenarios number three for both cooperatives .These models clearly indicate that two major herbs under production in both crops efficiently allocated optimum proportions of land in our allocation plan of our cooperatives .The rational of crop diversification has great potential to improve farmers net revenue through. Factors such as pests and diseases can be suppressed and transmission of pathogenic agents is dampened. However the problems encountered with diversification of crop plans is that adoption of this strategy by small scale farmers is slow (Lin, 2011). Our model was taken as scenario 3 because the crop allocation plan offsets risks associated with mono-cropping. We basically achieved the second objective of optimum land use allocation through diversification of herb crops in scenario 3 taken as our model scenario.

Kvitiri differs with Dovlati only on the parameters quantities used and in this case quantity of land available ,cash resources and market constraint However the patterns followed by the cooperative exhibit the same trend as in Dovlati scenarios .

Table 8: Kvitiri Scenarios Result

	Profit	**Land**	**Bounds**	**Land Margin**	**Cash**	**bounds**	**Cash Margin**	**Market bounds**		**Market**	**Crop Allocation**	
	(GEL)	**(ACRES)**		**(ACRES)**	**(GEL)**		**(GEL/ACRE)**	**(GEL)**		**Margin**	**(ACRES)**	
		Lower	***Upper***		***Lower***	***Upper***		***Lower***	***Upper***	**GEL/TON**	**Fennel**	**Parsley**
Sc 1	2,400	2	2	-	4,000	25,000	1.2	-	-	-	-	2
Sc 2	4,880	2	2	1,200	4,000	4,000	-	-	-	-	2	-
Sc 3	3,150	2	2	-	4,000	4,000	0.6	**500**	**500**	**1.5**	**1.25**	**0.75**

Sceanarios results indicate the constraints which were used and the level of usage for all the parameters in the scenarios .The boldened figures in market and crop bounds indicate the fundamental difference between scenario 3 and scenarios 1 and 2. The model scenario selected for both cooperatives is secanrio 3 due to even allocation of land to both crops under investigation.SS
Note that Sc is short form for scenario and the number of the scenario

Table 9: Dovlati Scenarios Result

	Profit	**Land Bounds**		**Land Marginal**	**Cash**	**Bounds**	**Cash Margin**	**Market Bounds**		**Market**	**Crop Allocation**	
	(GEL)	**(ACRES)**		**GEL/ACRE**	**(GEL)**		**GEL/ACRE**	**(TON)**		**Margin**	**(ACRES)**	
		Lower	***Upper***		***Lower***	***Upper***		***Lower***	***Upper***	**GEL/TON**	**Fennel**	**Parsley**
Sc 1	39040	16	16	2440	32000	95000	-	-	-	-	-	16
Sc 2	28800	16	16	-	32000	32000	0.9	-	-	-	-	16
Sc 3	23200	16	16	-	32000	32000	0.6	**2000**	**2000**	**2**	**6.666**	**9.333**

Figure 7 shows a visualised graphical solution of our linear model and shows the point at which the optimum profit is attainned .In simple terms it illustrates the cropping allocation plan for Dovlati farmers. As shown in the figure 7 the point at which the land, cash and market constraint line curve intersects with the profit line graph represents the optimal crop allocation strategy .The optimal solution represents the land area which should be allocated for each herb crop according to the variables under modelling .In accordance with the table 8 and 9 we recommend that farmers for Dovlati and Kvitiri cooperative use scenario 3 as their optimization model which allocates land to both herb crops. Scenarios 3 further went into the upper level of the available land which strongly illustrates that our model which is scenario is hungry for more land. Both cooperatives are presented with the opportunity to increase their land area capacity if they have enough cash. Land acquisition comes with additional costs but in the case of Georgia, land is inexpensive since the law

The models in both cooperatives advised us to drop coriander and specialise in only fennel and parsley .This points that our model is follows specialised and market oriented approach for attaining profit maximization goals (EU, 2013). Other studies share the same view and suggest that optimal land use results in a sharp drop in the number of crops grown on the farms. Farmers in these circumstances have to adopt and specialize in producing crops their farms are suited for, aligned with their objectives (Niragira et al., 2013).

Agriculture optimization can be used as an effective herb crop management tool to maximise profits especially in Imereti, cooperatives . Currently EU (2013) is implementing ENPARD programme in Georgia and is focusing on promoting farm cooperatives as a vehicle to boost small scale farmers net profit returns. The model we developed can also be further developed and implemented within the European Union ENPARD programme. The problem which is facing modern agriculture is that prediction of future trends is uncertain due to inadequacy of data to presicely model farm systems. Lack of data in Georgia where this research was done can make this model difficult to apply because of lack of actual feedback from other players like agro-input dealers and middlemen . Most agriculture dealers especially middlemen and input suppliers rarely reveal data on the quantities which they supply to farmers or purchase parse. the

topic,manufacturers and dealers rarely revealing sales data. A complete survey on small farms production systems is lacking, and if it is to be done it would help to better understand the organization of the optimization as an agriculture policy making tool (EU, 2013).

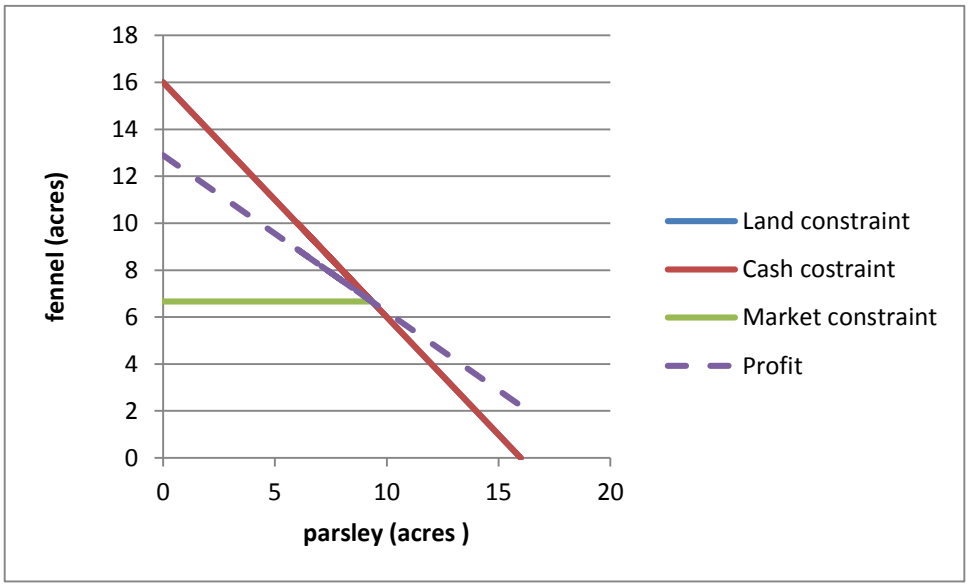

Figure 7: Graphic model scenario

In all the scenarios the labor costs contributed the significant amount of total costs incurred per unit acre per herb crop .Other variable costs such as seed and herbicides did not significantly affect the model outputs. It is important to note that the market is a dynamic system where price fluctuations are unavoidable, thus risks associated with market price fluctuations and market surplus should be considered whenever farm models are developed. Taking into account of obvious risks such as price fluctuations and market saturation can off-set the problems associated with the risks and it is recommended to diversify of crop plans in cooperative farm decision making.

Scenario 3 which signifies our chosen model had all its land bounds going to the upper level of the available land and this strongly illustrated that our model which is scenario 3 is hungry for more land. Both cooperatives are presented with the opportunity to increase their land area capacity if they have enough cash. Land acquisition comes with additional costs but in the case of Georgia, land is inexpensive since the law allows cooperatives to acquire land free of charge without paying land rentals. USAID (2012) reported that the law of Georgia on cooperatives allows small farmer cooperatives in the majority of agricultural enterprises to acquire land through the state at no costs and this

shows us that land acquisition is not an issue among small farmers. However the costs attributed to acquiring extra land such as construction of greenhouses can be a major hindrance in acquiring increasing land area available for herb crop farming.

5.6 Model Limitations

The price of inputs and outputs, the cropping patterns and the yields of the herb crops can be affected by factors such as market price fluctuations, pest and diseases. Furthermore the variables which were used in this model were used as static coefficients. Variability of prices is one of the major factors which affect our model. Intra-cooperative decisions and adaptability of farmers to new cropping techniques can also affect the applicability of our model in Imereti. One of the major assumptions we made is that the price of herbs do not fluctuate in 2016-2017 season .This model is a short term planning measure which is only used in accordance with the current situation in Imereti herbs production.

Our models used site specific calibration parameters and this minimizes the external influence of other parameters which might distort the crop planning decisions . Although Howitt (1994) hinted that the use of acreage elasticities as a source of calibrating information for second-order parameters such as marginals associated with land and cash constraints informs the farmer on the most realistic future trends in his or her farm optimization strategy .This assertion confirms some of the limitations of our model connected to lack of enough data .Our model can not work in isolation without other related external factors such as macro markets involved and thus might be necessary to conduct further modelling strategies to increase optimization optionsm to herb farmers.

6. Conclusion and recommendations

Dovlati and Kvitiri cooperatives have potential to increase the net profit returns from their herb output if they follow the optimization strategy which is highlighted by scenario 3. The model presented by scenario 3 is recommended for both cooperarives as a profit maximization startegy .The model (scenario 3) can be applied in the context of the parameters which were used in scenario formulation .However a significant increase in costs of production structure can alter the patterns of the scenario and can lead to a different crop combination with different profit margins associated with each herb crop.

Dovlati cooperative farmers can save up to 60000 GEL while Kvitiri cooperative can save up to 20000 GEL if they follow the strategy highlighted by our model scenario 3.The resources they save can also be used to acquire more land and cover the costs involved in production such as inputs. To achieve the intended model goals the cooperation amongst farmers should be both on the production and marketing side .This enables the farmers to reduce the costs such as those incuured on labor. Kvitiri is suitable for immediate adoption and application of our model since farmers already cooperation on both prodcution and marketing. The model (scenario 3) presents Dovlati with an opportunity to maximize their profit margin if the farmers cooperate also on production and not only on marketing .

The market prices of herbs both on local and foreign markets have slight fluctuations. Thus the model might not be affected significantly and thus our model can be used taking into consideration the 3 year price trend for herbs.However allocation of land to the different herb crops presented in our recommended model (scenario 3) shows that profit cannot be maximised by crop allocation. This is illustrated by the reduction in the profit as the model attempted to allocate both herb crops under prodcution. Crop allocation in our model has the advantage of diversifying our crop plan and this can enable both cooperatives to minimise risks associated with monocroppping as emphasised in the discussion chapter 5.

7.References

Adam K L. 2005. Herbs: Organic Greenhouse Production. Attra Journals. Available at ; www.attra.ncat.org/attra-pub/PDF/gh-herb.pdf

Affinitas Consulting. 2012. Georgia agriculture: herbs culture, existing investment opportunities. (on-line) Available at : http://emerging-markets-investmentnews./2012/11/georgia-agriculture-herbs-culture.html

Affinitas Consulting. 2013. Greenhouse farming in Georgia. (online) Available at: http://emerging-markets-investment-news./2013/01/greenhouse-farming-ingeorgia.html

Curtis J, DeCook B, Joynt H, Portree J. 2001. Planning For Profit; Culinary Herb- Fraser Valley 1000 square meters. British Columbia Ministry of Fisheries and Agriculture. Available at http://www.hort.vt.edu/ghvegetables/documents/Herbs/BC%20culinary_herb_2001.pdf 2016-02-25.

Clark P V, Arnold B, Barney D L. 1991. Small Farm Herb Production. University of Idaho Extension Department .Moscow Available at; http://www.cals.uidaho.edu/edcomm/pdf/cis/cis1079.pdf

EU . 2014. Precision agriculture: an opportunity for eu farmers - potential support with the cap 2014-2020. Available at http://www.europarl.europa.eu/RegData/etudes/note/join/2014/529049/IPOL-AGRI_NT(2014)529049_EN.pdf 2015-09-14

FAO. 2013. Coping with the food and agriculture challenge: smallholders' agenda. Available at http:// www.fao.org/fileadmin/template/nr/sustainablity_pathways _food and _agriculture _ smallholder _agenda_final.pdf

Fowler K .R, Jenkins E.W , Ostrove C, Chrispell J. C, Farthing M W, Parno M. 2014. A decision making framework with MODFLOW-FMP2 via optimization: Determining trade-offs in crop selection. Available at http://dx.doi.org/10.1016/j.envsoft.2014.11.031.

Gamba P, Komo I. undated. Evolution ,growth and decline of the cooperative sector. Center for governance and development. (online) Available at : http://cgd.or.ke/documents/Cooperatives%20policy%20brief.pdf : pp 4-8.

Garg A , Singh S R. 2005. Optimization under uncertainty in Agricultural production planning. Department of Mathematics, Banaras Hindu University,India. Available at https://www.iconceptpress.com/journal/...intelligence.../1006000041.pdfpp 1-10.

Gelashvili S, Kochlamazashvili I, Katsia I, Mamardashvili P. 2014. The Role of Family Farming in the Sustainable Development of the Agricultural Sector and Poverty Reduction in Georgia. Available at http://www.aea.am/files/papers/w1504.pdf : 2016-03-13.

Geneve R , Kaiser C, Ernst M. 2015. Culinary Herbs. University of Kentucky College of Agriculture, Food and Environment Center for Crop Diversification Crop Profile: 1-4.

Howitt R E. 1994. Positive Mathematical Programming. American Journal of Agricultural Economics, 77(2): 329-342

International Cooperative Alliance. 2015. What is a cooperative ? Avalaible on http://ica.coop/en/what-co-operative: 2016-01-27.

Levina M. 2013. The optimization of the structure of production and distribution of agricultural goods by suburban enterprises of Odessa Journal of Business Perspectives ,11(3): 56-61

Lin B. 2011. Resilience in Agriculture through Crop Diversification: Adaptive Management for Environmental Change. Oxford Journal of Bioscience,63(1): 183-193

LU Sha-sha1, LIU Yan-sui, LONG Hua-lou, GUAN Xing-liang. 2013. Agricultural Production Structure Optimization: A Case Study of Major Grain Producing Areas, China. Journal of Integrative Agriculture, 12(1): 184-197.

Majeke F. 2013. Optimum combination of crop farm enterprises: a case study of a small-scale farm in Marondera, Zimbabwe. The international research journal ,2(1): 60-65

Manos B ,Chatzinikolaou P , Kiomourtzi F. 2013. Sustainable Optimization of Agricultural Production. Asia-Pacific Chemical, Biological & Environmental Engineering Society. Procedia 5 (2013) 410 – 415

Ministry of Agriculture of Georgia ,GeoStat. 2015. Agriculture: The National Priority, Strategy of Agriculture of Georgia. (online) Available at ; http://cu4eu.by/upload/iblock/097/09792507a7acfde2a7e62e7cc24ebe04.pdf.

Mossler M A . 2014. Florida Crop/Pest Management Profile: Herbs (Basil, Cilantro, Dill, Mint, Parsley, Rosemary, Sage, Thyme). University of Florida Extension Dept .(online) Available at http://edis.ifas.ufl.edu/pdffiles/PI/PI10200.pdf .

Mugabe D, Chipunza N, Mupaso N, Munyati T V, Makarudze F V. 2013. Estimation of Optimal Land Use Allocation Among Small Holder (A1) Farmer Households in Zimbabwe. A Case Study of Long Croft Farm, in Mazowe District. Journal of Agricultural Science,6(2): 170- 179

Muncan M. 2009. The use of models in optimizing the field crop production in agricultural enterprise. Journal of Applied Studies in Agribusiness and Commerce, plos 5: 3-4. Available at http://purl.umn.edu/104681

Niragira S. 2011. Optimizing land use among small scale farms through agricultural specialization in the north of Burundi. Master Dissertation. University of Gent. German.pp 20 -27

Ogundari K. 2006. Determinants of profit effciency among small scale rice farmers in nigeria: a profit function approach. Federal university of Technology ,Akure, Nigeria: pp11

Onyenweaku C. E, Igwe K. C,Tanko L. 2013. A Linear Programming Approach to Combination of Crop, Monogastric Farm Animal and Fish Enterprises in Ohafia Agricultural Zone, Abia State, Nigeria. Global Journal of Science Frontier Research Agriculture and Veterinary Sciences,13(3): 1-11

Oxfam. 2015. Building Farmer Cooperatives In Georgia: Supporting smallholder farming in the post-socialist context. (online) Available at http://policy-practice.oxfam.org.uk/publications/building-farmer-cooperatives-in-georgia-supporting-smallholder-farming-in-the-p-561257

People in Need ,Czech University of Life sciences Faculty of Tropical Agrisciences ,Young Economist of Georgia .2015. Agricultural Value Chains in Imereti and Racha Greenhouse production of herbs. Avalaible at http://www.economists.ge/storage/uploads/publication/1509081133367666.pdf

People in Need . 2015. Accelerating development cooperative “dovlati” and cooperative “traditsia” business case. Available at : http : //pin.ge/ /opportunities/Dovlati and traditsia business case 140703 final.pdf : 2016-04-09.

Pinto A.C. 2009. Agricultural cooperatives and farmers organizations. Stockholm . Available at http://www.un.org/esa/socdev/egms/docs/2009/cooperatives/Pinto.pdf : 2016-03-17. pp 3- 4.

Ruben R, Kuiper M and ,Pender J. 2006. Searching development strategies for less favoured areas. Sience Direct Journals. 53 :327-330.

Ruhul A. Sarker M, Talukdar S, Anwarul A. F. M. 1997. Determination of Optimum Crop-mix for Crop Cultivation in Bangladesh. Elsevier Open Access Journals ,21 (10) :621–632

Sanus M, Sadiq. 2015. Optimization of farm resources in small-scale cotton production in niger state Nigeria. Journal of international academic research for multidisciplinary, 3(2): 151-159.

Shergelashvili T, Tokmazishvili M. 2012. Agriculture Transformation in Georgia: 20 years of independence. Available at http: //www.eilat.ge/images/doc /20% 20years% 20of %20 independence/ transformation %20of % 20 georgian % 20 agricultural%20 system% 20eng .pdf : 2016-02-27.

Sofi N A, Ahmed A, Ahmad M ,Ahmad B B. 2015. Decision Making in Agriculture: A Linear Programming Approach. International Journal of Modern Mathematical Sciences,13(2): 160-169.

Thorntona P K, Herreroa M. 2001. Integrated crop–livestock simulation models for scenario analysis and impact assessment . Agricultural System Journal: 70; pp 591-598.

USAID. 2012. Cultivating georgia's herb industry.(online) Available at ; https://www.usaid.gov/results-data/success-stories/cultivating-georgia%E2%80%99s-herb-industry

Vardiashvili M. 2015. Georgian herbs will cost 2-4 euro per kilo in the european market.(online) Available at http://eugeorgia.info/en/article/253/georgian-herbs-will-cost-2-4-euro-per-kilo-in-the-european-market/

Van der Walt L. 2008. Collective Entrepreneurship as a Means for Sustainable Community Development: A Cooperative Case Study in South Africa. Scientific Information System Network of Scientific Journals from Latin America, the Caribbean, Spain and Portugal. 13:2 ;pp14-17.

World Bank. 2012. Financing Farmers, Strengthening Georgia's Rural Development. (online) Availableat: http://www.worldbank.org/en/news/feature/2012/05/14/georgia-financing-farmers

8. Annex of Scenario Data Inputs and Outputs

Dovlati Scenario one

Simulation With Two Herb crops

```
$Ontext
Name          Cooperative Herb farming Optimization
Description   Linear Modelling in Gams
GAMS topics   GAMS
Type          LP

Notes
First linear programming model in GAMS syntax : simple linear model with just
two production activities and two resource constraints.
"Co-operative Farmers growing parsley ,fennel and coriander".
A group of cooperative farmers have a 16 acre farm on which they plant two
herb crops: parsley,coriander and fennel.
For each acre of fennel planted,their expenses are 2000 GEL and for each
acre of parsley planted 2000GEL
Each acre of parsley yields a profit of  1200GEL ;
each acre of fennel yields a profit of 1800 GEL.
If the total capital at hand is 32000 GEL , how many acres of each crop
should they plant in order to maximize their profit? What will be their profit if
they follow this strategy?
$Offtext

**********************************************sets**********************
******
 sets
c crops/fennel ,parsley/
;
scalars
lancons land size in acres /16/
cashcons available cash /32000/
marcon market constraint /0/
```

```
;
parameters
Fcash (C) equation
/
fennel 2000
parsley 2000
/
Fland(C) land equation
/
fennel 1
parsley 1
/

Fmarket(C) market equation
/
fennel 0
parsley 0/

GM(C) profit
/
parsley 1200
fennel 1800
/;
variables
prf profit
;
positive variables
ACT(C) activity levels;
Equations
profit  objective function
land constraint
cash constraint
market constraint
```

;

profit.. sum(C,GM(C)*ACT(C))=e=prf;

land.. sum(C,Fland(C)*ACT(C))=l=lancons;

cash.. sum(C,Fcash(C)*ACT(C))=l=cashcons;

market.. sum(C,Fmarket(C)*ACT(C))=l=marcon;

Model attempt1 first attempt /all/;

******solving********

solve attempt1 maximizing prf using LP;

Dovlati Cooperative ;

Scenario One Solve summary

Scenario One ;Output data summary

MODEL	attempt1	OBJECTIVE	prf
TYPE	LP	DIRECTION	MAXIMIZE
SOLVER	CPLEX	FROM LINE	70

**** SOLVER STATUS 1 Normal Completion

**** MODEL STATUS 1 Optimal

**** OBJECTIVE VALUE 28800.0000

RESOURCE USAGE, LIMIT	0.015	1000.000
ITERATION COUNT, LIMIT	0	2000000000

IBM ILOG CPLEX 24.4.1 r50296 Released Dec 20, 2014 WEI x86 64bit/MS Windows

Cplex 12.6.1.0

Space for names approximately 0.00 Mb

Use option 'names no' to turn use of names off

LP status(1): optimal

Cplex Time: 0.00sec (det. 0.00 ticks)

Optimal solution found.

Objective : 28800.000000

```
                            LOWER     LEVEL     UPPER    MARGINAL

---- EQU profit         .                .          .          -1.000
---- EQU land          -INF        16.000    16.000          .
---- EQU cash          -INF   32000.000 32000.000     0.900
---- EQU market                 (EMPTY)

  profit  objective function
  land  constraint
  cash  constraint
  market  constraint

                        LOWER     LEVEL     UPPER    MARGINAL

---- VAR prf           -INF   28800.000     +INF       .
  prf  profit

---- VAR ACT  activity levels
             LOWER       LEVEL     UPPER    MARGINAL

fennel       .                16          +INF             .
parsley      .                 .          +INF          -600

**** REPORT SUMMARY :        0     NONOPT
                             0 INFEASIBLE
                           0    UNBOUNDED
```

Dovlati Scenario Two

Simulation With Three Herb crops

Input Data(Parameters ,Scalars and Equations)

```
$Ontext
Name          Cooperative Herb farming Optimization
Description   Linear Modelling in Gams
GAMS topics   GAMS
Type          LP

Notes
First linear programming model in GAMS syntax : simple linear model with just
two production activities and two resource constraints.
"Co-operative Farmers growing parsley ,fennel and coriander".
A group of cooperative farmers have a 16 acre farm on which they plant three
herb crops: parsley,coriander and fennel.
For each acre of fennel planted,their expenses are 2000 GEL and for each
acre of parsley planted 2000GEL and for each acre of coriander
the expenses are 2000 GEL.
Each acre of parsley yields a profit of 1200 GEL ;
each acre of fennel yields a profit of 1800 GEL acre of coriander yields
2440 GEL .
If the total capital at hand is 95000 GEL , how many acres of each crop
should they plant in order to maximize their profit? What will be their profit if
they follows this strategy?
$Offtext

**********************************************sets**********************
******
 sets
c crops/fennel ,parsley,coriander/
;
scalars
```

```
lancons land size in acres /16/
cashcons available cash /95000/
marcon market constraint /0/
;
parameters
Fcash (C) equation
/
fennel 2000
parsley 2000
coriander 2000
/
Fland(C) land equation
/
fennel 1
parsley 1
coriander 1
/

Fmarket(C) market equation
/
fennel 0
parsley 0
coriander 0/
GM(C) profit
/
parsley 1200
fennel 1800
coriander 2440
/;
variables
prf profit
;
positive variables
```

```
ACT(C) activity levels;
Equations
profit  objective function
land constraint
cash constraint
market constraint
;
profit.. sum(C,GM(C)*ACT(C))=e=prf;
land.. sum(C,Fland(C)*ACT(C))=l=lancons;
cash.. sum(C,Fcash(C)*ACT(C))=l=cashcons;
market.. sum(C,Fmarket(C)*ACT(C))=l=marcon;
Model attempt1 first attempt /all/;
******solving********
solve attempt1 maximizing prf using LP;
```

Dovlati Scenario Two ;Output data summary

```
Solve summary
    MODEL   attempt1          OBJECTIVE  prf
    TYPE    LP                DIRECTION  MAXIMIZE

**** SOLVER STATUS     1 Normal Completion
**** MODEL STATUS      1 Optimal
**** OBJECTIVE VALUE           39040.0000

 RESOURCE USAGE, LIMIT          0.016      1000.000
 ITERATION COUNT, LIMIT         0    2000000000
IBM ILOG CPLEX   24.4.1 r50296 Released Dec 20, 2014 WEI x86 64bit/MS Windows
Cplex 12.6.1.0
Optimal solution found.
Objective :       39040.000000
                LOWER     LEVEL     UPPER    MARGINAL

---- EQU profit         .         .         .       -1.000
```

```
---- EQU land          -INF     16.000    16.000  2440.000
---- EQU cash          -INF  32000.000 95000.000      .
---- EQU market              (EMPTY)

  profit  objective function
  land  constraint
  cash  constraint
  market  constraint

                    LOWER     LEVEL     UPPER    MARGINAL
---- VAR prf          -INF  39040.000     +INF       .
         prf  profit
---- VAR ACT  activity levels

                    LOWER     LEVEL     UPPER    MARGINAL
fennel                .         .         +INF       -640.000
parsley               .         .         +INF      -1240.000
coriander             .       16.000      +INF          .


**** REPORT SUMMARY :0 NONOPT
                                 0 INFEASIBLE
                                 0 UNBOUNDED
```

Kvitiri Scenario one

Simulation With Three Herb crops

Input Data(Parameters ,Scalars and Equations)

```
$Ontext
 Name           Cooperative Herb farming Optimization
Description     Linear Modelling in Gams
GAMS topics     GAMS
```

Type LP

Notes

First linear programming model in GAMS syntax : simple linear model with just two production activities and two resource constraints.

"Co-operative Farmers growing parsley ,fennel and coriander".

A group of cooperative farmers have a 1.85 acre farm on which they plant three herb crops: parsley,coriander and fennel.

For each acre of fennel planted,their expenses are 2000GEL and for each acre of parsley planted 2000GEL and for each acre of coriander the expenses are 2000 GEL.

Each acre of parsley yields a profit of 1200GEL ;

each acre of fennel yields a profit of 1800 GEL and an acre of coriander yields 2440GEL .

If the total capital at hand is 25000 GEL , how many acres of each crop should he plant in order to maximize his profit? What will his profit be if he follows this strategy?

$Offtext

**********sets**********

```
 sets
c crops/fennel ,parsley,coriander/
;
scalars
lancons land size in acres /2/
cashcons available cash /4000/
marcon market constraint /0/
;
parameters
Fcash (C) equation
/
fennel  2000
```

```
parsley 2000
coriander 2000
/
Fland(C) land equation
/
fennel 1
parsley 1
coriander 1
/
Fmarket(C) market equation
/
fennel 0
parsley 0
coriander 0
/
GM(C) profit
/
parsley 1200
fennel 1800
coriander 2440
/;
variables
prf profit
;
positive variables
ACT(C) activity levels;
Equations
profit  objective function
land constraint
cash constraint
market constraint
;
profit.. sum(C,GM(C)*ACT(C))=e=prf;
```

land.. sum(C,Fland(C)*ACT(C))=l=lancons;

cash.. sum(C,Fcash(C)*ACT(C))=l=cashcons;

market.. sum(C,Fmarket(C)*ACT(C))=l=marcon;

Model attempt1 first attempt /all/;

******solving********

solve attempt1 maximizing prf using LP;

Scenario One ;Input data summary

MODEL attempt1 OBJECTIVE prf

TYPE LP DIRECTION MAXIMIZE

SOLVER CPLEX FROM LINE 76

**** SOLVER STATUS 1 Normal Completion

**** MODEL STATUS 1 Optimal

**** OBJECTIVE VALUE 4880.0000

RESOURCE USAGE, LIMIT 0.031 1000.000

ITERATION COUNT, LIMIT 0 2000000000

Optimal solution found.

Objective : 4880.000000

	LOWER	LEVEL	UPPER	MARGINAL
---- EQU profit	.	.	.	-1.000
---- EQU land	-INF	2.000	2.000	.
---- EQU cash	-INF	4000.000	4000.000	1.220
---- EQU market	(EMPTY)			

profit objective function

land constraint

cash constraint

market constraint

	LOWER	LEVEL	UPPER	MARGINAL
---- VAR prf	-INF	4880.000	+INF	.

prf profit

---- VAR ACT activity levels

	LOWER	LEVEL	UPPER	MARGINAL
fennel	.	.	+INF	-640.000
parsley	.	.	+INF	-1240.000
coriander	.	2.000	+INF	.

**** REPORT SUMMARY : 0 NONOPT

0 INFEASIBLE

0 UNBOUNDED

Scenario simulation with market constraint included

Input data sets

Name Cooperative Herb farming Optimization

Description Linear Modelling in Gams

GAMS topics GAMS

Type LP

Notes

First linear programming model in GAMS syntax : simple linear model with just two production activities and two resource constraints.

"Co-operative Farmers growing parsley ,fennel".

A group of cooperative farmers have a 16 acre farm on which they plant two herb crops: parsley and fennel.

For each acre of fennel planted,their expenses are 2000 GEL and for each acre of parsley planted 2000GEL

Each acre of parsley yields a profit of 1200GEL ;

each acre of fennel yields a profit of 1800 GEL.

If the total capital at hand is 32000 GEL , how many acres of each crop should they plant in order to maximize their profit? What will be their profit if

they follow this strategy?

```
$Offtext
**********************************************sets**********************
******
 sets
c crops/fennel ,parsley/
;
scalars
lancons land size in acres /16/
cashcons available cash /32000/
marcon market constraint /2000/
;
parameters
Fcash (C) cash equation
/
fennel 2000
parsley 2000
/
Fland(C) land equation
/
fennel 1
parsley 1
/

Fmarket(C) market equation
/
fennel 300
parsley 0/

GM(C) profit
/
parsley 1200
fennel 1800
```

```
/;
variables
prf profit
;
positive variables
ACT(C) activity levels;

Equations
profit  objective function
land constraint
cash constraint
market constraint
;
profit.. sum(C,GM(C)*ACT(C))=e=prf;
land.. sum(C,Fland(C)*ACT(C))=l=lancons;
cash.. sum(C,Fcash(C)*ACT(C))=l=cashcons;
market.. sum(C,Fmarket(C)*ACT(C))=l=marcon;
Model attempt1 first attempt /all/;
******solving********
solve attempt1 maximizing prf using LP;
```

Output data summary

```
S O L V E     S U M M A R Y

   MODEL   attempt1          OBJECTIVE  prf
   TYPE    LP                DIRECTION  MAXIMIZE
   SOLVER  CPLEX             FROM LINE  71

**** SOLVER STATUS     1 Normal Completion
**** MODEL STATUS      1 Optimal
**** OBJECTIVE VALUE           23200.0000
```

```
 RESOURCE USAGE, LIMIT          0.016      1000.000
 ITERATION COUNT, LIMIT         0    2000000000
LP status(1): optimal
Optimal solution found.
Objective :       23200.000000
                            LOWER     LEVEL     UPPER    MARGINAL

---- EQU profit                 .         .                 .         -1.000
---- EQU land                -INF      16.000    16.000           .
---- EQU cash                -INF   32000.000 32000.000      0.600
---- EQU market              -INF    2000.000  2000.000       2.000

  profit  objective function
  land  constraint
  cash  constraint
  market  constraint
---- Variable profit
                     LOWER     LEVEL     UPPER    MARGINAL
---- VAR prf            -INF  23200.000     +INF       .
                     prf  profit

---- VAR ACT  activity levels
                  LOWER     LEVEL     UPPER    MARGINAL

fennel             .         6.667       +INF             .
parsley            .         9.333       +INF             .
```

Proposed Model for Dovalti Cooperative

Scenario statement

Notes

First linear programming model in GAMS syntax : simple linear model with just two production activities and two resource constraints.

"Co-operative Farmers growing parsley ,fennel".

A group of cooperative farmers have a 2 acre farm on which they plant two herb crops: parsley and fennel.

For each acre of fennel planted,their expenses are 2000 GEL and for each acre of parsley planted 2000GEL

Each acre of parsley yields a profit of 1200GEL ;

each acre of fennel yields a profit of 1800 GEL.

If the total capital at hand is 4000 GEL , how many acres of each crop should they plant in order to maximize their profit? What will be their profit if they follow this strategy?

**********sets**********

```
 sets
c crops/fennel ,parsley/
;
scalars
lancons land size in acres /2/
cashcons available cash /4000/
marcon market constraint /500/
;
parameters
Fcash (C) cash equation
/
fennel 2000
parsley 2000
/
Fland(C) land equation
/
fennel 1
parsley 1
/

Fmarket(C) market equation
```

```
/
fennel 400
parsley 0/

GM(C) profit
/
parsley 1200
fennel 1800
/;
variables
prf profit
;
positive variables
ACT(C) activity levels;

Equations
profit  objective function
land constraint
cash constraint
market constraint
;
profit.. sum(C,GM(C)*ACT(C))=e=prf;
land.. sum(C,Fland(C)*ACT(C))=l=lancons;
cash.. sum(C,Fcash(C)*ACT(C))=l=cashcons;
market.. sum(C,Fmarket(C)*ACT(C))=l=marcon;
Model attempt1 first attempt /all/;
******solving********
solve attempt1 maximizing prf using LP;
```

Solve summary

```
   MODEL   attempt1          OBJECTIVE  prf
   TYPE    LP               DIRECTION  MAXIMIZE
```

```
    SOLVER  CPLEX            FROM LINE  66

**** SOLVER STATUS     1 Normal Completion
**** MODEL STATUS      1 Optimal
**** OBJECTIVE VALUE           3150.0000

 RESOURCE USAGE, LIMIT         0.031      1000.000
 ITERATION COUNT, LIMIT        0    2000000000

Space for names approximately 0.00 Mb
Use option 'names no' to turn use of names off
LP status(1): optimal
Cplex Time: 0.00sec (det. 0.00 ticks)
Optimal solution found.
Objective :        3150.00000

                    LOWER     LEVEL     UPPER    MARGINAL
---- EQU profit         .         .         .         -1
---- EQU land        -INF     2.000     2.000         .
---- EQU cash        -INF     4000      4000        0.6
---- EQU market      -INF     500       500         1.5

  profit  objective function
  land  constraint
  cash  constraint
  market  constraint

Variable Profit

                LOWER     LEVEL     UPPER    MARGINAL
---- VAR prf        -INF   3150.000     +INF       .
  prf  profit
```

---- VAR ACT activity levels

	LOWER	LEVEL	UPPER	MARGINAL
fennel	.	1.250	+INF	.
parsley	.	0.750	+INF	.

**** REPORT SUMMARY : 0 NONOPT
0 INFEASIBLE
0 UNBOUNDED

Excel values for proposed graphical model

Fennel	Parsley	0	9.333	6	16
	Land con	16	6.667	10	0
	Cash con	16	6.667	10	0
	Market con	6.67	6.667		
	Profit	12.889	6.667	8.889	2.222333

Questionnaire

Farmer's questionnaire (კითხვარი ფერმერთათვის)

A) Basic Information ძირითადი ინფორმაცია

1. Name of the interviewer …….ინტერვიუერის სახელი
2. Date of interview ……. /……. /…….ინტერვიუს თარიღი
3. Name of the respondent (farmer)……რესპონდენტის (ფერმერის) სახელი.
4. Name of the cooperative …… კოპერატივის დასახელება

B) Demographics and household characteristics of farmers' co-operative დემოგრაფია და ფერმერთა კოპერატივის საოჯახო დახასიათება

Co-operative member კოპერატივის წევრი	Age ასაკი	Education განათლება	Main activity /Secondary Activity ძირითადი საქმიანობა/ მეორადი საქმიანობა
Head of household /spouse ოჯახის უფროსი/ მეუღლე			

C) Objective of the farmer (yes/no) ფერმერის მიზანი (დიახ/არა)

1. Subsistence საარსებო საშუალება…….. ( )
2. Profit and market oriented სარგებელი და ბაზარზე ორიენტირებული…… ( )

D) Characteristics of Cooperative Plots კოპერატიულრი მიწის ნაკვეთის დახასიათება

1. Number of the plot მიწის ნაკვეთის რიცხვი …….
2. Major crops grown ძირითადი გაზრდილი მოსავალი …….
3. Hectarage of plot მიწის ნაკვეთის ჰექტარი ……(m^2)
4. Distance of Plot from market მანძილი მიწის ნაკვეთიდან მაღაზიამდე ……(km)
5. Land Quality (Soil Type) მიწის ხარისხი (ნიადაგის ტიპი) …….

E) Farming used to techniques to improve fertility (Please tick in brackets)

1. Which organic fertilizers do you use? რომელ ორგანულ სასუქებს იყენებთ?

a) Mulching ……. …….. ( )
b) Crop Residues მოსავლის ნარჩენები …… ( )

c) Animal waste ცხოველთა ნარჩენები …… …… ( )
d) Compost კომპოსტი …… ( )
e) Others სხვა …… ( )

2. Which chemicals do you use chemicals in improving fertility and crop quality?

a) Inorganic fertilizers არაორგანულ სასუქებს …… .( ) (specify type of chemical fertilizer) დააკონკრეტეთ ქიმიური სასუქის ტიპი
b) Insecticides and pesticides ინსექტივიდებსა და პესტიციდებს …… ( ) (specify type of chemical used) დააკონკრეტეთ ტიპი
c) Others სხვა …… ( )
d) None არცერთი …… ( )

3) Which crop water sources do you rely on? წყლის მოსავლის რომელ წყაროს ეყრდნობით?

a. Irrigation მორწყვა, ირიგაცია…… ( )
b. Seasonal rainfall სეზონურ წვიმას…… ( )
c. Others სხვა …… ( )

4. Which soil conservation and cultivation techniques do you use? ნიადაგის შენარჩუნებისა და მიწის დამუშავების რომელ ტექნიკებს იყენებთ?

a. Ridging …… ( )
b. Terracing …… ( )
c. Strip cropping …… ( )
d. Others …… ( )

F. Land Tenure and Ownership of plot

1. How many years have you been using this plot? ……(years /months)

2. What is the type of land tenure used on this plot? ……..

3. Which ownership do you have claim on this plot? ……

G.) Land management techniques

1. By how much land area is put under cultivation during the first cropping season (Hectares of the land used per season in past three years? ( ) (Hectares)

2. What are the major crops that were grown in first season? ……..

3. How much land is put under production in the second cropping season? (Hectares of land in the past three years)(……..)

4. What are the major crops that were grown on this Plot in second season?

……..

H. Agricultural Production inventory

Year 1

Crop	Average Yield/Plot (ha)	Market Price ($/kg)	Quantity Sold	Profit Margin	Season

Year 2

Crop	Average Yield/Plot (ha)	Market Price ($/kg)	Quantity Sold	Profit Margin	Season

Year 3

Crop	Average Yield/Plot (ha)	Market Price ($/kg)	Quantity Sold	Profit Margin	Season

Inputs production Inventory

Input	Average Price/per kg/litre	Quantity Purchased /Plot (kg /Litres/ha)	Average Quantity Used/plot Ha	Source of Input (private seller /govt)

J. Labor Factor

1. How many employees do you have ?.....
2. How many work hours do you have per week?.....
3. How much do you pay your employees per season (total amount)……
4. a) Do you hire employees in any season ?(Yes/No)
   b) If Yes, how many work days did you hire in first season in first year?……..
   c) If Yes, how many employees do you hire in second season first year?.....