Chapter 7

Analysis Hierarchy Process and Regression Analysis

This chapter will identify the farmers' preferences to the extension approaches that are applying at the study area for dissemination the improved technologies to farmers on coffee production and analyze how different inputs affect coffee yield as well as the impact of extension on coffee production. The chapter is divided into two sub-topics: Analytic Hierarchy Process (AHP) and production function analysis.

7.1 Analytic Hierarchy Process (AHP)

7.1.1 AHP procedures

Adhikarya (1994) said that one of the means to improve the effectiveness and efficiency of agricultural extension programs is through the application of improved and innovation of extension methods. Blanckenburg (1984) stated that the extension approach can decide how much farmers will be reached, and it plays a very striking role for the success of the extension programs. As above mentioned, the transferring of improved technology process to coffee farmers, the extension agents in DakLak province are currently applying five main extension approaches, which included demonstration, lecture, mass media, T & V system, and farmer-led approach. Each of these extension approaches has their own advantages and disadvantages. Selecting the suitable ones by farmers, who had been access to the extension programs, will be useful tool for the extension agents, who would be priority selection for their own situation aimed to improve the extension efficiency and meet the farmers' basal requirements. Oakley and Garforth (1985) stated that it should ensure the selected method to promote the farmers' better understanding of the technologies involved. The AHP approach (Analytic Hierarchy Process) was adopted to solve this objective.

The Analytical Hierarchy Process (AHP) is a decision-aiding method developed. It is aimed at quantifying relative priorities for a given set of alternatives on a ratio scale based on the judgment of the relevant participants and stresses the importance of the intuitive judgments of a decision-maker as well as the consistency of the comparison of alternatives in the decision-making process (Saaty, 1980). Since a decision-maker bases judgment on knowledge and experience, they make decisions accordingly. The AHP approach agrees well with the behavior of a decision-maker. The strength of this approach is that it organizes tangible and intangible factors in a systematic way, and provides a structured yet relatively simple solution to the decision-making problems (Skibniewski *et al.*, 1992, cited in Alharbi, 2001). Furthermore, by breaking a problem down in a logical fashion from the large, descending in gradual steps to the smaller and smaller one that is able to connect through simple pair-wise comparison judgments. The AHP allows group decision-making, where a group of some members can use their experiences, values and knowledge to break down a problem into a hierarchy and solve it by the AHP steps (Duke and Aull-hyde, 2002). Brainstorming and sharing ideas and insights often leads to a more complete representation and understanding the issues, it has been used for capturing the perceptions of stakeholders on the relative severity of different socio-economic impacts, which will help the authorities in prioritizing the environmental planning (Ramanathan, 2001).

Duke and Aull-hyde (2002) proved that AHP is not a statistically based methodology, a sample size of one is enough to implement as it was originally developed to enable a single decision maker's to select an alternative among multiple alternatives. The method has been extended to enable the use of AHP in group decision making process where the single decision maker is actually a group of (N) people. The author used surveyed data to compare the public sources of value for the environment, agriculture, growth control, and open space attributes of preserved land. Then, the AHP found that the public preference is strongest for environmental criteria. Similar to Alharbi (2001) based on the proposal criteria like experience, quality performance, equipment resources, financial stability, manpower, and current works load to select the best contractors to perform project in Saudi Arabia.

Besides, AHP allows the participations more than one person as a decision maker. It can accommodate the non-linear preferences and interdependence of criteria. One of the key attractions is the transparency of the decision process and results. Simplifying preference structures can eliminate hidden ambiguities and criteria so that everybody understands the mechanics of the process, which in turn increase credibility. AHP facilitates the easier communication between different parties who often find it difficult to come to a consensus (Ananda and Herath, 2002). When more than one member of a particular stakeholder is presented in the process and a consensus cannot be reached among that group, the representative democracy approach could be applied.

7.1.2 Farmers' preferences on the extension approach

A series of participatory workshop were organized, of which, 30 participants at Cu Sue commune were selected for this exercise. The participants included coffee farmers who had access to the extension programs, and representatives from relevant unions of Cu Sue commune. They were the member of women association, local leaders, credit, irrigation, and farmers association. The purposes of the participatory workshop obtained the overview information as regards to demography, land use patterns, crops, livestock, farming system, credit, crop calendar, and other aspects related to extension activities, extension methods, and farmers' practices on coffee. Of which, the participants spent much time to identify the farmers' preferences to extension approaches on dissemination the innovative technologies.

The participants were assigned to list the criteria to be contributed to the efficiency of the extension approaches. Then, eight criteria were listed, namely interactive, responsible, effective, realistic, broad-based impact, adoptable, accessible and understandable in Table 33 (these criteria will be defined in next paragraphs). In order to reduce the overlap or similar meaning criteria and limit the complication for matrix comparison in the next step, the participants again were assigned to rank the mentioned criteria to select the most representative ones that might contribute most to the efficiency of the extension programs. This stage is called pair-wise comparison matrix among the extension approaches based on individual criteria.

Table 33 Scoring to select criteria for the efficiency extension approaches

Criteria	Ranking								Total	Total	Rank
	I	II	III	IV	V	VI	VII	VIII	row	score	order
Interactive	3	1	7	6	5	4	1	3	30	130	4
Responsible	1	7	3	4	5	4	3	3	30	134	5
Effective	0	4	2	3	5	5	9	2	30	160	6
Realistic	7	4	4	5	4	3	0	3	30	109	3
Broad-based Impact	9	5	3	4	3	2	1	3	30	102	2
Adoptable	10	6	3	5	3	1	2	0	30	86	1
Accessional	0	2	3	3	5	5	7	5	30	169	7
Understandable	0	1	5	0	0	6	7	11	30	190	8
Total column	30	30	30	30	30	30	30	30	240		

Source: Participatory workshop, 2002.

Each participant in the workshop was asked to rank themselves within 8 criteria, which ranged from one to eight according to their own ideas. The result obtained from accumulation of 30 participants was filled in Table 33 with total score recorded in the last column. Total score is obtained by multiplying the priority ranking by the number of respondents. The lower the score the higher considered important criteria. Then five priority criteria were selected for pair-wise comparison matrix, consisted of adoptable (1), broad-based impactive (2), realistic (3), interactive (4), and responsible (5).

Interactive criteria in extension, as agricultural extension itself cannot supply farmers with all information that could possible be used. Extension, however, was often successful when it facilitates farmers' access to other sources of information, such as potential new markets or new techniques. Successful programs are those cases in which direct contact between farmers and other actors was established. This means that research, extension and market are presented for exchanging in a management unit dominated by producers. The participants were asked to make the pair-wise comparison matrix among the five extension approaches, which based on the interactive criteria, and Table 34 shows the result of this comparison. As the value of CR (Consistency Ratio) is less than 0.1, the judgment was acceptable and the value of priority vectors and options for each extension approach were calculated in the final column. The values obtained from pair-wise judgment in Table 34 in term of interactive criteria imply that demonstration is equally important to T & V approach (importance ratio 1:1), and half as important to the farmer-led approach (important ratio 1:1/2) while threefold and fourfold as more important to class room and mass media (important ratio are 3:1/3 and 4:1/4).

Table 34 Pair-wise comparison matrix for interactive criteria

Interactive	Demons-tration	Class room	Farmer-led approach	Mass Media	T & V Approach	Row Sum	Priority vector
Demonstration	1.00	3.00	0.50	4.00	1.00	1.21	0.243
Class room	0.33	1.00	0.25	1.25	0.50	0.47	0.094
Farmer-led	2.00	4.00	1.00	3.00	1.50	1.75	0.350
Mass media	0.25	0.80	0.33	1.00	0.25	0.38	0.077
T & V appr.	1.00	2.00	0.67	4.00	1.00	1.18	0.237
Column Total	4.58	10.80	2.75	13.25	4.25	5.00	0.9990

Source: Participatory workshop, 2002, $\lambda max = 5.326$*, CI = 0.814, CR = 0.073*

Note: CI: Consistency Index, RI: Random Index, CR: Consistency Ratio, CI = $\frac{\lambda \max - n}{n - 1}$, λmax called maximum or principle eigenvalue, n: number of activities in matrix, sample size (n = 5), RI = 1.12, CR = CI/RI Saaty (1980).

Saaty (1980) defined the consistency ratio as CR = CI/RI. Of which, RI (Random index) is the consistency index of a randomly generated reciprocal matrix from the nine points scale with reciprocal forced for the size of matrix or number of activities in the matrix (n = 5) denotes its value at 1.12. An average RI generates for matrix of order 1 to 15 using a sample size of 100. One would expect the RI to increase as the order of the matrix increases. The RI values for matrix of different sizes are shown in Table 35. Value of CR ≤ 0.1 are desired. Higher CR values imply an unacceptable level of inconsistency, it means that the inputs judgment are not consistent, and hence are not reliable and participants would be asked to revise their pair-wise comparison ratings (Detail steps of the AHP calculation method is attached in the Appendix III).

Table 35 The average consistencies of random index – RI values

Size	1	2	3	4	5	6	7	8	9	10
RI	0.00	0.00	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49

Source: Saaty, 1980.

Realistic criteria in extension, as an extension agents often help farmers adjust skills to promote rapidly production and market conditions changes or play a direct role in changing them. Therefore, extension must access these conditions realistically. In the past, this has generally enticed into new production areas on the basis of unrealistic assessments of their market opportunities or techniques that were promoted for which logistical, institutional or social conditions lacking, such as a sales network for inputs or local condition requirements. In this case, the participants were asked to rate the pair-wise comparison matrix among the five extension approaches, which based on the realistic criteria, and Table 36 shows the result of this comparison with the acceptable value of CR less than 0.1. Priority vectors and options for each extension approach were calculated and evaluated respectively in the final column. The values obtained from pair-wise judgment in Table 36 in term of realistic criteria imply that demonstration is equally important to T & V approach (importance ratio 1:1), and half as important to the farmer-led approach (important ratio 1:1/2) while threefold and fourfold as more important to class room and mass media (important ratio are 3:1/3 and 4:1/4).

Table 36 Pair-wise comparison matrix for realistic criteria

Realistic	Demons-tration	Class Room	Farmer-led approach	Mass Media	T & V approach	Row Sum	Priority vector
Demonstration	1.00	3.00	0.50	4.00	1.00	1.24	0.249
Class room	0.33	1.00	0.50	2.50	0.50	0.64	0.129
Farmer-led	2.00	2.00	1.00	5.00	1.50	1.69	0.338
Mass media	0.25	0.40	0.20	1.00	0.50	0.35	0.070
T & V appr.	1.00	2.00	0.75	2.00	1.00	1.07	0.214
Column Total	4.58	8.40	2.95	14.50	4.50	5.00	0.9990

Source: Participatory workshop, 2002, $\lambda max = 5.395$, $CI = 0.0987$, $CR = 0.0881$

Broad-based impactive criteria in extension, as extension is expensive, it must finance out of the profits from increased agricultural production. This is only possible whether the quality of extension is measured in term of contents and methods is high access or many farmers are reached simultaneously. The average quality of the extension agents drop and inefficiencies creep as a result of widespread geographic and thematic dispersal whilst the number of extension staff is limited in dealing with their clients. The participants were also asked to rate the pair-wise comparison matrix among the five extension approaches, which based on this criteria, and Table 37 shows the result of this comparison with the acceptable value of CR less than 0.1. Priority vectors and options for each extension approach were calculated and evaluated in the final column respectively.

In term of realistic criteria, the value of priority vector shows that the farmer-led approach obtained the highest value, followed by demonstration, then T & V approach while mass media and classroom were less preferable by farmers, it seems that the farmer-led and demonstration approaches shared to farmers with actually and realistic information "fit" their needs and interests, such components as fertilization, pruning, irrigation, and the people as well as the climate, access to markets, price policies, and other relevant factors were all be taken realistic consideration.

Table 37 Pair-wise comparison matrix for broad-based impact criteria

Broad-based impact	Demons-tration	Class Room	Farmer-led approach	Mass Media	T & V approach	Row Sum	Priority vector
Demonstration	1.00	2.00	1.00	2.50	1.25	1.34	0.268
Class room	0.50	1.00	0.60	1.25	0.60	0.69	0.138
Farmer-led	1.00	1.70	1.00	3.00	1.60	1.42	0.284
Mass media	0.40	0.80	0.33	1.00	0.50	0.52	0.103
T & V appr.	0.80	1.70	0.63	2.00	1.00	1.04	0.207
Column Total	3.70	7.20	3.56	9.75	4.95	5.00	0.9990

Source: Participatory workshop, 2002, λmax = 5.445, CI = 0.111, CR = 0.093

Responsible criteria, acceptance of agricultural extension programs increase the positive impact on farm practices when farmers take more responsibility for a program. They must occur themselves at several levels in managing, planning, and evaluating the extension programs. For instance, it is critical that the extension agency defines programs by working with farmers to achieve a balance of interests and base on farmer-driven. Similar to above procedure, the participants also assigned to make the pair-wise comparison matrix among the five extension approaches, which based on responsible criteria, and Table 38 shows the result of this comparison with the acceptable value of CR less than 0.1, and priority vectors and options for each extension approach were calculated and evaluated in the final column respectively. The values obtained from pair-wise judgment in Table 38 in term of responsible criteria imply that demonstration is equally important to T & V approach (importance ratio 1:1), and 0.55 as important to the farmer-led approach 1.8 (important of 0.55: 1.8) while twofold and threefold as more important to class room and mass media (important ratio are 2:1/2 and 3:1/3).

Table 38 Pair-wise comparison matrix for responsible criteria

Responsible	Demons-tration	Class Room	Farmer-led approach	Mass Media	T & V approach	Row Sum	Priority vector
Demonstration	1.00	2.00	0.55	3.00	1.00	1.29	0.258
Class room	0.50	1.00	0.50	2.00	0.50	0.69	0.137
Farmer-led	1.80	2.00	1.00	4.00	1.50	1.66	0.332
Mass media	0.33	0.50	0.25	1.00	0.50	0.42	0.083
T & V appr.	1.00	2.00	0.67	2.00	1.00	1.10	0.219
Column Total	4.63	7.50	2.97	12.00	4.50	5.15	0.9990

Source: Participatory workshop, 2002, $\lambda max = 5.450$, $CI = 0.113$, $CR = 0.1$

Adoptable criteria in extension, one of the tasks of extensionist is promoting the spread of innovations, and how extension clients decide whether to adopt or reject these innovations. Implementation often implies that the innovations are modified to suit more closely with the needs of the farmers and more attention is paid to the development of appropriated technologies or ideas and methods are suited to the needs and conditions of the majority farmers. Finally, the participants were assigned to do the pair-wise comparison matrix among the five extension approaches, which based on the adoptable criteria, and Table 39 shows the result of this comparison with the acceptable value of CR less than 0.1; priority vectors and alternatives for each extension approach were calculated and evaluated respectively in the final column. The values obtained from pair-wise judgment in Table 39 in term of adoptable criteria imply that demonstration is equally important to farmer-lead approach (importance ratio 1:1), and 1.5 as important to the class room (important of 1.5: 2/3) while 2.5 and 1.25 as more important to mass media and T & V system.

Table 39 Pair-wise comparison matrix for adoptable criteria

Adoptable	Demons-tration	Class Room	Farmer-led Approach	Mass Media	T & V approach	Row Sum	Priority vector
Demonstration	1.00	1.50	1.00	2.50	1.25	1.26	0.251
Class room	0.67	1.00	0.80	1.70	0.60	0.83	0.166
Farmer-led	1.00	1.25	1.00	2.00	2.00	1.31	0.262
Mass media	0.40	0.60	0.50	1.00	0.33	0.50	0.099
T & V appr.	0.80	1.70	0.50	3.00	1.00	1.11	0.221
Column Total	3.87	6.05	3.80	10.20	5.18	5.00	0.9999

Source: Participatory workshop, 2002, $\lambda max = 5.443$*,* $CI = 0.110$*,* $CR = 0.0989$

The pair-wise comparison matrixes were implemented to measure the value of priority vector for each extension approach, which based on the five individual criteria. The same pair-wise comparison procedure to set priority for all five criteria was carried out aiming to contribute into the overall goal of the AHP process. Table 37 shows the result of pair-wise comparison matrix and priority vector for the five criteria were calculated with the value respectively in the priority vector column.

Table 40 Pair-wise comparison matrix for 5 criteria

Criteria	Interactive	Realistic	Broad based Impact	Respo-nsible	Adoptable	Row Sum	Priority vector
Interactive	1.00	0.50	0.33	1.00	0.50	0.55	0.110
Realistic	2.00	1.00	0.50	1.50	1.25	1.07	0.213
Broad impact	3.00	2.00	1.00	1.70	0.67	1.38	0.275
Responsible	1.00	0.67	0.60	1.00	0.33	0.61	0.122
Adoptable	2.00	0.80	1.50	3.00	1.00	1.40	0.279
Column Total	9.00	4.97	3.93	8.20	3.75	5.00	0.9990

Source: Participatory workshop, 2002, $\lambda max = 5.323$*,* $CI = 0.080$*,* $CR = 0.072$

Combining the priority vectors of pair-wise comparison matrix of each criteria with the result of pair-wise comparison matrix for five criteria, the overall priority ranking of the decision alternative was developed, which was termed as the priority matrix as followed in Table 41. Of which, the overall priority vector was calculated by multiply the value of each extension approach match with the value of each individual criteria, and result is presented as followed Table.

Table 41 Priority matrix for selecting the extension approaches

Extension Approaches	Interactive (0.110)	Realistic (0.213)	Broad impact (0.275)	Responsible (0.122)	Adoptable (0.279)	Overall priority vector	Rank
Demonstration	0.243	0.249	0.268	0.258	0.251	0.243	2
Class room	0.094	0.129	0.138	0.137	0.166	0.163	4
Farmer-led	0.35	0.338	0.284	0.332	0.262	0.302	1
Mass Media	0.077	0.07	0.103	0.083	0.099	0.089	5
T & V	0.237	0.214	0.207	0.219	0.221	0.217	3

Source: Participatory workshop, 2002.

In other words, as the value of CR is less than and equal to 0.1 or 10 percent, the judgments were acceptable for the entire above matrixes. For pre-qualification purposes, the extension approaches were ranked according to their overall priorities in Table 40: Farmer-led approach (0.302), demonstration (0.243), T & V approach (0.217), classroom (0.163) and mass media (0.089). Of all the extension methods used by the extension agents on coffee production, farmer-led approach was the most preferred one. Farmers preferred this approach because it addresses their needs. It reflects the need for the extension programs to be more strategically planned, need-based, and problem solving oriented. Hussain *et al.* (1994) found that the role of the contact farmers would become one of the catalyst and co-researcher rather than "bringer of messages". Such revision of extension approach represents acceptance of the overriding validity of the farmers' understanding of the circumstances and environments in which they operate.

The mass media approach was the least preferred by the farmers at the study area due to limited opportunities for providing feedbacks, and provided information were in general aspects for the whole region with unselected specific sites. This approach can not do all the jobs of an extension agent like personnel advise, teaching practical skills, or answer the questions immediately. It can't be applied to different ecological and social conditions. Hussain *et al.* (1994) found that the recommendations distributed by the extension agents were generally not specific location. Rather, they made for a wide area without taking into account the considerable variability in the socio-economic and agro-ecological circumstances of farmers in what appears at first to be a relatively homogeneous. It is, however (Heong *et al.*, 1998) found that the mass media channels relatively important at the awareness of knowledge in the innovation process. They can reach in a large audience rapidly, created knowledge and spread information, and these can lead to changes in farmers' attitudes. The information on the leaflets and posters encourage farmers to contact the plant protection department to learn more about pest and disease management aimed facilitating the learning process. It is evident that the new information had diffused to a large population changing the farmers' attitudes toward reducing insecticides application.

For lecture, this method is easy to implement and it can be introduced for many people at the same time. Currently the contents are introduced in general, the trainees perceive mostly on the theory lessons while the practical items are very limited that is why the comparison result was not so high compared to other approaches, the farmers soon forgot and trouble in real application. Farmers stated that they could not follow any things that were taught in the training class, but it was a good source information and knowledge, which created awareness for trainees.

T & V system was also preferred by farmers as the extension agents on their regular field visits or monitor fields, report their observation, give advise and suggest the course of action to be followed by farmers. It is, however, the extension agents, who seem to have inadequate knowledge to cover all relevant knowledge to recommend to farmers as well as workload status. Therefore, the extension agents could not devote all of their time to the fieldwork. Hussain *et al.* (1994) indicated that the limited success of T&V in Pakistan reflects the problems of implementation, for instance only a small proportion of farmers had contact with the extension agents as well as lack of adaptive research to make the recommendations are more relevant to farmers.

Extension and farmers normally carry out the demonstrations jointly. This approach was ranked as the second preferred by farmers, this can be explained that the method seems closely interaction between farmers and the extension agents, and the extension programs often provide the demonstrators with a subsidy costs called "sharing costs", the costs for implementation the models like fertilizer, pesticide or irrigation. Farmers need to be assured that what they heard, how new ideas are indeed workable, and it is the complementary activity when lecture is not understood. Result from the demonstration implementation shows the local farmers that a particular new recommendation is practical under local conditions. Field days are recommended because they allow individuals to reinforce their interest by viewing the tangible evidences, it aims present to farmers a comparison between their own practices and extension's recommended ideas. During the field day workshop, exchangeable among farmer is an important chance for them to learn from each other aim improving their knowledge and accumulate experiences. These types of experiences allow the removal of doubts. Some skills in training may be necessary at this stage to facilitate the individual's progression to the trials. Oakley *et al.* (1985) stated that the advantage of demonstration method is proposed that the extension agents can explain farming skills to a large number of people, thus increasing the impact of their extension work. There is a greater chance that they will benefit from the demonstration than if they were passively hearing it in a lecture. It is, however, this method takes a long time to mature and is thus a costly of extension resources, carefully planning, and efficient execution. If the end the new practice failures because of lack of rain, for instance, are outside the control of extension agents, it could have disastrous consequences.

One of the major benefits of the extension approach is that it eliminates the separate traditional top-down technology transfer model by merging the technology generation and diffusion process together. By the time a technology is developed, it is already known, understood, and experimented by farmers. As technological innovation is based on farmers' needs, and farmers play an active role as problem identifiers, collaborators, testers, and evaluators. The traditional work of extensionist is the technology transfer process, diffusing research-oriented and research-station developed the technologies to farmers. Here, it changes to a role of networking and building collaborative relationship between farmers and extension agents.

7.2 Production function analysis

7.2.1 Descriptive statistics

Table 42 shows the inputs used for all interviewed farmers of two groups of Cu Sue commune, the contact and the non-contact farmers. As the recommendation comes from research and extension for fertilizer application rated of 340 N: 100 P: 230 K. The result illustrated that the amount of nitrogen and potassium were not so much different compared to the recommended ratio, in average 365.8 kg nitrogen was applied, a little bit higher and 210.6 kg of potassium a little bit lower to recommended ratio. Phosphorous was quite high compared to the recommendation ratio of 113.5 kg pure-phosphorous or equivalent to 709.4 kg super-phosphate ha^{-1} $year^{-1}$. The gap among farmers on fertilizers usage was high for nitrogen that ranged from 235 to 470 kg ha^{-1} $year^{-1}$, phosphorous ranged from 110 kg up to 350 kg, and potassium 70 kg up to 350 kg ha^{-1} $year^{-1}$. Water's usage was 2,836 cubic meters as compared to the recommended of 2,500 cubic meters (in the drought years). There is, however, a big ranging among farmers from 2,400 up to 3,600 cubic meters even if their coffee gardens were located at the area with similar ecological conditions; in fact, some farmers had irrigate their farms with double amount of water in comparison to others.

Table 42 Annual inputs used by contact and non-contact farmers and coffee yield

Variables	Unit	Mean	Std.dev	Min	Max
Nitrogen	Kg ha^{-1}	365.8	38.6	235	470
Phosphorous	Kg ha^{-1}	213.5	59.3	110	350
Potassium	Kg ha^{-1}	210.6	55.6	70	350
Pest and disease control	Litter	461.8	124.6	192.8	760
Irrigation	M^3 ha^{-1}	2,836	265	2,400	3,600
Labour	Man-day	287.1	33.3	213	375
Yield	Ton ha^{-1}	2.9	0.302	2.0	4.0

Source: Survey, 2002

7.2.2 Multiple Regression Analysis for both groups

Multiple regression analysis was carried out under the Cobb-Douglas production function form, which was adopted as explained in the chapter three. The parameters or coefficients and related statistical test results of the independent variables obtained from regression analysis are given in Table 43. It explains about the relationship or the responses of coffee yield to a set of different inputs, which included nitrogen, phosphorous, potassium, irrigation, pest and disease management, labour, and dummy variables consisted of extension, pruning and manure.

Potassium variable had positive coefficient (0.064) and statistically significant at 10 percent effect level on coffee's yield. Therefore, holding others variables in the model constant, increase or decrease in the use of this input will lead to the increase or decrease in output in appropriate proportion. One percent increase in potassium input will lead to increase the output by about 0.064 percent on the average. Nam and Hong (1999) stated that young coffee rarely respond to the application of potassium fertilizer, but it is more sensitive for the bearing coffee period, and potassium usually becomes inadequate when the trees are bearing a heavy crop as in terms of losses in the crops and promote for the development of fruits.

Table 43 Result of regression analysis on factors affecting coffee yield

Independent variable	Coefficients	Standard Error	t Stat
Intercept	0.422887***	0.19357	2.18467
Ln.nitrogen	0.150446 ***	0.061302	2.454183
Ln.phosphorous	-0.01143 ^{ns}	0.053279	-0.21459
Ln.potassium	0.063996 *	0.022581	1.948313
Ln.irrigartion	-0.15277 **	0.07716	-1.97989
Ln. pest & disease control	-0.02679 ^{ns}	0.035129	-0.76269
Ln.labor	0.150023 *	0.080206	1.870455
D.extension	0.110306 ***	0.043495	2.536060
D.pruning	0.045952 ***	0.015092	3.044834
D.manure	0.042776 ***	0.014229	3.0063
R^2	0.628978		
Adjusted R	0.601151		
Number of observation	130		
F computed	22.60		

$^{***, **, *, ns}$ *indicate statistical significant at 1 percent, 5 percent, 10 percent, and none significant, respectively.*

Phosphorous was found to have negative and insignificant effect on coffee yield, implying that the farmers did not use phosphorous at optimal level. Farmers may overuse this input, or application time may not be appropriate. The result from the survey indicated that the amount of this input invested through the whole commune was found to be higher as compared to the recommended ratio of 113.5 kg ha^{-1} $year^{-1}$ that was equal to 709.4 kg super-phosphate ha^{-1} $year^{-1}$ whilst the recommendation ratio from extension was 100 kg ha^{-1} $year^{-1}$ equivalent to 625 kg ha^{-1} $year^{-1}$. As the amount of phosphate removed in the crop is small, but coffee in the bearing period have almost developed the root system compared to the young coffee tree so direct responses applications of phosphate to the mature are rare. Wrigley (1988) found phosphorous element always associated with root growth. Therefore, it is better to apply for the establishment of coffee gardens or immature coffee aims to encourage the root system development, and the level is reduced during the productive life of the tree. Moreover, the phosphorous is considered as an unabsorbable fertilizer, especially application in the low temperature, therefore, it will be better if applied with cattle manure (Chinh, 2001). The actual amount of phosphorous applied found to be consistent with the recommended ratio. Hence, coffee production was not affected by the amount of phosphorous applied. Farmers should reduce the quantity of this element. As Wrigley (1988) found in many tropical soils immobilize phosphorous, iron and aluminum phosphates are formed, and in calcareous soils, calcium and magnesium phosphate. All these compounds are in low solubility and make the crops difficult to take up phosphorous. This has resulted in negative impact on ecosystem deterioration in the soil where their income did not significantly increase.

Nitrogen had positive coefficient (0.15) and statistical significance on coffee yield at one percent level. The contact farmers applied equal to the recommended rate whilst for the whole farmers in this commune, a little bit higher as compared to recommended rate of 72.8 kg Urea ha^{-1} $year^{-1}$. Wrigley (1988) stated that all conditions are right for the coffee tree--management, soil moisture, and no elements are deficient then the available nitrogen has the greatest effect on coffee yield. Consequently, for the whole commune, increase or decrease in the use of this input will lead to the increase or decrease in output in appropriate proportions. One percent increase in nitrogen will increase the output by about 0.15 percent for farmers in average whilst holding the others variables in the model in constant. Snoeck and de Reffye (1980), cited in Clifford and Willson (1985) stated that the increase yield as a consequence of an increased in the number of fruiting nodes which was significantly related to the application level of nitrogen as putting nitrogen to robusta coffee will promote the vegetative growth because nitrogen promote increase of nodes per branch without affecting the internodal distance.

Coefficient of family labour variable was found to be positive coefficient (0.15) and statistically significant at 10 percent level. The family labour consists of pruning, weeding, enlarging basal irrigation, irrigation, fertilization and harvesting.

As above explained, maintenance of coffee garden cost a lot of family labour, it is not only normal labour, but also need skilled labour for some activities like pruning or grafting and even harvesting. The result indicated that increase one percent of labour spend would increase the output by about 0.15 percent in average whilst holding other variables in constant. This could be explained that the coffee garden is near farmers' households so it does not take time for distance and all activities can be done by all sources of labor in the family at anytime.

The elasticity of pest control is small and negative (-0.027) and not statistically significant. It means forecasting or predicting of farmers on damaging due to harmful insects and diseases are weak and not timely. The farmers had less knowledge to describe the behavior of each individual ones as well as their damage on coffee. Farmers cannot differentiate disease from insects or identify exactly the reasonable types of pesticides and insecticides to control each individual object species. This leads to spray the insecticide untimely or farmers might use over dosage with high concentration. As the coffee tree pollen is wind borne, and coffee flowers, which are white and a pleasant sweet smell, are so attractive in both, color and scent that they are frequented by many insects such as, bees and wasps. The spray of pesticides might kill these beneficial insects, which leads to the reduction of flowering pollination process.

As sated above, irrigation is one of the important management practices, which can either increase or reduce yield by applying sensible water technique. It is therefore, important to know how best to utilize the amount of water, when is the optimum time to irrigate to obtain the optimum benefit. The result of model shows the negative coefficient (-0.153) with statistical significant at 5 percent level. It can be explained that farmers might use in excess or wrong timely for their coffee gardens. Huge amount of irrigation per time not only waste water resource but also cause erosion and leach out nutrients following the drainage water, especially in the mountainous areas without erosion management provided. Wrong time irrigation might upset the natural growth and flowering rhythm of the coffee trees. Clifford and Willson (1985) found that the most requirements for coffee growing is a good drainage or water logging will reduce yield by a substantial amount and kill tree if it is prolonged. The soil structure should therefore be such that the water from peak precipitation rates will drain away quickly from the root zones.

Pruning is restricted to the replacement of the old leaders by the new suckers, and the removal of any dead wood. It aims to concentrate the nutrients, air, water and others materials for main bearing branches and promote develop fruit branches. The result of the model shows the positive coefficient and statistically significant at one percent level on coffee yield at the coefficient of 0.046. It means that whoever prunes their coffee garden; it makes positive impact on coffee yield.

Result of the model shows the positive and statistic significant for dummy manure variable with the coefficient value of 0.043, it suggests that the manure had positive effect on coffee yield for the farmers who put the manure compared to other none applied. Farmers used manure by mixing of coffee husk and pulp with pig's, cow's dung or buffalo's dung. As this mixed material decays, the mineral nutrients, which contain in these materials would release to the soil in an available form for stimulating the growth of roots and maintenance of soil moisture.

The R^2 of the regression is 0.63, which implies that 63 percent of the total variation of output can be explained by variables in the model. The rest of 37 percent can be attributed to other factors or the variables outside the model. The adjusted coefficient of determination is 0.60. This illustrates that the estimated functions can be used to explain the effectiveness of the above variables on the yield of coffee by around 60 percent. All coefficients except phosphorous, pest control and irrigation variables have positive values, meaning that farmers could increase the productivity from the additional use of these inputs. Irrigation, pest control, and phosphorous found to have negative and insignificantally effect on outputs, implying that the farmers did not use the inputs at optimal levels. Farmers may overuse these inputs or wrong technical application in term of quantity and frequency on using these inputs.

7.2.3 Estimation the contribution of extension on coffee yield

The result of the multiple regression analysis for both groups proves that the extension variable has the largest coefficient among the dummy variables in the model (0.11) and statistically significant at one percent level (Table 43). In order to measure the contribution of the extension variable to the contact farmers' yield, the fundamental form is based on the Cobb-Douglas production function, which estimated the coefficient value and the statistical test results of each independent variable (Table 43) for both groups of farmers. The undertaken form was described in chapter three as Y (yield) = $\beta_0 X_i^{\beta i} e^{Dz}$; i = 1 – 6, z = 1 – 3 (Table 44). Of which, all the coefficient values from the model and their average inputs for each independent variable were used for this contribution calculation.

Using the average inputs of each independent variable and the coefficient values obtained from the model and directly supersede into the Cobb–Douglas production. The findings in Table 44 shows that the non-contact farmers in average used 373.5 kg N, 238 kg P_2O_5, 200 kg K_2O, 2905 water cubic meters, 273 labor day etc. in one year production without directly consultant from the extension agents. Then, the estimated yield obtained in average of 2,782 kg of coffee bean ha^{-1} $year^{-1}$ compared with the contact farmers obtained about 3,164 kg ha^{-1} $year^{-1}$ after investing 341 kg N, 135.7 kg phosphorous, 244 kg potassium etc. with the technical package consultant from the extension agents. It seems that the extension contributed about 13.7 percent to coffee yield higher for the contact farmer than the non-contact farmer group in average. It suggests that the extension agents might affect farmers' technical knowledge and skills to directly increase productivity through higher technical efficiency in using inputs or increase the general knowledge of farmers for better coffee farm management to indirectly through changes in inputs level using.

Table 44 The estimation of extension variables of the general model

Independent variables		Average inputs of independent variables	
Iterms	Coefficient value	Contact Farmer group	Non-contact farmer group
β_0 Intercept	0.422870		
X1 Nitrogen	0.159446	341.0	373.5
X2 Phosphorous	-0.011430	135.7	238.0
X3 Potassium	0.063996	244.2	200.0
X4 Irrigation	-0.15277	2617	2905
X5 Pest control	-0.02679	286,6	517,3
X6 Labor	0.150023	332.8	272.8
D1 Dummy extension	0.110306		
D2 Dummy pruning	0.045952		
D3 Dummy manure	0.042776		
Cobb –Douglas production function	$Y = \beta_0 X_i^{\beta i} e^{Dz}$; i = 1 – 6, z = 1 - 3		
Yield estimation (kg ha^{-1})		3164	2782
Yield gap as extension variable (%)		13.7	0

7.2.4 Multiple Regression Analysis for the contact farmer group

Following the same procedure, the multiple regression analysis was carried out for the contact farmer group only. The parameters and related statistical test results of independent variables obtained from regression analysis are given in Table 45. It explains about the relationship of coffee yield to a set of different inputs, which included nitrogen, phosphorous, potassium, irrigation and one dummy variable namely extension. The dummy variable extension in this model assigns the value of "1"for the contact farmers, who had access to the extension programs for over three years compared to other contact farmer who had access to the extension program less than one year. It aims seeing how different performances among the contact farmers themselves within different time of extension access.

Table 45 Result of regression analysis for the contact farmer group

Independent variable	Coefficients	Standard Error	t Stat
Intercept	0.71059**	0.567542	1.261404
Ln.nitrogen	0.356967 ***	0.061302	2.01568
Ln.phosphorous	-0.17474**	0.088901	- 1.96555
Ln.potassium	0.06702 ***	0.025381	2.640557
Ln.irrigation	0.044161 **	0.024256	1.820621
D.extension	0.061903 ***	0.023577	2.625534
R^2	0.45		
Number of observation	31		
F computed	6.3		

***, **, *, ns indicate statistical significant at 1 percent, 5 percent, 10 percent, and none significant, respectively.

Table 45 indicates that all variables except phosphorous has the positive values, it means that the nitrogen, potassium, irrigation and extension variables had positive effect on coffee yield. Of which, the extension variable has the coefficient value of (0.06) in the model and statistically significant at one percent level. It means that the contact farmers, who had been access to the extension programs earlier, would harvest higher output than the other farmers, who have just been access to the extension programs less than one year. This result can be explained that the earlier extension contact farmers accumulated more experience from the extension agents on coffee production and they were more confident in applying the extension agents' recommended practices. Therefore, those farmers might use the inputs and technologies more efficient than other in term of chemical fertilizers, irrigation, pest control and pruning practices etc.

The irrigation variable has the coefficient value (0.04) in the model and statistically significant at five percent level. It indicates that the irrigation had positive effect on the coffee yield. Compared with the previous model for both group in term of irrigation variable, it seems that the contact farmer group used the water more efficient than the non-contact farmers. It can be explained that the irrigation technique in term of time, water quantity, number of irrigation, and the frequency were more suitable recorded for the contact farmers so that these techniques can promote the natural growth and flowering rhythm of the coffee trees.