COMPARATIVE ANALYSIS OF DRY AND WET PROCESSING OF COFFEE WITH RESPECT TO QUALITY IN KAVRE DISTRICT, NEPAL

A research project submitted to Larenstein University of Professional Education in Partial Fulfillment of the Requirements for degree of Master of Agricultural Production Chain Management, specialization in Post-Harvest Technology and Logistics

By
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Wageningen
The Netherlands

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ACRONYMS

ADB	Agriculture Development Bank
AEC	Agriculture Enterprise Centre
AGDP	Agriculture Gross Domestic Products
APP	Agriculture Perspective Plan
AW	Available Water (Water Activity)
CBS	Central Bureau of Statistics
CCP	Critical Control Point
CoPP	Coffee Promotion Programme
CPGs	Coffee Producers' Groups
DADO	District Agriculture Development Office
DC	Dry Cherry
DCPA	District Coffee Producers' Association
DP	Dry Parchment
ECIBON	Enhancing the Capacity of Intermediary Business Organizations in Nepal
EEC	European Economic Chamber
EU	European Union
FC	Fresh Cherry
FNCCI	Federation of Nepalese Chamber of Commerce and Industry
GB	Green Bean
GC	Ground Coffee
GDP	Gross Domestic Products
GR	Gross Return
GMP	Good Manufacturing Practice
HACCP	Hazard Analysis Critical Control Point
ICO	International Coffee Organization
IIRR	International Institute of Rural Reconstruction
ISO	International Standard Organization
KIT	Royal Tropical Institute
MC	Moisture Content
MoAC	Ministry of Agriculture and Cooperatives
NCPA	Nepal Coffee Producers' Association
NPC	National Planning Commission
NTCDB	National Tea and Coffee Development Board
NYBOT	New York Exchange Board
OTA	Ochratoxin A
QMS	Quality Management System
RB	Roasted Bean
TC	Total Cost
VDC	Village Development Committee

EQUIVALENTS

Area

1 Hectare= 20 Ropani= 30 Kattha
1 Ropani= 500 m^2
1 Kattha= 333.33 m^2

Weight

1 Metric ton= 10 Quintal= 1000 kg
1 Bag= 60 kg

Currency

€1= 97.50 Nepalese Rupees
$1= 74.50 Nepalese Rupees

ABSTRACT

Coffee is a high value and relatively new cash crop grown in the mid-hills of Nepal with an altitude range of 800-1600 m above sea level providing on-farm employment and income generating activities for rural poor smallholder farmers.

The problem of this research study was variation in quality of coffee obtained from two processing method that has affected export market. This study was aimed to compare and analyze two processing methods with respect to quality. It also has tried to recommend the one with best that ensures good quality for the export market.

The study was conducted at Panchkhal VDC in Kavre district through case studies with seven chain actors (2 farmers, 2 processors: dry and wet, 2 traders and 1 local roaster) and survey with 30 respondents (10 farmers, 5 processors, 5 traders and 10 consumers). Six chain actors (except local roaster) who were selected for case study were taken from the 30 respondents involved in survey. The research was mainly based on qualitative and few quantitative approaches. The whole research study took three months (July-September) to complete. Detailed case studies with seven chain actors was done through semi-structured interview with a checklists prepared for each actor. Survey was done with multiple choice questions as checklists for interview.

Moisture content in the green bean of different samples was measured by using digital moisture meter. Standard commercial moisture range (9-12%) recommended by International Coffee Organization (ICO) was referred to compare the moisture percentage of green bean. Survey for cup taste test was done to find out the taste difference between coffees processed from two methods. The data obtained were analyzed using Excel and SPSS. Benefit-cost ratio for each method was also calculated based on the data available from National Tea and Coffee Board (NTCDB).

It was found from the case study with wet processor that 70% of total coffee produced in the district was processed through wet method. In dry processing, sorting and grading of cherries and drying were found to be critical control point (CCP). Similarly, sorting and grading of cherries, fermentation, and drying were CCP assumed in wet method whereas sorting and grading of green beans and roasting were the common CCP for both methods. The optimum level of moisture recommended by the processors for dry cherry, parchment and green bean was 11-12% for storage up to four months. The optimum time duration for fermentation of parchment was 24-72 hours depending on the weather conditions. Critical control limits for roasting was at 200-250^{o}C temperature and for about 10-15 minutes respectively.

The average moisture content of green bean taken from different lots from dry method was found to be 12.83% which was a bit higher than the standard moisture range (9-12%), whereas moisture content of green bean from wet method was within the range i.e. 11.7%. Out of 30 respondents surveyed, 24 respondents rated 'very good' for the cup of coffee processed from wet method and reported that the cup had an excellent fruity aroma (at 5% significance level, p = 0.001).

Majority of the respondents (43%) reported that moisture content and flavour are the major determinants of coffee quality. Determination of moisture content was found to be the most reliable method followed by laboratory reports. Similarly, 33% respondents considered coffee processing step as an important value chain function determining coffee quality followed by selection of good nursery (27%). Knowledge and training was the major influencing factor for

quality coffee production followed by supply of quality input. The respondents criticized that the main reasons for adopting two processing methods was processors inaccessibility to get credit to buy pulping machine as well as lack of proper training on processing of coffee.

Benefit cost ratio for dry method was found to be higher (1.4) than wet method (1.2). Wet method was found to be more advantageous than dry method based on sustainability of quality coffee production. The main problem associated with dry method was risk of secondary fermentation due to insufficient drying of cherries. Under and over fermentation, troubleshoot in pulping machine and water pollution were the major problems associated with wet method.

It was concluded from the research study that method of processing has more impact on coffee quality. Moisture content, aroma, taste, flavour and acidity are important quality attributes and are the major factors determining coffee quality. Coffee with pleasant aroma and purer flavour was obtained from wet processing method. Wet processing was found far better than dry one with respect to quality of coffee.

Finally wet method of processing was recommended for the processors to produce quality coffee for the export market. Establishment of pulping centers, standardization of processing method, chain coordination, increased accessibility of farmers and processors to get credit and capacity building of coffee chain actors through knowledge and training are recommended to increase and maintain the quality of coffee through wet processing method.

CHAPTER 1. INTRODUCTION

1.1 Introduction to the thesis

This study has been carried out as a final thesis research for the partial fulfillment of the course requirements of Master in Agriculture Production Chain Management, specialization in Postharvest Technology and Logistics at Van Hall Larenstein, University of Applied Sciences in Wageningen. This research report gives insight into comparative analysis of dry and wet processing methods of coffee with regards to quality in coffee value chain. This research was carried out in Kavre district, Nepal.

This thesis report consists of 6 chapters. The first chapter gives an introduction and background of Nepalese agriculture and coffee in Nepal. This chapter also includes the objective of the research study, the main research questions and sub-questions for research. Chapter two gives the literature related to coffee production, processing, marketing and major concerns about analysis of quality management aspects regarding coffee processing techniques. The third chapter covers the methodology which mainly includes the research design, sampling procedures and data analysis techniques, selection of the study area, presents brief introduction of the study area. Chapter four and five describe the results of the data collection and discussions on the findings respectively. Conclusions and recommendations are mentioned in chapter six.

1.2 General background

1.2.1 Nepalese agriculture

Nepal is an agricultural country where 65% of the total economically active populations are engaged in agriculture. The share of agriculture in national gross domestic product (GDP) is 39%. The government of Nepal has clearly described and placed agriculture in a priority sector since tenth five year plan as poverty alleviation strategy. Still 31% of total populations live below poverty line, less than one dollar per day. This widespread poverty in country is mainly due to the traditional agricultural system. Therefore, commercialization of agriculture with higher growth rate is a good way to reduce poverty in Nepal. Modernization and increased access of farmers to modern agricultural inputs and credits is a good way to increase the agricultural growth rate (NPC, 2009).

Nepal is natural paradise because of its climate and biodiversity with diverse ecosystems ranging from tropical plains to high Himalayas. The biodiversity of crops, livestock and fisheries is vital to marginalized rural communities for maintaining food security and livelihoods. Rural Nepal with 86% of total population has extreme variation in altitude, a complex topography, and diverse climatic conditions and integrated farming systems. Agriculture, services, small scale manufacturing industries and tourism, including remittances, are the major sources of income, employment and livelihoods. Industrial activities mainly involve processing of agro-products. The major export items include woolen carpet and garments followed by agricultural products like pulses, jutes, medicinal herbs and leather products. Niche products and commodities such as tea, coffee, ginger, honey and off-season vegetables have shown high export potentials in the recent years (Shrestha *et al.,* 2007).

In order to enhance the growth in agricultural sector in Nepal, the government has put into operation the 20 years strategic plan, Agriculture Perspective Plan (APP, 1995-2015). APP has been regarded as worth seeing to raise AGDP growth rate from 3% to 5% by the end of 2015

(APP, 2008). Therefore to achieve the targeted growth rate in agriculture, APP has mainly given emphasis on the production of high value cash crops (tea, coffee, ginger, cardamom) through pocket package program.

1.2.2 Coffee in Nepal

Coffee is one of the high value cash crops grown in Nepal with potential high quality for domestic as well as international niche market. Among the various cash crops for commercialization, coffee is emerging as a likely agro-enterprise with great potential to provide farm employment and income generation opportunities in the mid hills of Nepal (CoPP, 2007).

Coffee can be well grown to the climate of mid-hills of Nepal and is emerging as one of the potential cash crops to provide rural farmers with on-farm employment. Superior highland organic coffee for niche export market can be produced above 800 m altitude from sea level. However, being a new crop to Nepal, coffee production and processing technologies are still in a rudimentary stage. Considering its potential for poverty reduction of rural mid-hills people, both governmental and non-governmental organizations have initiated research and development works in coffee (Shrestha *et al.,* 2007).

In Nepal, coffee can be grown from low to mid-hills (800-1600 m asl) covering about 60,000 hectare of land. Most suitable are the northern slope along this altitude range. The coffee grown above 800 meters is labeled as highland coffee, which if grown and processed correctly, will have high quality and flavour. Since even smallholders can grow coffee in their marginal lands, coffee expansion holds promise for effective poverty reduction, the main goal set by the 10th Five Year Plan of the country (Koirala, 2003).

Coffee is cultivated in Nepal with no use of synthetic fertilizers and pesticides. This crop has an important occupation in the rural economics with massive participation of marginal, poor and down trodden class of rural communities, and has contributed for the soil conservation, bio-diversity maintenance and watershed balance in the mid-hills of Nepal. Coffee farming in Nepal is proven as promising due to the availability of soil with good structure (physical and chemical) and appropriate micro-climate in the mid hills (Nepal, 2006 as cited in Poudel *et al.,* 2009).

Coffee is processed either by wet method to produce parchment coffee or by dry method to obtain cherry coffee. In Nepal, dry processing was predominantly practiced in the past (10 years ago). But nowadays, this method has gradually been replaced by wet processing method. Wet method has also becoming more popular and been introduced for export of green beans (Deoju and Manandhar, 2004).

1.3 Research problem

The major problem currently facing Nepali coffee production is the great variation in the quality of dried coffee beans. The problem comes from the fact that the coffee beans are collected from the many small scale farmers and, in the absence of quality standards for coffee, this has led to variation in quality. There are a number of reoccurring processing errors in both dry and wet processing systems. By removing many of these errors, it would be possible to significantly improve the quality of the coffee (ECIBON, 2009).

The quality and productivity of coffee is low at the farmer's level. Lack of organized cherry collection system is leading to lower quality green beans entering into the market and primary producers are exploited by the traders. There is a high post-harvest loss at the farmers, and

processors level due to high sorting and grading losses. Processing 100 kg of fresh cherry yields about 12.5 kg of green beans which about 50% lower than the world average yield of Arabica coffee (Bajracharya and Pathak, 2004).

Coffee is a complex product with attributes (flavour, acidity, body, and aroma) that emerge from a combination of these characteristics displaying a rich variability of that cannot be totally disintegrated. These natural variations of coffee that complexly produce the final quality relate to different coffee varieties, soil altitude and rainfall conditions and cultivation and processing methods used by producers in different producing regions (Roseberry, 1996 as cited in Donnet and Weatherspoon, 2006). These factors can contribute to rich attributes that signal the sensory quality of coffee. These quality attributes thus enhance the sensory evaluation of the product.

It is well accepted that green coffees resulted from the wet method which is called as washed Arabicas yield roasted beans and coffee beverages, respectively, that are characteristically different from those produced from the dry method- the so called unwashed Arabicas. There is no doubt, that these flavour differences in part have to be attributed to difference in the thorough processing applied during either of the two methods due to the fact that only fully ripe coffee cherries are used for wet processing, whereas fruits of all stages of ripeness are utilized by dry processing. During post-harvest treatment, various metabolic processes occur inside the coffee seeds which significantly alter the chemical composition of the green bean resulting in differences in cup quality (Knopp *et al.*, 2005).

The decisive quality criterion of coffee as a beverage is its aroma being composed of more than 800 compounds. Amazingly, only about 30 of these contribute significantly to the specific coffee aroma. These aroma impact compounds are suitable indicators to estimate objectively the aroma differences resulting from different processing methods. Till now, the reasons for the quality differences of technologically distinctively produced coffees are unknown. In this context, the biochemical and physiological processes which occur in the living coffee bean during postharvest processing, and which are related to quality, must be taken into consideration (Bytof *et al.*, 2000).

These two common processing methods are practiced by the coffee processors in the Kavre district. The quality of coffee produced from these two processing methods has some differences which is not clear. Coffee importers always claim differences in the coffee quality processed by the two methods, whether this difference exists significantly or not has yet to be analyzed through research. This has been a major concern from a quality management perspective. Therefore to maintain the quality of coffee through these two processing methods is very important especially for the export market and of course is interesting issue for research. The problem owners in this research are coffee processors and traders.

1.4 Justification

Quality control measures (time between harvest and pulp, duration of fermentation, type of water used to wash the parchment, optimum drying of parchment and beans) are applied by the processors at various steps in coffee processing. The control measures are applied as per the perception of the individual actor and objective measurements (moisture percentage, acidity, number of defective beans) are done. There is no systematic and uniformity in the application of these control measures throughout the chain. Most of the coffee chain actors in Nepal are unaware of quality management system except for the organic certification which is being sought by the importing clients (Munankami, 2004).

Though both methods are aimed at removing the fruit flesh of the coffee cherry and reducing the water content in the raw coffee beans to about 10-12%, it has been realized that some factors such as grading and the homogeneity of the material affect the quality of the final product. The differences in the cup quality between coffees processed from dry and wet method has been the major concern for the coffee importers and quality experts (Bytof *et al.*, 2004).

Application of dry and wet processing techniques of coffee by the processors has certainly led to differences in the quality to some extent. If the qualities of coffee processed from these two methods get difference significantly, then the market will be affected. Customers always want coffee with uniform quality and in consistency that will fetch higher price in market. So it is necessary to assess the quality through comparative analysis between the two methods and recommend one to the processors that is economically and technologically sound.

1.5 Research objective

To compare and analyze the two processing methods of coffee in Kavre district in terms of quality and identify one which is more feasible both economically and technologically.

1.5.1 Research questions

i. What are the quality criteria for coffee to be considered in both dry and wet processing methods?

- What are the steps followed in both processing methods?
- What are the minimum quality criteria for coffee for the local and export market?
- What kind of quality measures are the processors practicing in both methods?
- What are the critical control points (CCP) at processing level for coffee?
- Which method of processing is widely practiced by farmers?

ii. Which method of processing is more recommendable both economically and technologically?

-What is the B/C ratio of each processing method?
-What are the advantages and disadvantages of both methods?
-What are the problems in both processing methods?
-What recommendations can be given to use one type of processing techniques?

1.6 Definition of concepts

Fresh cherry: Fully matured fruit in the coffee plant ready to harvest.

Dry cherry: Coffee cherry dried after harvest up to moisture level of 12%.

Wet parchment: When fresh cherry is depulped within 24 hours after harvest, then the coffee produced is called wet parchment.

Dry parchment: This is the coffee obtained after complete fermentation (free from mucilage) and drying of wet parchment. It has a moisture range of 11-12%.

Green bean: This is the product obtained after hulling the dry parchment which contains standard moisture range of 11-12% and is ready for the export market. The colour of the green bean is bluish green in colour.

Quakers: They are the defective coffee green beans that fail to roast properly, remaining stubbornly light-coloured.

Stinkers: They are also the defective green beans. When they are cut, release a putrid, nauseating odour, which is also volatile and the odour will have disappeared after a few hours. It is often difficult to distinguish this kind of bean with healthy one because the appearance is no or slightly difference between two. The bad odour ultimately results in unpleasant taste (Mutua, 2000).

Specialty coffee: Specialty coffees are high quality coffees that differ from normal coffee with relevance to visual quality or cup or both. Specialty coffee in the green bean phase is defined as it has distinctive trait without defects in the cup. They are getting increasingly popular in the world coffee market (Deoju and Manandhar, 2004).

Quality: It is defined as product performance that results in customer satisfaction and freedom from deficiencies, in short fitness for use. Therefore, quality is meeting or exceeding customer and consumer expectations (Luning and Marcellis, 2009).

Value chain finance: Value chain finance is when one or more financial institutions link into the value chain, offering financial services which build on the relationships in the chain. The seller, buyer and the financial agent works together in a triangular cooperation, using the business relations in the value chain as a career to provide financial services (KIT and IIRR, 2010).

1.7 Scope and limitation of the study

The study was conducted in August 2010 when new coffee cherries were still on the tree and the case study was conducted with the respondents (processors and traders) who usually had green beans in stock ready for the export and local market.

The study was done on the basis of existing situation of the village development committee (Panchkahal VDC) in Kavre district and coffee produced by few respondent farmers was followed through the chain. Therefore, the results obtained may not reflect and represent coffee growing situations of the whole country.

The survey will focussed more on the qualitative issues rather than quantitative figures of actual yields and post-harvest losses that occurred during the various processing activities. The stakeholders' boundary in the supply chain excluded the breeders and retailers.

CHAPTER 2. LITERATURE REVIEW

2.1 Coffee production and consumption in world

Coffee is the world's most popular beverage after water and it is the second most traded commodity after raw oil. The vast majority of world coffee is the Arabica species. Global production of coffee has reached to 124, 064, 000 bags (60 kg/bag) of green bean in 2009. This has been decreased by 3.2% as compared to production of 128, 183, 000 bags in 2008 (Figure 2.1). Similarly world coffee exports reached to 94.7 million bags in 2009 as compared to 97.6 million bags in 2008. The decrease in the coffee export is due to world economic crisis. Brazil is the largest producer and of coffee followed by Vietnam and Indonesia while in terms of export share, Brazil is ranked in first followed by Vietnam and Columbia (ICO, 2010). Country wise coffee production and their export share are presented in Figures 2.2 and 2.3 respectively.

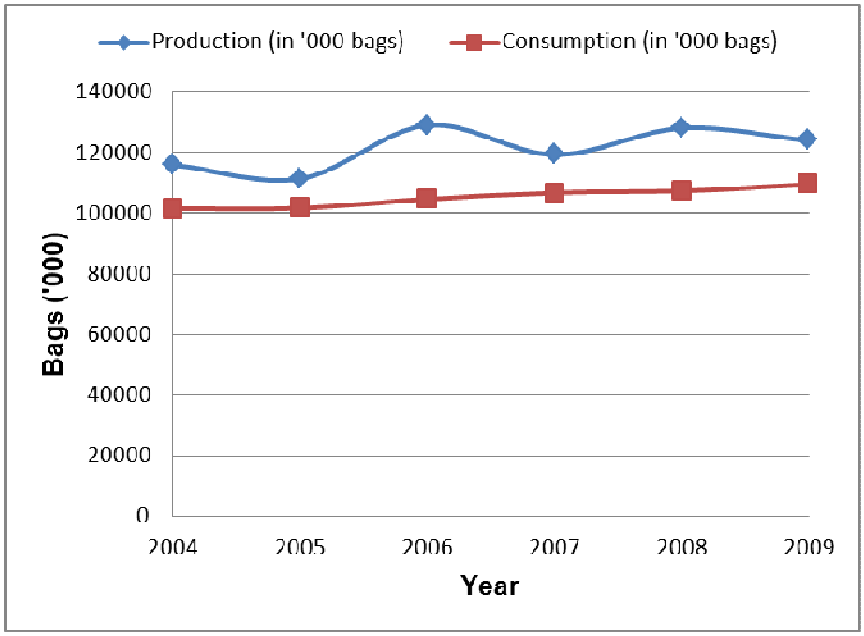

Figure 2.1 World coffee production and consumption
(source: ICO, 2010)

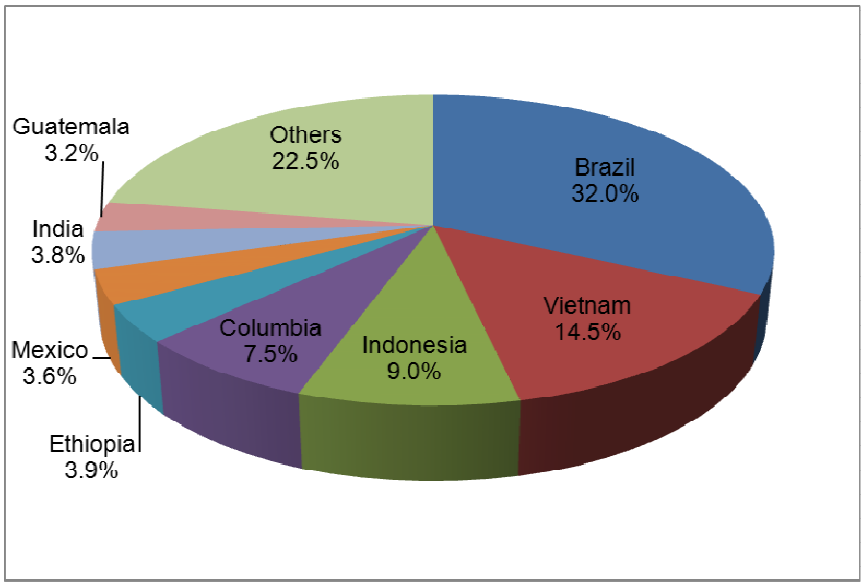

Figure 2.2 Country wise share of coffee production in the world
(source: ICO, 2010)

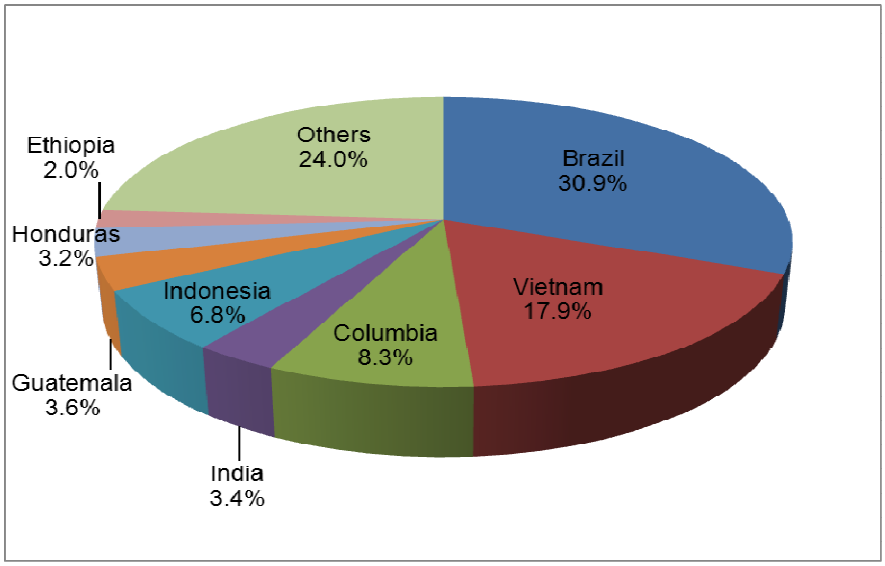

Figure 2.3 Export share of major coffee producing countries in the world
(source: ICO, 2009)

2.2 Coffee production, processing and marketing in Nepal

Coffee is emerging as one of the potential crops to provide rural farmers with on-farm employment and income and is well suited to the climate of mid-hills of Nepal. Superior highland organic coffee for niche export markets can be produced at an altitude higher than 800 meters.

However, being a new crop in Nepal, coffee production and processing technologies are still in a rudimentary stage. Considering its potential for poverty reduction of rural hill people, both government and non-government organizations have initiated research and development works on coffee (Shrestha *et al.,* 2008).

2.2.1 Area and production

In Nepal, the total areas under coffee cultivation, as well as, total yield have been increasing over the last decades. Over the period 2000 to 2008, the cultivated area has increased almost five-fold and the production of green bean almost seven fold while the export volume has increased by more than 90%. The total area under cultivation in 2008 was 1495 ha (Figure 2.4) and the numbers of growers were 20,000. The total production and export of green beans were 233 mt and 140 mt respectively in the year 2008 (Figure 2.5). The average yield of green bean is 183 kg/ha which is comparatively lower than the major coffee producing Asian countries like India, Vietnam and Indonesia (NTCDB, 2009).

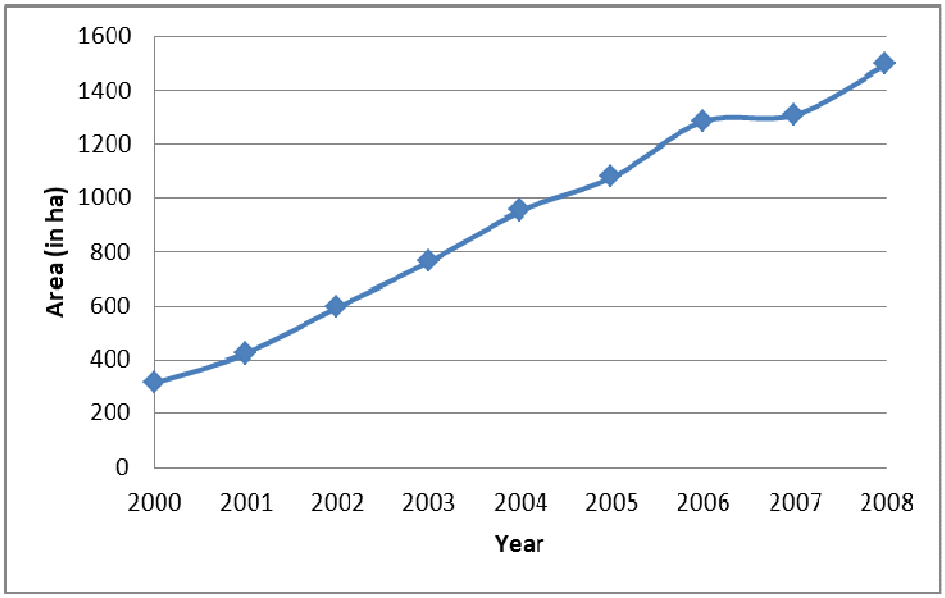

Figure 2.4 Coffee production area in Nepal
(Source: NTCDB, 2009)

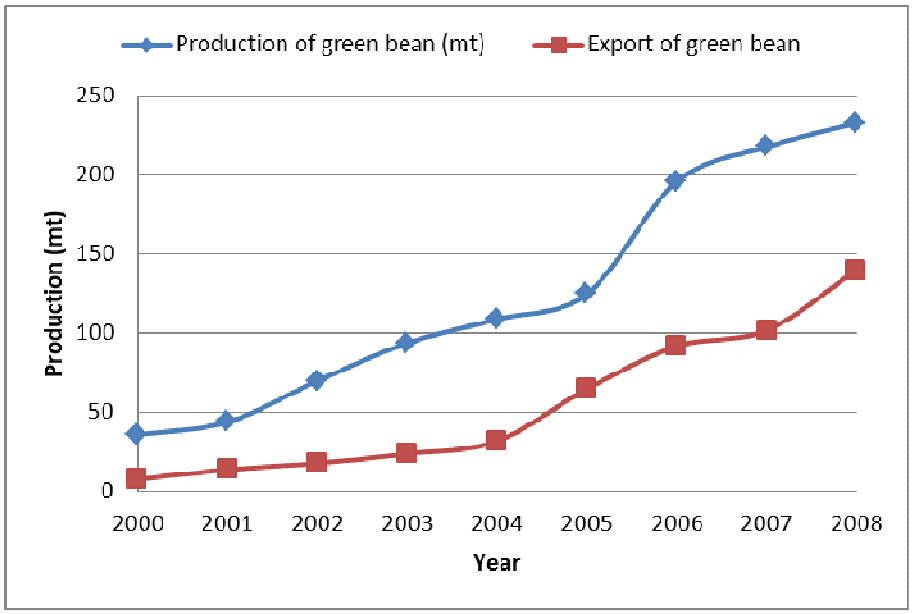

Figure 2.5 Production and export of coffee in Nepal
(Source: NTCDB, 2009)

2.2.2 Market and price

Domestic market for Nepali coffee is confined to tourists, residential expatriates, recognized offices (I/NGOs), some hotels and restaurants. Marketing of Nepalese coffee is primarily done through direct supply to departmental stores, trekking agencies and restaurants. The recent export trend of Nepalese coffee has been very encouraging. Japan, USA, and major EU countries (Germany, UK, Netherlands and Spain) are the major export markets for Nepalese coffee. In 2008/09 Nepal exported 127 mt of green bean mainly to Japan, Holland, UK, Germany and United States (ECIBON, 2009).

The niche in organic and specialty highland organic coffee offers real opportunities in terms of price. The trend of coffee price was in increasing till 2007 and suddenly dropped due to world economic crisis in 2008/09. The present price structure of coffee produced in Nepal is relatively higher as compared to the international market price due to specialty nature of Nepali coffee which is penetrating in to the market. India, Sri Lanka, Vietnam and Indonesia are major competitors of Nepali coffee in Asia (CoPP, 2009).

2.2.3 Coffee production in Kavre district

Coffee is a relatively new crop in the Kavre district. This is the second largest coffee producing district in Nepal. The favourable microclimate and geography has been beneficial for coffee cultivation. The total area under coffee cultivation was 130 hectares of land followed by 29 mt of dry parchment in 2008 (DCPA, 2009). Coffee production and cultivation for the last five years is shown in Figures 2.6 and 2.7. The productivity is still lower because many of the coffee trees are still too young to yield fruits.

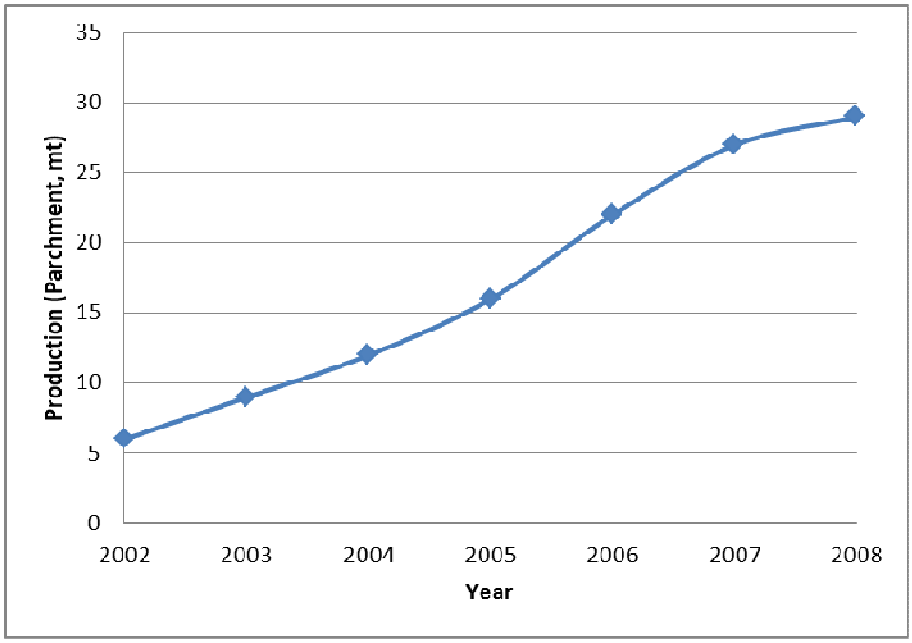

Figure 2.6 Coffee Production in Kavre district
(Source: DCPA, 2009)

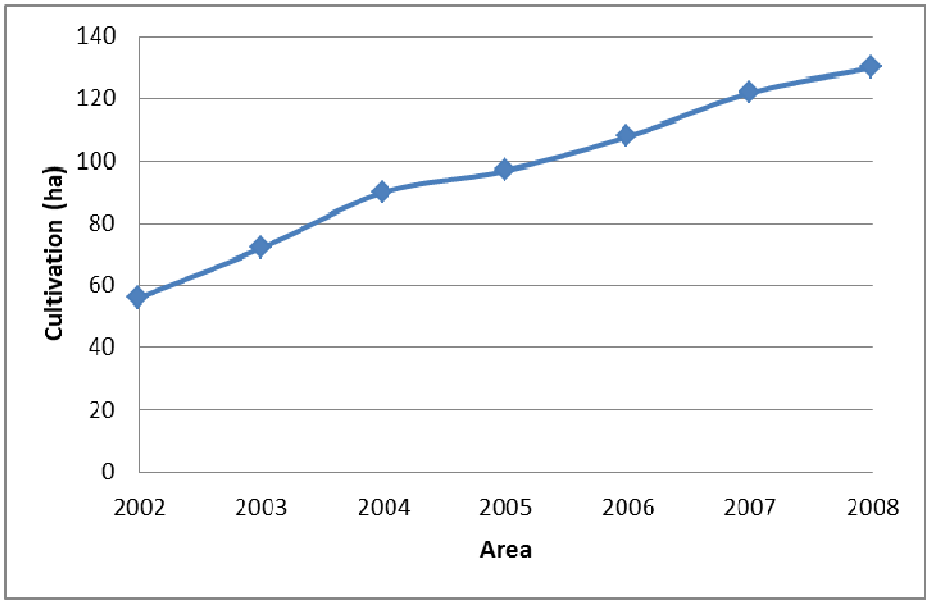

Figure 2.7 Coffee cultivation in Kavre district
(source: DCPA, 2009)

2.3 Processing of coffee

In Nepal, about 70% of the coffee produced is processed by wet method, but farmers in rural areas are still practicing dry method as they are not being easily accessed by transportation to sell their fresh cherry to the pulping centres. Most of the pulping centres are managed and run by farmers' groups, cooperatives, and coffee producers' association or by processor. Wet method requires more care than dry one which enhances the bean appearances thus rendering the batches more valuable (CoPP, 2005). Both the techniques consist of a series of operation which is presented in Figure 2.8.

The pulp containing water and sugar, the moist parchment skin and beans all would ferment rapidly, moulder or rot if transported or stored as fresh. The entire coating i.e. covering of the pulp, mucilage, parchment and the silverskin of the actual seed of the coffee fruit must be removed and the beans dried and cleaned to make it ready for the final consumption (CPC, 2007).

2.3.1 Dry Processing of coffee

In dry method, whole cherry is dried and when this is finished, the pulp and the parchment are removed in one single operation. This is simple method which includes less labour cost. The cherries are either sun-dried or machine dried with the outer fruit intact until the fruit gets moisture content of 12%. After drying they are de-hulled mechanically, producing beans that are characteristically lower in acidity, sweet, smooth and more complex in flavour than wet processed coffees (Wanyonyi, 1999).

Under Nepalese conditions, where the coffee growers are predominantly small holders who grow limited number of coffee plants, dry method is common in practice, but this has been gradually been replaced by the wet processing ones due to more demand on international market (Deoju and Manandhar, 2004).

Although there are fewer operations involved in dry processing than in wet processing, this method is more time consuming as drying cherries takes longer time than drying parchment. The risk of secondary fermentation is greater due to the presence of mucilage which is very hygroscopic (Coste, 2003).

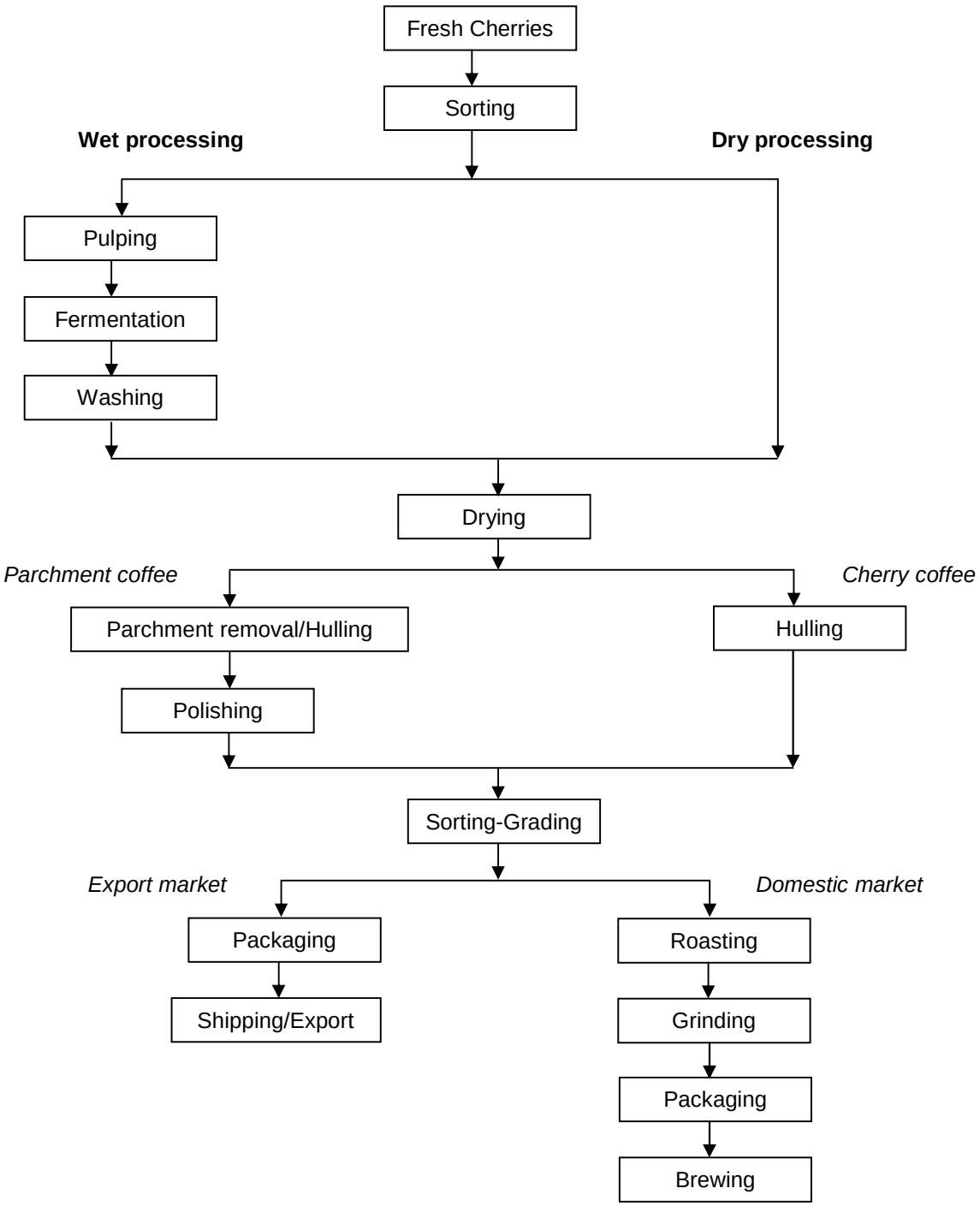

Figure 2.8 Successions of operations in dry and wet processing of coffee
(Source: Coste, 2003)

2.3.2 Wet processing of coffee

In this wet method, the pulp is separated from the parchment. In this way slippery mucilage is exposed which is commonly removed by a process commonly called fermentation. This is followed by drying and washing of the beans in the parchment. Removal of parchment by hulling gives the clean coffee. The many steps in the wet method of coffee processing make it rather expensive but, if properly carried out, it gives a very high quality coffee (Wanyonyi, 1999).

In Nepal, wet processing technology has been introduced recently for quality export of green beans. Several wet processing plants are established in the major coffee producing areas of the country. The major steps involved in this method are described as follows:

2.3.2.1 Harvesting

Coffee is generally harvested when berries turn dark red colour which is about 8-9 months after flowering has taken place. The harvest generally starts from October and continues up to March. Ripe fruit can be plucked by hand, or picked with small rakes, or else with poles depending up on the availability of the labour (CPC, 2007).

2.3.2.2 Cherry sorting and grading

The cherry is sorted out before pulping. This helps to eliminate the immature, diseased, pest damaged and dry cherries as well as the leaves, twigs and other foreign materials present. The sorted out quality coffee cherries are the subjected to pulping to remove the outer layer. (Mutua, 2000).

Grading of fresh harvested coffee is done based on ripeness. Ripe and unripe cherries are separated to facilitate processing and to obtain a better product quality. Sorting and grading in wet processing can be done in washing vats. Foreign matters as well as cherry of different ripeness and dryness are separated in a washing vat due to their differences in density. Stones and heavy impurities are removed from the bottom; hard, partially dried cherries float and are discarded from the top (Willson, 1999).

2.3.2.3 Pulping

It is the process of mechanical removal of the pulp from the fresh cherry to have parchment coffee. The flesh and skin of the fruits are left on one side and the beans, enclosed in their parchment covering, on the other side (Annex A). The lighter immature beans are then separated from the heavier, mature beans through specially designed washing channels or by shaking the beans through a strainer into a tank of water (Hicks, 2002).

2.3.2.4 Fermentation

It involves the process that allows the mucilage layer on the parchment to be washed off easily. The beans are stored in fermentation tanks for 2-3 days depending up on the weather condition during which time, the slimy layer of the berry is separate from its parchment like covering, by natural enzymes. Completion of fermentation is determined by washing a bit of the parchment with clean water and then feeling the coffee with the hand. A gritty feel is an indication of the completion of fermentation. Different chemical products like lime, alkaline carbonates can also be used for removal of the mucilage which precipitates the pectines in the form of soluble pectates, which are then easily removed by washing (Mutua, 2000).

2.3.2.5 Soaking and washing

After the completion of fermentation which can be found out by gritty feeling, not slippery, the coffee beans are then washed without delay to remove the fermentation break-down products. Delay or insufficient washing at this stage can produce undesirable flavours in final product. Fully wet parchment coffee has a moisture content of 50-54%. Soaking of parchment under water after complete fermentation for about 12 hours helps in improving the quality of coffee both in colour and taste. The fermented parchment is subjected to wash thoroughly in order to remove the degraded mucilage and acid before soaking (Wickramasinghe *et al.,* 2001).

After fermentation and soaking, the parchment coffee is again washed with clean water to remove any dirt or remains of mucilage or sugars. Final washing is done in concrete channels by pushing the parchment with wooden paddles against a stream of water. About 100 liter of water is used in order to wash 10 Kg of parchment.

2.3.2.6 Drying

The main propose of drying is to maintain the moisture content of the parchment optimum for storage. Freshly pulped coffee has a moisture content of about 55% and that has to be reduced by drying to 11%. This is the ideal level of moisture content required for proper storage, hulling and roasting. In most of the developing countries, sun drying is predominantly used and mainly by the producers' organizations/cooperatives, and the coffee is spread on the wire mesh tables for normally about two weeks in sunny days, until fully dry. Few commercial companies use mechanical drying method (Mutua, 2000).

If drying is carried out too rapidly, 'case hardening' may occur which is common in the drying of many grains. The surface is overdried and shrinks irreversibly to prevent easy movement of moisture from within the bean in an outward direction. Worse than this, the bean may become pale and bleached in appearance signifying flavour deterioration. Field evidences have shown that when drying is done too rapidly under excessively warm temperatures, the valuable cup flavour is largely lost from coffees that otherwise would have been considered excellent (Sivetz and Foote, 2004).

2.3.3 Common steps for both methods

2.3.3.1 Hulling

This is the process of removing husk either from the dry parchment coffee or dry cherry in order to give the commercial green coffee. When the coffee gets to this stage, all intrinsic quality (moisture content, colour) has already been obtained. The different sorting techniques to which it is subjected can only reduce its percentage of defects in coffee beans. Hulling is achieved by creating friction among the beans lying along the screw of machine. It is crucial not to heat the beans during hulling otherwise it will affect the final colour and taste of coffee. There is another final layer closest to bean, called as silverskin, which may or may not be removed during hulling process. For removal of silverskin, separate equipment following hulling called polishers is needed. The green bean received is then subjected for sorting according to density, size and colour (Wanyonyi, 1999).

2.3.3.2 Bean size sorting

Sorting of green beans is an important operation during coffee processing which also facilitates to carry out roasting. Roasting is carried out with beans of similar size, if not done, the beans with smaller size get burned earlier while the larger ones get insufficiently roasted. Larger beans also fetch premium price in the market and ultimately beans with higher percentage of defects get concentrated in low grade coffee (Mutua, 2000).

The green beans are sorted according to size, density and colour. Manual sorting, which is tedious and labour intensive, is practiced in Nepal. Machine sorting is also used by some trading companies. Machines for size sorting use the sieving principle which is either one using screens mounted in the drums or the vibrating flat bed of rectangular shape (NTCDB, 2009). Electronic colour sorting is used to separate beans with an undesirable colour, such as black, white or brown beans.

2.3.3.3 Roasting

This is the most critical stage during postharvest handling of coffee. The main purpose behind roasting is to release the aroma, an operation which many coffee lovers insist on performing themselves. A good roaster must be a part artist, and part scientist, to maintain quality and consistency. In the development of flavours, roasting is probably the most important of the steps considered so far. Well roasted coffee should be brown, of varying degrees of darkness, but never black. Both traditional and modern roasters are used, but in order to get better uniform quality of roasted beans, modern (electric) roasters are preferred. The roasting process causes the coffee beans to swell and increase their size by over 50%, while at the same time greatly reducing their weight (Hicks, 2002).

Temperature and time are two critical things that have to keep in mind during roasting to obtain better quality coffee. During roasting, the coffee beans are heated at 200-240^0 C about 10-15 minutes depending on the degree of roasting required, which is mainly evaluated by colour. The amount of oil drawn to the surface of the bean due to caramelization of sugar and carbohydrates inside the bean increases proportionately to the length of roasting time. After roasting, coffee does not keep its aroma for long; it is, therefore, better not to roast or not to buy coffee exceeding current needs. It is advisable to keep it in airtight package-aging to prevent light, heat and moisture ingress (Deoju and Manandhar, 2004).

2.3.3.4 Grinding

This is the last operation through which coffee bean has to go before being actually made cup for brewing. In order to avoid the loss of aroma, coffee should be ground immediately before being made for brewing purpose as aroma is quickly lost from ground coffee (Hicks, 2002). In Nepal, traditional grinding using wooden or marble mortars with a pestle are common. Electric grinders are also used by some coffee exporting companies.

2.4 Quality attributes

Quality attributes are the result of various product properties, which are noticeable by sensory observation or via communication, and in this way contribute to the quality perception and experience of consumers and costumers. The intrinsic-extrinsic model is the basis for selection and classification of the different quality attributes (Figure 2.9). The model distinguishes

between two different types of quality attributes i.e. intrinsic and extrinsic, both of which can influence the acceptance of the products. The intrinsic attributes are inherent to the physical product whereas extrinsic attributes do not necessarily have a direct relationship with the product properties but can affect consumers' quality perceptions which are mainly related to production and marketing aspects of a product (Lunning and Marcelis, 2009).

Although eating quality is a combination of characteristics, attributes and properties that lead to enjoyment, consumers say that appearance and freshness are most important in initial purchase. The select products that are the appropriate colour, size, and shape, with the proper firmness. Expectation of nutritional value and health-enhancing properties are also of importance (Bruhn, 2002).

2.4.1 Quality attributes in coffee

Coffee is drunk for pleasure; its flavour is, therefore, the most important quality criterion. It is the sum of different parameters all coming into play during primary production of green coffee bean. Criteria used to measure quality of green beans are bean size, shape of bean, density, color and the bean chemistry of the raw bean. These criteria are influenced by a wide range of factors like plant genetics, orchard practices and postharvest treatment. All the downstream operations (storage, roasting, brewing) can only preserve cup quality. Besides its flavour characteristics, other factors such as environmental impact, purity and safety are becoming important for the global evaluation of coffee quality (Viani, 2001).

The most important quality parameters are ripeness of cherry and time to processing. The coffee may give an astringent or impure cup, if harvested immature or kept too long before processing. Careful picking, collecting, and storing of cherries should be précised to produce high quality coffee. Coffee cherries should be stored in the shadow because in the full sun cherries will start to ferment earlier (Njoroge, 2004).

Analytical (moisture content and defective bean count) and organoleptic (taste testing) criteria are generally used by the coffee roaster to determine the choice of the green coffee beans. Moreover, quality evaluation for the roaster requires reliability of supply, uniform low moisture and agreed defect count, regular roasting characteristics and of course the cupping quality (Laderach, 2007).

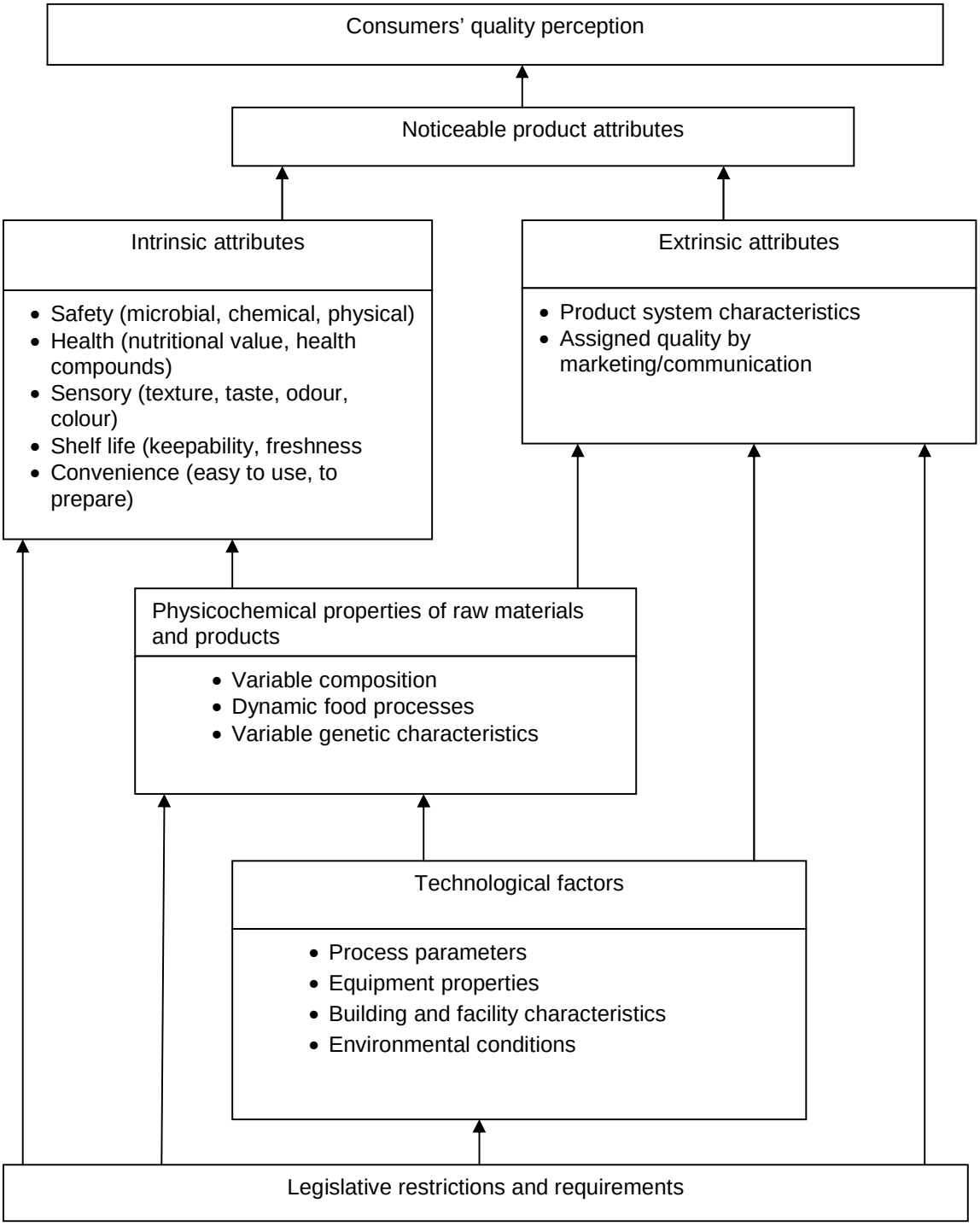

Figure 2.9 Intrinsic-extrinsic quality attributes model
(Source: Luning and Marcelis, 2009)

2.4.2 Coffee quality assessment

2.4.2.1 Moisture content determination

This is the analytical measurement with regards to quality assessment in coffee associated with water content inside coffee seeds.

According to International Coffee Council (ICC) Resolution number 420, for both Arabica and Robusta coffees, a moisture content range of 9-12% has been recommended in order to adopt the quality standards for exported coffees (ICO, 2004). If a moisture percentage below 12% has currently been received, coffee exporting members can work with set purpose in order to ensure that this level is maintained or decreased.

Exceptions to the 12% maximum limit can be permitted for specialty coffees which traditionally have high moisture percentages e.g. Indian coffees harvested during monsoon season. Such kind of coffees can be clearly noticed by specific grade nomenclature (origin, growing condition) (ICO, 2004).

2.4.2.2 Defective bean counts and cup tasting

In general quality determination of green coffee bean can be done in three main categories: coffee grading, sensory evaluation and analytical measurements. In grading the main objective is to determine the size distribution of the coffee along with the assessment of the defective beans and their colour. Sensory evaluation focuses on determining the flavour profile while analytical measurements can determine moisture percentage, chemical composition and possible pesticide residues (Wintgens, 2004).

Bean size play an important role for roasted whole coffee beans because many consumers associate bean size with quality, however, larger beans do not necessarily taste better than smaller one. It has to be pointed out that for roasting, the more uniform the bean size, the better the heat transfer and consequently the roast. The amount of defective beans is also associated with quality. Larger amount of imperfections will increase the probability of finding off-flavours and lesser homogeneity in the cup, but low amounts of visible defects do not necessarily correlate higher cup quality. The assessment of defective beans count is done by hand picking all defects from a specified amount of coffee, then grouping similar defects, counting and weighting them (Piechaczek, 2009). According to New York Exchange Board (NYBOT), as shown in Tables 2.1 and 2.2, to qualify as exchange grade coffee, 9 to 23 full defects per 300 g sample of green beans are permitted and 50% of the coffee by weight must be above screen size 15 (6 mm = medium) and only less than 5% below screen size 14 (5.5 mm = small).

Table 2.1 NYBOT Classification system in coffee quality assessment

Classes	Description of full defects allowed in each class
Class 1	Specialty grade (0-5 full defects)
Class 2	Premium grade (6-8 full defects)
Class 3	Exchange grade (9-23 full defects)
Class 4	Below standard grade (24-86 full defects)
Class 5	Off grade (more than 86 full defects)

Source: ICO, 2004

Similarly, specialty coffee refers to class 1 in which no primary defects are permitted, and only 5% by weight can be above or below the indicated screen size, which implies that the customer chooses according to his preferences (Table 2.2).

Table 2.2 Quality requirements for different grades of coffee

Exchange Grade (9-23 full defects)	Specialty Grade (0-5 full defects)
Primary defects permitted, 50% by weight above screen size 15, less than 5% below screen size 14	No primary defects, 5% above below indicated screen size
No faults permitted, 5 quakers permitted	No faults and taints, no quakers
Sound cup, good roasting	Most possess at least one distinctive attribute in the body, aroma or acidity

Source: ICO, 2004

Cup tasting is also the way to evaluate the coffee in an objective and reproducible way. Its main objective is to describe the flavour profile by attributes and values related to the intensity of each attribute, seek objectivity. Only trained coffee experts can judge coffee by this method. This kind of assessment, in some way, is inevitably subjective, since it is based above all on personal experience and memory. The basic attributes evaluated in cup tasting are: aroma, flavour, body and acidity (Deoju and Manandhar, 2004).

Wintgens (2004) in his literature defined the terms that are frequently used to assess the cup characteristics of coffee include:

Aroma: the fragrance or odour perceived by nose of freshly ground coffee and in cup aroma after 4 minute contact with hot water.

Taste: perceived by the tongue

Flavour: combination of aroma and taste. The flavour is described in terms of winey, spicy and fragrant. Off flavours, such as grassy, onion, musty or earthy reduce coffee quality.

Body: feeling of heaviness or richness on tongue.

Acidity: sharp and pleasing taste. It can range from sweet to fruity and is considered as a favourable attribute. Also roasting has an effect on acidity, the more intense the roasting, the more acidity is affected.

2.5 Quality management systems

Good quality produce is very important to consumers and retailers, and it is a key factor consumer's use in evaluating a supermarket. High quality produce is second only to a clean, neat store as top factors in selecting a supermarket. High quality fruits and vegetables are rated very important by all income and geographic groups, but they are especially valued among the highest income households (Bruhn, 2002).

It is important to realize that the physicochemical properties of products for consumption are the result of a complex food production chain where various technological conditions and many quality decisions contribute to final food quality. It is necessary to look at this from a chain perspective because it gives some insight into where and how to take design, control,

improvement and or assurance measures to realize physicochemical properties and related attributes that comply with consumer demands (Luning and Marcelis, 2009).

With respect to food safety control and assurance, processing can often eliminate many pathogens and spoilage micro-organisms but heat stable toxins, many environmental contaminants and various residues cannot be removed by processing. Their occurrence should be kept below certain limits by preventive measures as early in the food production chain as possible.

It becomes apparent that it is not always clear what belongs to quality management system and what not. The boundaries between quality management systems and other management systems (market) of the firm (enterprise, company) are blurring. Information structures that are created for the transfer of information about quality compliance are increasingly used for the transfer of all kinds of products and process related information. One should note that the term 'best practice' quality management system depends on the market a firm is operating in (Plaggenhoef *et al.,* 2009). At the bottom of the market in particular quality regulations are regarded as something firms have to comply with and the perception exists that it should do as little as possible for the assurance of quality.

2.5.1 Quality management in coffee processing

Coffee beans and ground coffee are more likely to be attacked by toxicogenic fungi as compared to cherries and parchment if not stored properly. Although the issue of time of invasion of coffee by toxicogenic fungi has not been properly carried out, this is of great importance in understanding the problem of Ochratoxin A (toxin produced by the fungus *Aspergilus*) in coffee and developing control strategies. Experiences have shown that if invasion occurs during preharvest operation, control will be much more difficult than if it occurs postharvest, i.e. during drying and storage of dry cherry, parchment, green beans and ground coffee. Postharvest problems seem to be appeared due to unfavourable climates for drying, poor drying practice, quality control or inadequate storage conditions (Taniwaki *et al.,* 2003).

Moisture content (MC) and water activity (aw) are the most important factors that influence fungal growth in coffee bean. To avoid the development of toxicogenic fungi in coffee, the water activity should be kept under control from postharvest to final processing. Drying coffee beans to 11-12% moisture content, which corresponds to water activity (aw) of 0.60, avoids subsequent fungal growth and consequently Ochratoxin A production. Coffee roasting can remove level of Ochratoxin A to a significant percentage i.e. 20-60% reductions. However, depending on the roasting process, the residual Ochratoxin A percentage in coffee may differ from 0-100% (FAO, 2008).

Coffee processing and trading company has to put in place a system to assure quality standards for coffee all the way from its pulping centres, through the milling process, to the market. It should check for the size and maturity of the coffee cherries and moisture levels of parchment and also grade the coffee using special grading machine and a trained specialist in the processing factory who are responsible to check that the green beans are unbroken and free of foreign particles to ensure good quality control system (KIT and IIRR, 2008).

2.6 Coffee value chain

A value chain is a specific type of supply chain one where the actors actively seek to support each other so they can increase their efficiency and competitiveness. They invest time, effort

and money and build relationships with other actors to reach a common goal of satisfying consumer needs so they can increase their profits (KIT *et al.,* 2006).

Value chain map of coffee in Kavre district includes the linkages of many actors from the input supply up to the consumers. Different actors, their roles and interrelationship among them fall under the scope of the chain map (Annex B).

Some of the coffee industries in Nepal do all the activities from the production of seedlings to pulping, hulling and even export covering the entire chain. These industries are not specializing their roles but exporting small volumes of green beans by performing all the roles from seedling production to all kinds of processing. The exportable product is costly due to the fact that all the functions such as pulping, fermentation, hulling, drying, roasting, grinding and exporting are done by a single enterprise in small volume (Tiwari, 2009).

Value chain of coffee in Nepal is not well defined and is still unorganized owing to the reasons of low volume of production. Before 2000 A.D., most of the coffee production was concentrated only in the Western region of the country and farmers were dependent on few coffee processing factories to sell their fresh cherries which have resulted in a sort of monopoly in the coffee market. In recent years, with the gradual increase in the area, production and demand, many processing companies, private and run by farmers' cooperatives, have been emerged (Sapkota, 2007).

In Nepal, most of the coffee is processed by wet method i.e. 75%, however dry processing methods is still in practice (25%) in rural areas where transportation is major problem and farmers are not accessed by pulping machines. More farmers have been showing interest towards wet processing methods as the price premium for the parchment coffee is higher (Koirala, 2003).

2.7 Quality management in coffee supply chain

Coffee farmers union has greater power in controlling the chain activities such as logistics, processing, marketing and exporting. It has capability to negotiate on prices, coordinates the producers and organizes the quality control throughout the chain (KIT *et al.*, 2006). An expert from the agricultural department checks the quality of coffee bean brought by cooperative to the processing factory for moisture content and colour.

Wet processing is more controlled technique than dry processing, and produces better quality coffee, which fetches better prices (KIT and IIRR, 2008). Coffee processing company has greater role to create a sustainable business by improving the end-quality of dried coffee beans through better post-harvest processing techniques. Coffee cherries are bulky in nature, perishable product which has to be processed quickly.

The striking emergence of dynamic markets for certified organic, fair trade and eco-friendly coffees firmly place the coffee industry at the forefront in developing innovative responses that are relevant to the difficulties of the rural development and trade in coffee producing countries (Giovannuci, 2003).

In Nepal, improvement in quality of coffee through the supply chain not only depends on coffee production management system adopted by the coffee producers, but also on postharvest on-farm quality management system. Lack of appropriate equipment (pulping machine) and well

established pulping centres to pulp substantial amount of fresh cherry in one pulping center has also created problem on the uniformity of quality of coffee (Tiwari, 2009).

Giovannnucci (2003) also reported that 90% consumers and traders consider overall quality to be the most important factor in making sustainable coffee valuable to their business. Because of the consumers' emphasis on quality, only production system that includes high quality coffee will be sustainable. The consumer apart from the product quality believes that these three general types possesses intrinsic qualities that most closely fulfill the balanced social, environmental and economic requirements necessary for sustainability in coffee production and consumption.

Sustainability in the coffee industry which is being led by overall quality in coffee is mainly concerned with three major ideas: fair trade, organic and eco-friendly or shade coffee. Steiman (2002) distinguishes these three groups as:

Fair trade coffee is bought directly from the cooperatives of the small coffee farmers that are guaranteed a minimum pre-set contract price. This coffee addresses the pillar of social acceptability. Organizations that make fair trade agreements with farmers guarantee a living wage for those farmers as well as access to credit and consumer markets. They seek to ensure that coffee farmers and processors lead good, healthy, productive lives.

Organic coffee is certified to be produced with methods that preserve the soil and without the use of synthetic chemicals. It is mainly concerned with the health of the environment.

Eco-friendly coffee is certified to be grown in shaded forest settings in a manner that is good for biodiversity, bird habitat etc. Large shade trees are used as a canopy to cover the coffee crop. These shade trees not only serve as habitat for birds, but also a great deal of biodiversity thereby reducing the risk through enhancement in the farmers' social and economic lives.

More and more large coffee companies are getting involved with their own private systems for the production of sustainable coffee. Famous coffee brands like Nestle and Starbucks have developed their own coffee quality management systems. Traditional quality assessment such as taste, smell and reliability are now extended with the food safety systems e.g. HACCP throughout the supply chain. With the coffee consumers growing interest in the environment and sustainability of coffee supply, these companies have also integrated and supports for the production and processing of sustainable coffee in the country of origin.

2.8 Critical control points at coffee processing

Critical control point (CCP) is a step at which control can be applied and where control is essential to prevent or eliminate a food safety hazard to reduce it to an acceptable level (Luning and Marcelis, 2009). CCP decision trees can be applied to determine the critical control points at coffee processing level (Figure 10). After determining the critical control points, establishment of critical limits for each CCP is a sequential step. The main reason behind establishing the control limit is to control the hazard at an identified CCP level. The quality manager needs to specify which factors are associated with the particular CCP. For each factor influencing the control of CCP, the desired or norms and tolerances should be established. Critical control points at processing level of coffee and control limits associate with each CCP is presented in Table 2.3.

Regular monitoring is needed in order to measure and observe the CCP in relation to its critical limits. Regarding CCP at coffee processing level, it can be monitored by observation (e.g. visual monitoring of colour, appearances of cherries and beans) and by measurements (weight, size moisture content, number of defective beans). Laboratory test is mainly done to check the chemical composition and pesticide residues in the coffee beans. Larger the variation in the harvested cherries and processed beans then more monitoring is required. Accuracy, preciseness, reliability and sensitivity are also important consideration for monitoring the CCP (Viani, 2001).

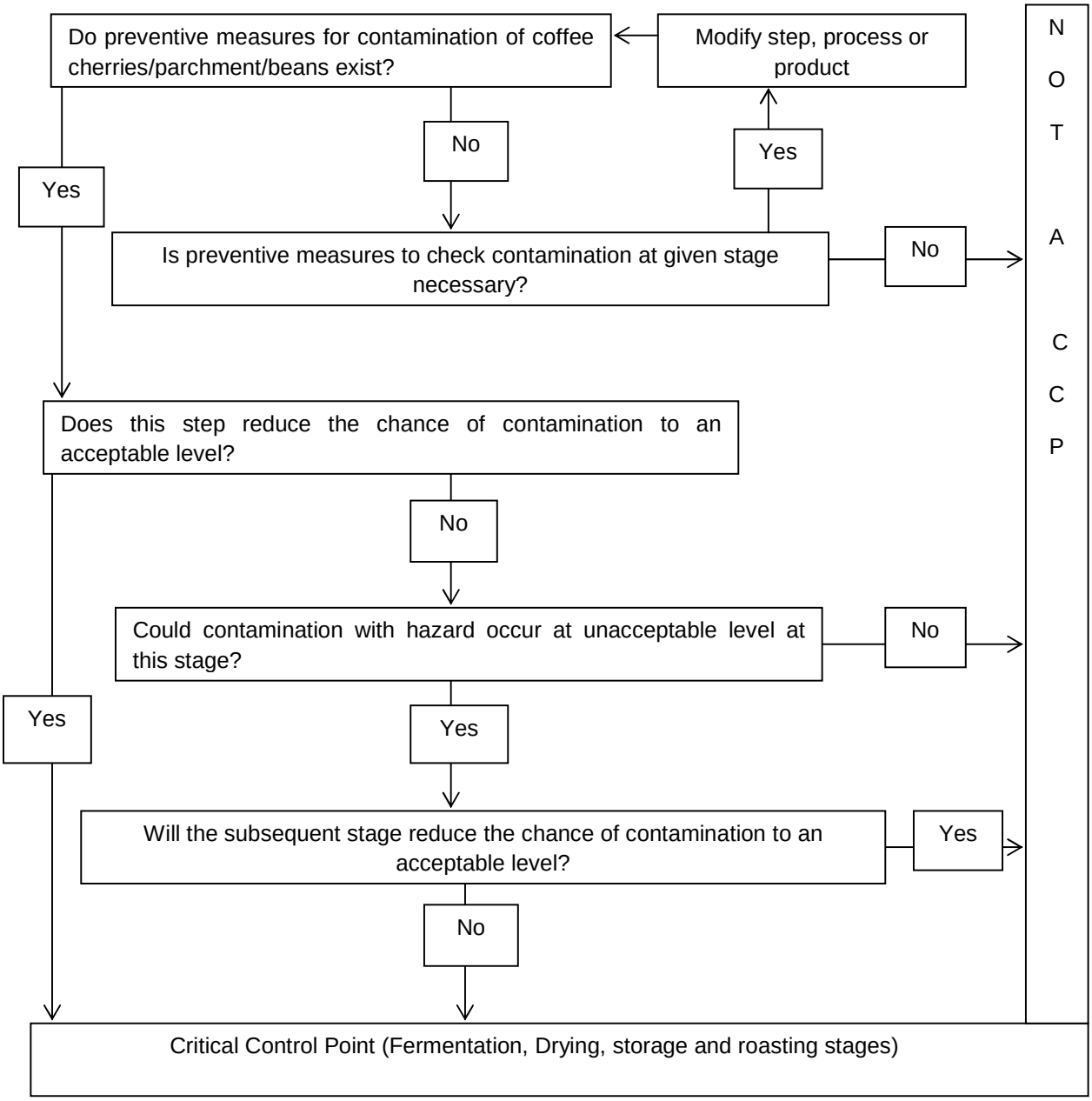

Figure 2.10 CCP decision tree at coffee processing level
(Source: Luning and Marcelis, 2009)

Table 2.3 Critical control limits for each CCP at processing stage of coffee

CCP step	Critical limits*
Fermentation	24-72 hours
Drying	At 11-12% moisture
Storage (parchments/beans)	At 20-25^{o} C, 50-60% RH
Roasting	At 200-240^{o} C for about 10-15 minutes

Source: FAO, 2008

*Critical limits: The maximum or minimum value to which a hazard must be controlled in order to prevent a food safety hazard or reduce its occurrence to an acceptable level.

CHAPTER 3. METHODOLOGY

This section includes the selection of study area, description of the study area, selection of respondents, selection of coffee traders, data sources and their collection techniques, and methods of data analysis.

3.1 Site selection

Panchkhal Village Development (VDC) of Kavre district is selected purposefully for the study of coffee producers and processors. Selection of site is due to the active involvement of most of the farmers, processors and traders in coffee plantation, processing and trading activities and familiarity of the researcher with research site and the people of that site.

3.1.1 Description of Kavre district

Kavre is a mid-hill district of central development region of Nepal. It is situated in Mahabharat mountain range covering 140486 hectares of land with its altitude range 300-3018 meters from the sea level (Figure 3.1). The average size of household in this district is 5.4. The average land holding is 0.8 ha per family (DADO, 2008).

Kavre is one of the most nearby district from the capital valley, Kathmandu. A total of 120 ha of land is under coffee farming in the district producing 27 metric tons of dry parchment. Almost 22,000 coffee growers are involved in coffee production (MOAC, 2008).

Panchkahal is the second largest VDC in the district with almost 150 coffee growers with average number of coffee plants per grower is 80 (DCPA, 2009).

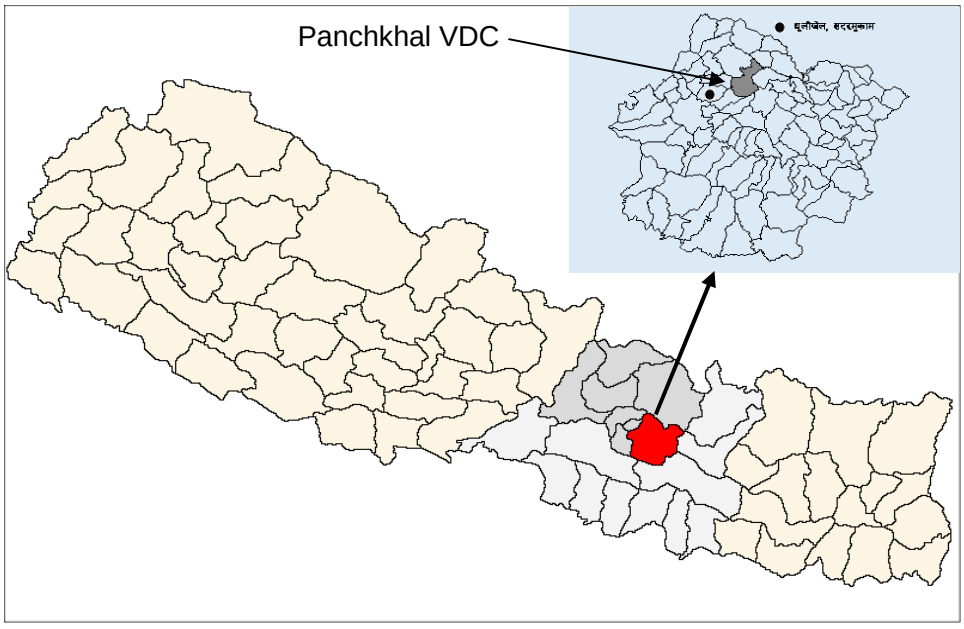

Figure 3.1 Map of Nepal and Kavre district
(Source: Google Image, 2010)

3.2 Sources of information

3.2.1 Primary sources of information

Farmers, processors, traders, local roasters and consumers were the primary sources of information. Group discussion and interview were the means to collect information from the respondents

3.2.2 Secondary sources of information

Different institutes and organization such as marketing development division, Ministry of Agriculture and Cooperatives, Central Bureau of Statistics, National Tea and Coffee Development Board, Nepal Coffee Producers' Association, District Coffee Producers' Association were the secondary sources of information. Other secondary sources included the different related coffee cooperatives as well as various governmental and non-governmental organizations working for coffee promotion and development.

3.3 Research Design

The research has more qualitative and few quantitative approaches based on data collection from case studies and survey. In a qualitative approach regarding case studies, the research aims to gather an in-depth understanding about the postharvest processing and trading of coffee with regard to quality management aspect in the coffee value chain. A survey was also done concerning quality of coffee produced from dry and wet processing techniques. This is mainly based on the observation of numerical parameters related to coffee processing and quality management. The whole research work took a total of three months. A desk study was conducted in the month of June and early weeks of July while the actual field work to collect the data for the study was carried out from third week of July to first week of August. Data analysis, findings and write up were done after second week of August till the first week of September.

3.4 Sampling procedure and data collection

3.4.1 Sampling procedure

All farmers, processors, traders, local roasters and consumers of Panchkhal VDC of Kavre district constituted the sampling frame of this study. Respondents were selected through random sampling procedure from different wards of that VDC. Panchkhal VDC was selected for sampling site on the basis of concentration of coffee growers, processers and traders in that area. The list of coffee producers, processors by dry and wet method and the traders was prepared with the help of District Coffee Producers' Association (DCPA), District Agriculture Development Office (DADO) and Coffee Producers' Groups (CPGs). Detailed case studies with 7 chain actors including 2 leader farmers (Annex C), 2 processors (dry and wet) (Annex D), 2 traders (Annex E), and 1 local roaster (Annex F) were done followed by a survey consisting of 30 respondents including 10 farmers, 5 processors, 5 traders, 10 consumers (Table 3.1) was done with multiple choice questions as checklists for the interview (Annex G). See 3.4.2.2 for more details.

Table 3.1 Sample size for survey and case study

Actors	Case study	Survey	Remarks
Farmers	2	10	Due to time constraint, only 30 chain actors were selected for survey.
Processors (dry and wet)	2	5	
Traders	2	5	
Local roasters	1	-	
Consumers	-	10	
Total	7	30	

Note: Six actors in the case studies except local roaster were also included in survey.

3.4.2 Data collection techniques

The respondents were given precise information about the questionnaires used during survey prior to interview. A brief presentation was given in order to make easier understanding pertaining to research study to the respondents covering the processing, trading and quality management aspect of coffee.

The interview schedule and checklists were pretested prior to administering to the actual respondents. It was done using 5 respondents near to the study area. The suggestions given during pretesting were considered as an important feedback for the final interview schedule.

After group discussion, presentation and pre-testing the questionnaires, the respondents were interviewed individually and in group. The researcher himself was involved for interviewing the respondents in case study while other 2 persons helped in taking interview with respondents for survey.

3.4.2.1 Instruments used on data collection

Digital moisture meter was used for measuring the moisture content of the coffee bean obtained from either of the two processing methods (Annex K). Moisture content of the bean was taken randomly from six different lots per methods (dry/wet). Same weight of sample (250 gm) was used from each lot. Each sample was put on the tray fixed in meter and the instrument showed the reading while pressing the button provided with this. The reading shown by the instrument for each sample was noted down carefully. The average reading value obtained was compared with standard moisture range recommended by International Coffee Organization (ICO) for interpretation (Refer section 2.4.2.1).

3.4.2.2 Survey for cup taste test

A survey was done to analyze the significant differences between cup ratings from either of two processing methods. The respondents (n=30) were asked the questions dealing with the attitude towards taste of coffee beverages and their cup rating pattern. Each respondent was served by the two cups of coffee, one from dry processed and another one from wet processed, at 15 minutes interval. The respondents were not known about the cup from either of the processing method. The qualitative data obtained during survey was analyzed using SPSS.

3.5 Benefit-cost ratio analysis

For the benefit cost analysis of both processing techniques, the variable cost of production and processing of coffee and gross return from coffee production and processing was used. The benefit cost ratio of each coffee processing method was calculated as B/C ratio = Gross return/ Total cost.

The gross return for both dry and wet methods was calculated. Similarly, the costs involved in both methods were calculated for different processing steps. So, on deriving the gross return and total costs incurred, the B/C ratio was calculated. The gross return for dry and wet methods and the total costs was collected using a B/C ratio calculation format (Annex H).

The data on prices and production costs of coffee at different processing steps (harvesting, drying, pulping, hulling) was available from National Tea and Coffee Development Board.

3.6 Methods and techniques of data analysis

Both the primary and secondary data collected from the field survey and case study were coded, tabulated and analyzed according to the objective of research carried out using SPSS and Micro-Soft Excel. The data collected during survey were mostly qualitative i.e. opinions and perceptions of respondents on coffee quality aspects whereas few quantitative data like moisture content of the green bean obtained by two processing methods were interpreted simply by comparing the value with the standard commercial range (Refer section 2.4.2.1).

CHAPTER 4. RESULTS

The collected information was analyzed using proper statistical tools and the results have been presented in this section.

4.1 Results base on case study

4.1.1 Status of coffee processing in Kavre district

The key respondent (wet processor) of the case study confirmed that 70% of total coffee produced in the district was processed by wet method. Rest of the 30% was produced by dry method. Only producers and processors who live in remote areas with transportation problem and inability to buy pulping machine were practicing this method.

4.1.2 Dry processing

The respondent who practiced dry method reported that freshly harvested cherries were spread over straw mats without sorting and grading. The cherries were sun-dried until it was fully dried. Depending on the intensity of sunlight, it took about 2-3 weeks for the coffee cherry to dry completely. The dryness was determined by feeling with the hand and sound produced while shaking dried cherries. The sharp crackling sound on shaking was an indication of low moisture level and ready for storage. The key factor they considered for dry processing was the sunny weather. The processor used only locally available materials like mat and basket for drying. The practice of sorting and grading was not common among the dry processors.

Their knowledge on dry processing was simple and indigenous that they knew through their own working experiences. The processor manually carried their coffee cherries for sale. The problem of dry processor was their inability to buy pulping and drier machine due to financial crisis.

4.1.3 Wet processing

It was found from the district chairperson that 67% of coffee processors produced parchment coffee by wet processing method. Eighty percent of the processors harvested cherries and pulped on the same day (within 24 hours). He also reported that 90% of the wet processors followed cherry sorting by floatation technique.

4.1.3.1 Harvesting of coffee cherries

The respondents told that colour was an important indicator for harvesting fresh cherries. They harvested the fresh cherries at fully ripened stage once the skin colour start turning deep red. Harvesting was done manually by hand-picking. Ripened cherries were hand-picked and collected in plastic bags. They also reported that harvesting was time consuming. It takes about a day to harvest 15kg for a person. The harvesting starts from November till March. The sale of harvested coffee happened on the same day of harvesting.

4.1.3.2 Sorting and grading of fresh cherries

It was found that only the processor who practiced wet method followed sorting and grading of fresh cherries after harvesting. He sorted out fresh through floatation technique. The cherries were put into bucket of water and floating cherries were separated and processed separately. The practice of grading fresh cherry after sorting was passed through the wire mesh of $16mm^2$

sizes to maintain uniform size of the cherries. The cherries that pass through the wire mesh holes were considered as down-graded cherries and processed separately. Only those cherries that did not pass through the holes were processed for the export market.

4.1.3.3 Pulping and fermentation

The pulping centre reported that it had to cater many small farmers and during coffee harvesting season, all farmers brought fresh cherries at the same day for sale. The fresh cherries had to wait for more than 24 hours before pulping and fermentation due to the poor condition (inefficient) of pulping machine and few in number.

The processor used plastic bags or jute sacks for fermentation. The average batch size of fermentation used was 20kg. He also reported that the performance of the pulping machine was unsatisfactory as it did not remove the skin completely. Neither chemicals/additives nor any processing parameters (time, temperature) were used to control fermentation. It took about 24-72 hours depending on the weather condition. The end of fermentation was determined by gritty feel of parchment by the hand.

4.1.3.4 Washing and drying

The processor used water from well to clean the parchment. The cleaning completes with changing water three times to wash every lot of parchment. He dried the parchment in direct sunlight over the raised wire mesh tables from ground level. Depending on the sunshine, it took 3-7 days to dry. The optimum moisture content of the parchment was determined by biting. The wet processor was provided with moisture meter. It was used to check the moisture content of the parchment and green bean maintaining moisture level at 11-12% for storage up to 6 months in a room temperature with provision of ventilation.

4.1.3.5 Hulling

Both dry cherries and dry parchment were hulled in the same machine and stored in separate bags. The processor experienced difficulty in hulling dry cherry than parchment. In such cases, the processor dried further to facilitate better hulling process. There was not much problem with the dry parchment bought from the pulping centres (wet processors). Moisture content of every lot of parchment was checked before hulling. They stored green beans obtained after hulling in jute sacks for the export market and in plastic or jute bags for the local market.

4.1.3.6 Sorting and grading of green beans

Manual sorting was done by using wire mesh. During sorting, all defective beans (quakers, stinkers, diseased and pest attacked) and extraneous materials present were separated completely. The sorted beans were graded into different grades (I, II, III and IV) according to sizes (Table 4.1). Green beans of grade I and II were exported and III and IV were sold in the domestic market (hotels, restaurants, offices). Sorting and grading were done for both the method. However, green beans obtained from dried cherries were sorted and graded only after hulling. Sorting and grading in wet method took place twice; before pulping and after hulling.

Table 4.1 Commercial grade standards for green bean

Grades	Description
I	Beans passing through screen size 18 (7 mm holes)
II	Beans passing through scree size 16 (6.3 mm holes)
III	Beans passing through screen size 14 (5.5 mm holes)
IV	Beans passing through screen size 12 (4.7 mm holes)

(Source: Field survey, 2010)

4.1.3.7 Roasting and grinding

Local roaster in Kavre district used both electric and traditional roaster. Coffee beans were roasted at 200-250^{0}C for about 10-15 minutes depending on the category of roasting. Beans were roasted in light, medium and dark colour according to consumers' preference. In traditional method, metallic pots were also used for roasting green beans. Roasting was done to add aroma and flavour quality to coffee. Electric grinding machine was used for commercial scale. Traditional grinding was also practiced using mortar and pestle.

4.1.4 Critical control points (processing level)

Dry processor in the study area reported that drying of cherries up to recommended moisture level of 11-12% was a critical point. Sorting and grading of fresh cherry according to colour, size and weight was necessary at this stage.

Wet processors (pulping operators) in the Kavre district said that in sorting and grading of fresh cherries, fermentation and drying were the CCP at primary processing level of coffee. As revealed by the pulper, sorting and grading operations was done by them. Optimum stage of fermentation of parchment after pulping was a control point, which otherwise results into off-flavour in the cup quality due to blackening spots. Also drying stage was considered as a CCP since optimum moisture content has to be maintained for the parchment for longer storability of 4-6 months without any deterioration in quality.

Secondary processing level: Sorting and grading of the green beans after hulling was critical stage and was important for the export market. During sorting, they mostly separated beans of off-size, blackened, diseased, pest damaged and extraneous materials. The storage of green beans was critical due to higher possibility of quality deterioration if not stored in an ambient temperature of 18-25^{o}C and desired relative humidity of 50-60%. The beans were mainly exported within two weeks after hulling.

Local roaster in Panchkhal VDC reported that roasting was the major critical control point at secondary coffee processing level. This was responsible for contributing the flavour for coffee. Temperature and time was considered important at this stage to produce light (grey), medium and dark (black) categories of roasted beans.

4.1.5 Quality parameters at different coffee processing levels

The coffee processors looked for the following quality parameters of the raw materials they procured:

Table 4.2 Quality parameters of raw coffee at different steps

Processors	Raw materials	Desired quality parameters
Dry processor	Dried coffee cherry	- Uniformly dried to 11-12% moisture content - Uniform in size and colour, free from extraneous materials
Wet processor (pulper)	Fresh cherry	- Non-floating coffee cherries - Free of extraneous materials - Fully ripened and uniform size beans
	Parchment coffee	- Uniformly dried to 11-12% moisture level - Uniform light blue/grey colour - Uniform size - Free from extraneous material
Huller	Green beans	- Uniformly dried to 11-12% moisture content - Uniform light green in colour - Uniform size - Free of extraneous material
Local roaster	Roasted beans	- Uniformly roasted to optimum temperature (200-250^0 C) and time (10-15 minutes), - Pleasant aroma
	Ground coffee	- Uniformly ground with good texture (grittiness) - Pleasant aroma

(Source: Interview, 2010)

The dry processor inspected the quality of dry cherries for size, colour, and presence of extraneous materials. The wet processor inspected the quality of fresh cherries based on their experience and visual inspection (colour, size). Quality of dry parchment was inspected with reference to moisture content, uniform light grey colour and cleanness.

Hullers considered moisture content of green bean, uniform size and colour (light green) and cleanness as important quality parameters for green bean for export market. Local roasters reported that time and temperatures were two crucial parameters for determining the flavour of coffee at roasting stage.

4.2 Results based on survey

4.2.1 Determination of moisture content in green bean

The moisture content of GB taken from different samples obtained from both dry and wet method of processing was recorded by using digital moisture meter which is presented in Table 4.3. The average moisture percentages obtained were compared with the standard moisture range (9-12%) recommended by International Coffee Organization (Section 2.4.2.1). It was found that the moisture content of green bean obtained from dry processing was above the standard range, which was due to the reason that farmers had not given attention while drying

and storage of coffee cherries after harvest. The moisture content of dry parchment obtained from wet method of processing was found within the standard moisture range.

Table 4.3 Moisture% of green bean obtained from dry cherry and dry parchment

Sample no.	MC (%) of GB obtained from Dry Cherry (dry method)	Sample no.	MC (%) of GB obtained from Dry Parchment (wet method)
1	13.2	1	11.6
2	12.8	2	12.1
3	12.4	3	11.8
4	13.0	4	11.2
5	12.7	5	12.0
6	12.9	6	11.5
Total	**77.0**	**Total**	**70.2**
Average	**12.83**	**Average**	**11.7**

Source: Field survey, 2010

4.2.2 Cup quality comparison based on organoleptic taste

Based on the organoleptic taste done among 30 respondents for cup quality comparison, the following results were obtained:

Out of 30 respondents who tasted both dry and wet processed coffee, 24 respondents rated "very good" for the taste from wet processed coffee (Figure 4.1). They were again asked the reason for rating 'very good' for the cup from wet processed coffee. They reported that the cup had an excellent aroma (fruity) along with sharp and pleasing taste. Again majority of respondents (19) who rated 'good' for the cup given from dry processed claimed that even the cup tasted well but it did not have well aroma i.e. dull and also gave earthy flavour.

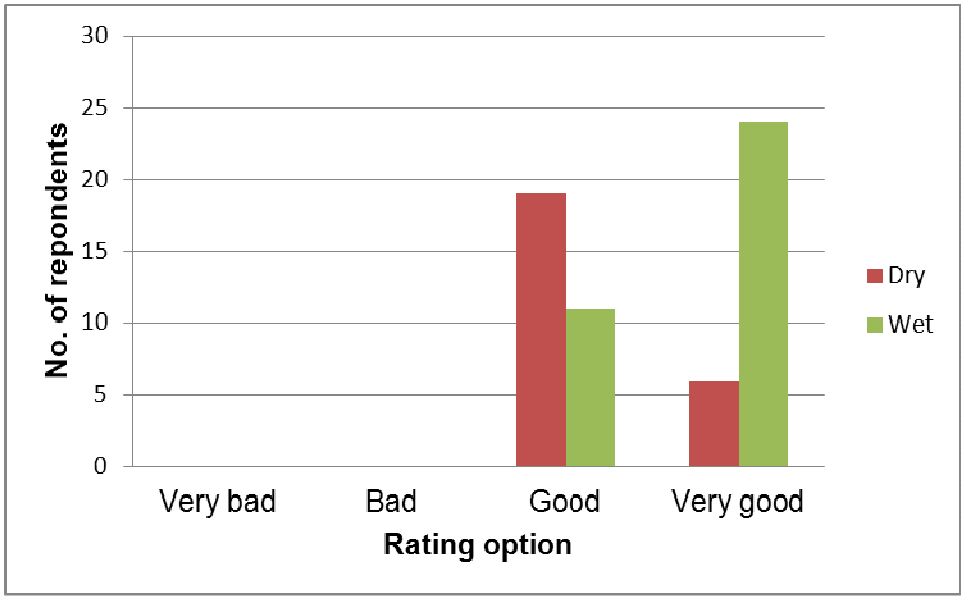

Figure 4.1 Cup rating by respondents on dry and wet method
(n=30) (Source: Field survey, 2010)

The Chi Square (X^2) test revealed that at 5% significance level (p = 0.001), there was significant difference in taste of coffee produced from dry and wet method (Annex I).

4.2.3 Respondents' perception on coffee quality

Thirty respondents were given the option to rank six important quality attributes of coffee. Each respondent ranked in their own order of importance (Annex J). Based on their own experiences and personal judgment, moisture content was the most important factor and colour least important. Moisture content was followed closely by flavour, aroma, size, and acidity (Table 4.4).

Table 4.4 Quality attributes ranking of coffee

Quality attributes	Respondents (n = 30)			Total scores	Rank
	Scores				
	1	2	3		
Moisture content	2	6	22	80	I
Flavour	6	9	15	69	II
Aroma	9	7	14	65	III
Size	10	11	9	59	IV
Acidity	8	17	5	57	V
Colour	15	8	7	52	VI
(Rating: 1 = least important, 2=important and 3 = most important)					

Source: Field survey, 2010

Evaluation of quality attributes that determine the quality of coffee bean is presented in Figure 4.2. Out of total respondents (n = 30), 43% judged moisture content as a major quality attribute. Similarly, 27% accounted size of green bean as an important attributes for good quality green bean (Figure 4.2).

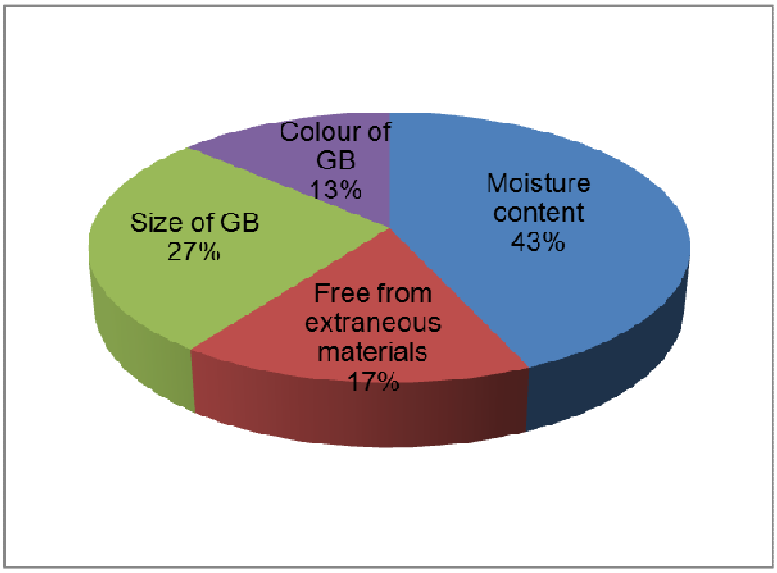

Figure 4.2 Respondents' perception on quality attributes for green bean
(n= 30) (Source: Field survey, 2010)

Evaluation of quality attribute that determines the coffee cup quality is presented in Figure 4.3. Thirty six percent of respondents rated flavour as major attribute for determining the cup quality followed by acidity, taste and aroma.

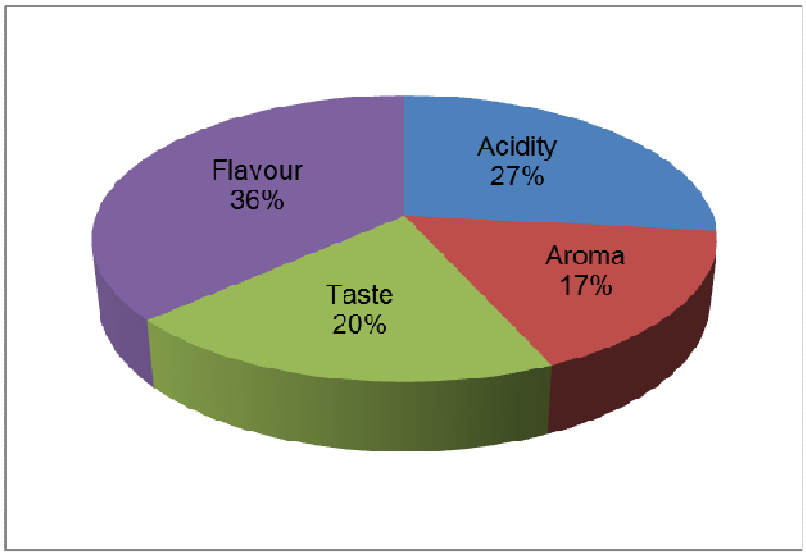

Figure 4.3 Respondents' perception on attributes for coffee cup quality
(n= 30) (Source: Field survey, 2010)

Evaluation of coffee quality in relation to the value chain functions through the coffee supply chain was assessed with the respondents. Processing (33% respondents) was the key function

followed by good nursery, proper storage facility, harvesting technique and transportation for quality coffee production (Figure 4.4).

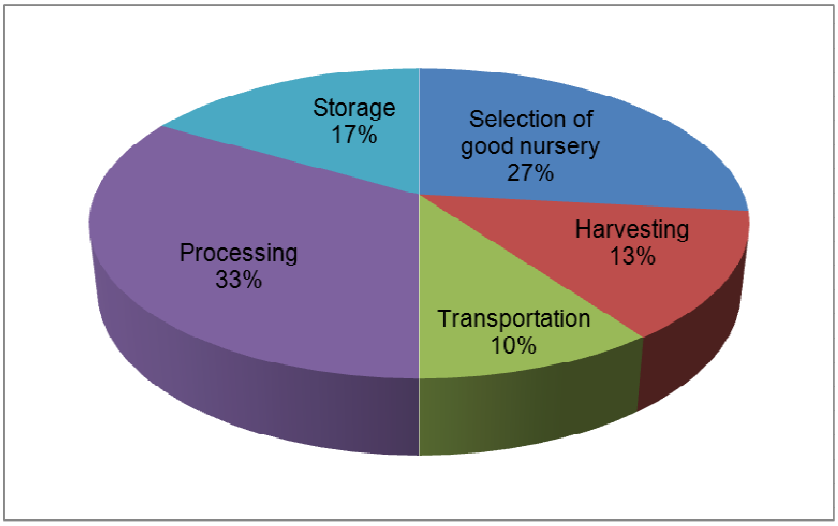

Figure 4.4 Evaluation of coffee value chain functions determining quality
(n = 30) (Source: Field survey, 2010)

On the reliability on methods to assess the coffee quality, moisture content determination was considered the most important (42% respondents) with colour as least important (10% respondents) (Figure 4.5).

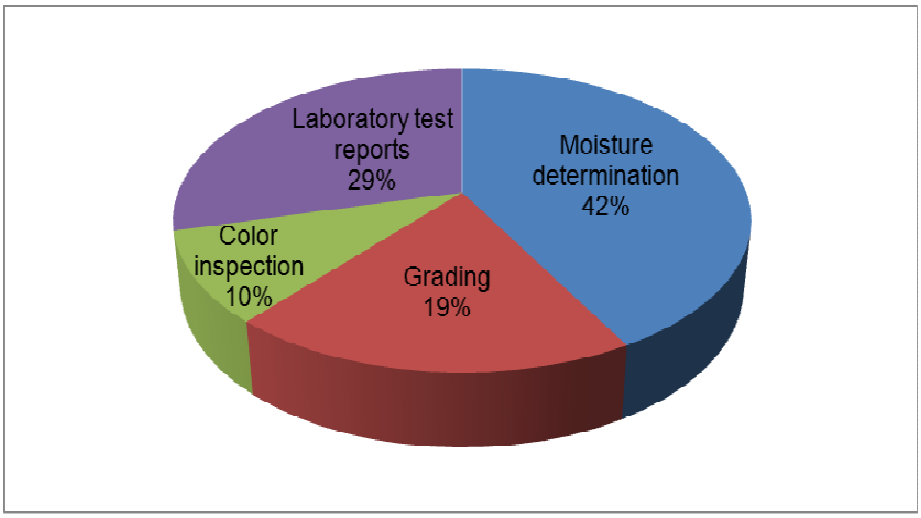

Figure 4.5 Evaluation of reliability on methods to judge the coffee quality
(n = 30) (Source: Field survey, 2010)

Evaluation of primary processing steps that determined the quality of coffee in respondents' perception in the order of importance was fermentation, sorting and grading for fresh cherries, de-pulping, washing and storage (Figure 4.6).

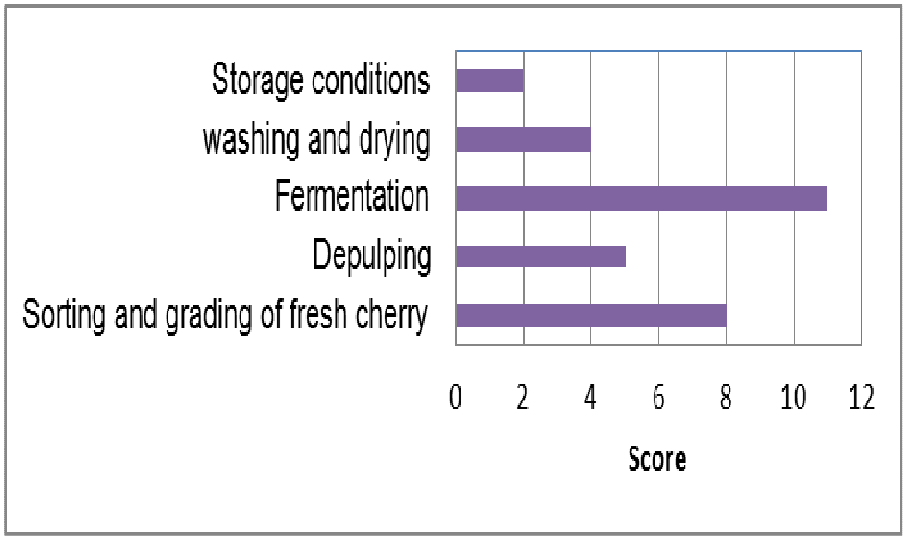

Figure 4.6 Evaluation of primary coffee processing steps in relation to quality
(n = 30) (source: Field survey, 2010

Respondents were asked to prioritise secondary coffee processing steps determining quality. Based on their experiences, roasting scored the highest (12). Grinding and packaging was given the least priority (3) (Figure 4.7). The second in the order of importance was given for hulling followed by storage conditions and sorting and grading of green beans.

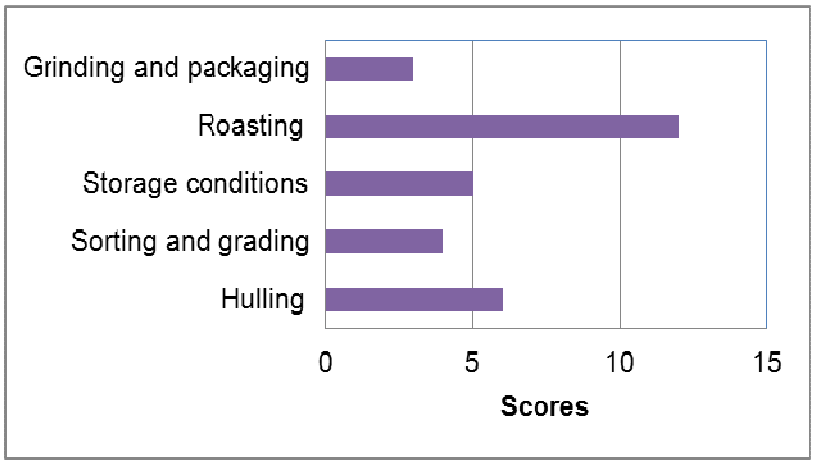

Figure 4.7 Evaluation of secondary coffee processing steps determining quality
(n = 30) (Source: Field survey, 2010)

4.2.3.1 Factors responsible for quality coffee production

The respondents gave more emphasis on training of quality management system in coffee production and processing methods. Therefore, knowledge and training was scored the highest (10). Institutional development and information flow and sharing was rated the lowest in the order of importance. Supply of quality input, policy on coffee production and processing were given mediocre priority (Figure 4.8).

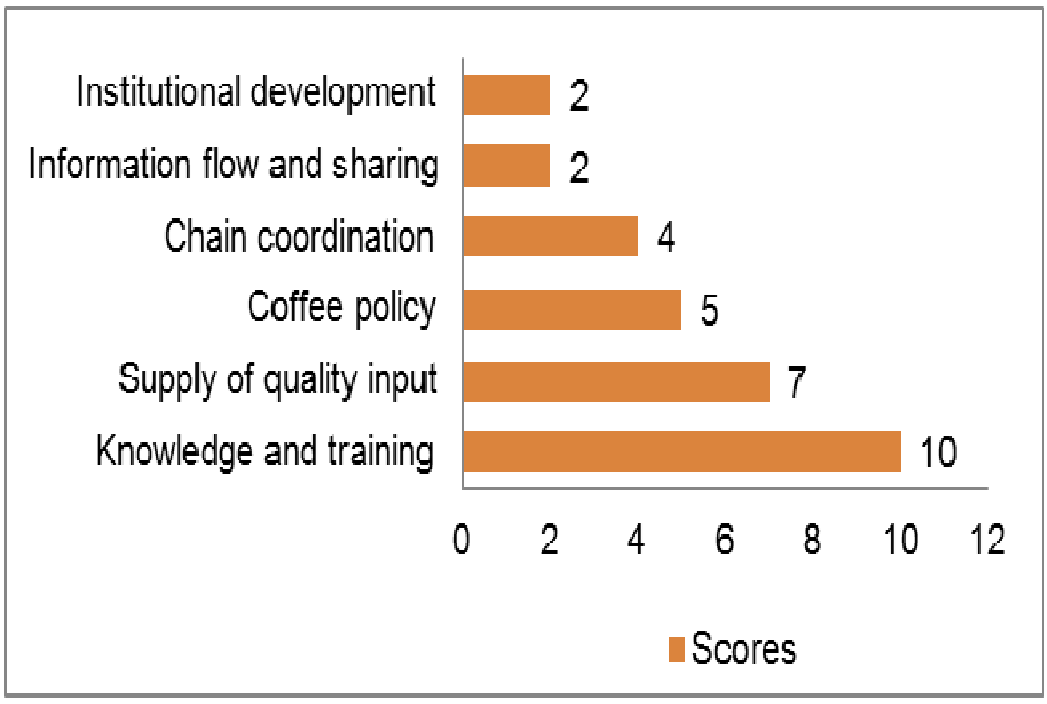

Figure 4.8 Factors responsible for quality coffee production
(n = 30) (Source: Field survey, 2010)

4.2.3.2 Reasons for using two methods of processing

Respondents were given chance to choose the options on reasons for practicing two processing methods. Maximum number of respondents (12 out of 30) scored on inaccessibility to credit as the main reason followed by proper training, inadequate backstopping with the least to unchanging habits of the coffee processors (Figure 4.9).

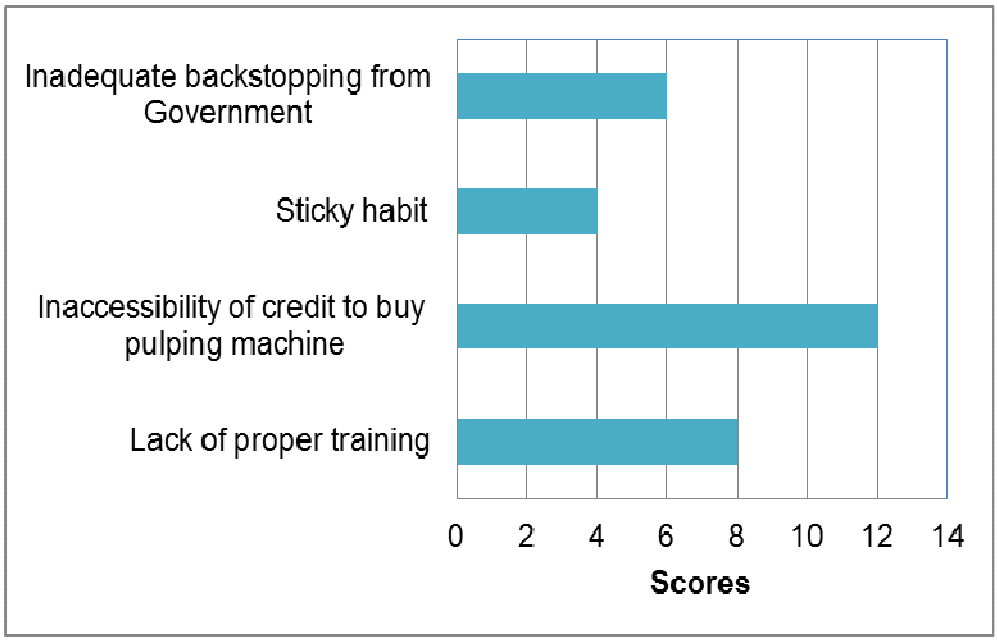

Figure 4.9 Reasons for adopting two processing methods
(Source: Field survey, 2010)

4.2.4 Economic analysis of dry and wet processing methods

The economic analysis of two coffee processing methods was done by calculating ratio of benefit to cost for each processing method which is presented in Table 4.5. Dry method of coffee processing had the higher benefit-cost ratio (1.4) than wet method (1.2). The sales price of raw coffee at each step and production and processing cost was provided by NTCDB.

Table 4.5 Benefit-cost ratio analysis of dry and wet method

Description	Dry method Price or cost/kg (NRs.)	Wet method Price or cost/kg (NRs.)
A. Gross return		
Farmer		
Sales price of fresh cherry	-	27
Dry processor		
Sale of dry cherry	95	-
Pulper (wet)		
Sales of dry parchment	-	140
Huller		
Sale of green beans	220	250
Total GR	**315**	**417**
B. Costs		
Farmers		
Production cost of fresh cherry	-	17
Dry processors		
Production cost of dry cherry	25	-
Pulper (wet)		
Production cost of dry parchment	-	130
Huller		
Production cost of green bean	198	198
Total Costs	**223**	**345**
B/C Ratio	**1.4**	**1.2**

(Source: NTCDB, 2009 and own calculation)
Note: The data related to production cost were based on average estimation by NTCDB.

4.3 Results based on both case study and survey

4.3.1 Advantages and disadvantages of dry and wet methods

Table 4.6 assures there are more advantages in wet method than dry. However, wet processing has also more disadvantages. Based on the sustainability in coffee production; quality, price and market are the three key factors which was found in wet method.

Table 4.6 Advantages and disadvantages of dry and wet method

Processing methods	Advantages	Disadvantages
Dry processing	- Simple - Low cost - Few handling steps - Relatively shorter process - Saves time - Less labour - Relatively cheaper in price	- Drying cherry takes longer time - High risk of secondary fermentation - Prone to fungal attack - Poor quality coffee - Not suitable for export market
Wet processing	- Produces clean parchment - Quality green bean - Better cup quality - Pleasant aroma - Original/natural flavour - Better taste - Less prone to fungal attack - Parchment dries faster than dry cherry - Export quality coffee - Fetches higher price (producers/processors and traders)	- High cost - Labourious - More time consuming - Tedious - Water pollution - Water scarcity - More handling steps - Mechanical failure (Pulping machine) - Requires energy (electricity) - Expensive coffee (local consumers)

4.3.2 Problems in both processing methods

Based on case study with coffee farmers, processors and traders and survey with 30 respondents, following problems were recognized:

4.3.2.1 Dry method

- It was found from case study though the dry method is simple one, the quality of coffee was comparatively found to be inferior.

- Farmers did not pay attention to sorting and grading of fresh cherries according to size and colour after harvesting, this resulted in green bean with inferior quality and was not well suited for export market.

- Although few operations were involved during dry processing, it took longer time for drying the coffee cherry to an acceptable level of moisture (11-12%) than dry parchment.

- It was found that the risk of secondary fermentation is high in dried coffee cherries.

- Poor ventilation was observed in a room where dry coffee cherries got stored.

- The silverskin attached to the surface of the green bean was also difficult to remove after hulling the dry cherries.

4.3.2.2 Wet method

- It requires more processing costs.
- There were not enough pulping machines in the coffee producing area.
- Farmers and processors did not have easy access for the loan to buy pulping machine.
- Fresh cherries had to wait more than 24 hours after harvest to de-pulp during peak season.
- The fermentation process was not properly followed to remove the mucilage from the parchment.
- Lack of technical expert and poor support from the institutions (I/NGOs, GOs) with regards to wet processing.
- Water scarcity was problem especially during pulping season (November to March) and the processors used unclean water to wash the parchment in scarce period in that district.
- Water pollution was also major issue as this method needs a lot of water to wash the parchment after fermentation.
- Over and under drying of parchment was also problem. The processors also get lack of drying infrastructure (wire mesh tables).

CHAPTER 5. DISCUSSION

Based on the results achieved from previous chapter, discussion was done on each section of results with regards to coffee processing and quality management.

5.1 Coffee processing

Quality of coffee is highly dependent on careful postharvest processing techniques. The main objective of processing is to remove the pulp, mucilage and parchment from the ripe coffee cherries. Processing of coffee improves its appearance and cup characteristics. Therefore, the improvement in quality of coffee not only depends on coffee production management system adopted by the coffee producers, but also on postharvest on-farm quality management system (Tiwari, 2009).

Well cultivated and fine coffee grown at high altitudes in particular when treated by wet process reveals a fragrance and taste never obtained by the dry method (Rothfos, 1998). The traditional way of processing (dry) is done mainly by sun drying directly on the floor. The raw coffee then becomes dirty and blotchy, the roast dull and the liquor earthy. The processing method used in coffee is usually the single largest contributor to the flavour profile of a coffee (Duarte *et al.,* 2005).

5.1.1 Status of coffee processing in Kavre district

Bulk part (70%) of the coffee produced was processed by wet method. The reason cited by the respondents was due to higher demand for wet processed coffee mainly for the export. Other reason could be due to higher price fetched by green beans. Rest of the production was processed by dry method due to inaccessibility to transport and inability to buy pulping machine. The dry processors' inability to buy machine for wet processing had resulted due to poor economic situation and absence of credit facility for them.

5.1.2 Dry processing

In dry processing method, the pulp and the parchment were removed in one single operation. This is a simple method, which does not produce high quality coffee (Wanyonyi, 1999). It is also a low cost processing method that does not demand expensive modern equipment like pulping machine. However, it requires good amount of sunlight for drying. At times when the weather is not favourable for drying, deterioration of cherries take place due to fungal attack rendering losses to the processors. Therefore, quality of dry processed coffee is weather dependent. Unlike wet processing, processors do not practice sorting and grading that saves labour. Also dry cherries can be taken for hulling at their and hullers' convenient time since coffee is not a full time work for them. Despite dry processing being simple and low cost, the quality of the coffee is compromised fetching low price.

The dry method produces heavy, sweet, smooth and complex body coffee. This method is often used in countries where rainfall is scarce and long hours of sunshine are available to dry cherries properly. Country like Brazil, Indonesia, Ethiopia and Yemen also practice this method (Duarte *et al.,* 2005). Many experienced dry processors reasoned that the sweetening taste of coffee in dry method basically appears due to longer time contact of mucilage, a sweetening agent in the inner layer of the pulp with the beans. Therefore, this supports the view of Duarte.

5.1.3 Wet processing

In the wet method, the pulp is separated from the parchment. The slippery mucilage is exposed which is removed by a process called fermentation. This process is followed by washing and drying of the parchment. Removal of the parchment by milling gives clean coffee. As there are many steps in the wet method of coffee processing, this certainly makes it expensive but, if properly carried out, it gives a high quality coffee (Wanyonyi, 1999). Coffee produced from wet method has lesser sweetness than dry processed coffee and is acidic. This method of processing is common in countries where there is sufficient water availability (Duarte *et al.*, 2005).

Unlike dry method, wet processing is laborious and expensive. It also requires lot of water for washing parchment. It is obvious that this method cannot be performed where there is water scarcity. However, weather is not much detrimental to wet processing.

The harvesting of cherries is laborious and tedious. It incurs higher labour cost. The time of harvesting is known to affect coffee quality. Either too early or delay in harvesting is detrimental to coffee quality. So, right time of harvesting and at the right stage (deep red) of maturity is required to perfect the coffee quality.

Sorting and grading of cherries is common with wet processing at the processor level. It is necessary to maintain uniform size of cherries, which facilitates pulping easier. If this is not done, there is a higher chance of getting semi or un-pulped cherries during pulping. Inefficient pulping machine prolongs pulping for fermentation. It often leads to poor quality coffee due to delay in pulping after sorting and grading. Further, the delay in pulping affected fermentation that results into poor coffee quality ultimately.

Fermentation is a critical processing stage, which needs careful attention. Processors in Kavre district practiced natural fermentation. This entails problems that are linked to poor control. If fermentation lasts too long, a microbial infection leads to mass formation of compounds such as propionic and butyric acids, which give pungent flavour that ultimately results in cup quality deterioration. Besides this, the stinker bean results due to prolonged or repeated fermentation and delay in pulping (Wintgens, 2004).

Some coffee specialists argue that certain bitter and soluble components of the coffee bean permeate the liquid medium by osmosis during natural fermentation. Those kinds of coffees have better aroma with floral, fruity and caramel taste (Gonzalez *et al.*, 2006).

Washing parchment after complete fermentation leads to consumption of large amount of water that becomes highly contaminated and difficult to treat. Source and quality of water used for washing is also a concern. Use of dirty water for washing the parchment also results into stinker beans.

Drying of the parchment in a raised wire mesh tables allow air circulation. Sun drying is common practice in Panchkhal district area and only few coffee companies have mechanical dryer. The decision of evaluating the optimum moisture content in the parchment through biting is a traditional practice and is not reliable. The processors need to have accessed with moisture meter for getting the reliable data.

To maintain quality of green bean, drying under 40^{o}C for parchment and 45^{o}C for cherry coffee by allowing hot air flows that are compatible to the removed quantity of moisture, and sufficient time for moisture migration from inner to outer side of the bean is necessary (Wintgens, 2004). Griffin (2001) states, final taste of coffee differ depending on the drying method. For instance, drying on clay patio results into a clay-earthy taste.

Wintgens (2004) has summarized the impacts of different postharvest operation on coffee quality as presented in Table 5.1. This summary (overview) on postharvest processing in relation to coffee quality strongly supports the views and opinions given by researcher, respondents and other people in above two sections (5.1.2 and 5.1.3).

Table 5.1 Postharvest treatment of coffee

Operations	Expression	Effect on quality	Reasons
Pulping	Green cherries Fermented cherries Nipped, bruised beans	Yes	Early harvesting Delay before pulping Unadjusted pulping machine
Fermentation	Pungent taste Bitter, fermented taste Stinker beans	Yes	Dirty water Inadequate removal of mucilage Unhygienic, dry fermentation
Washing	Stinker Fermented Earthy beans	Yes	Inappropriate equipment Dirty water Earth contact when drying
Drying	Green cherries Discoloured green beans Burnt, soft beans	Yes	Early harvesting Drying on the ground Over drying
Hulling	Broken beans Quakers	Yes	Poor adjustment of machine Improper sorting and grading

(Source: Wintgens, 2004)

Hulling of parchment is also an important stage in coffee processing. Hulling operates only at the secondary processing level (mid stage) because of high capital investment required for the machines. In order to hull out the beans from dry cherries, the pulp and parchment skin have to be removed in one operation. The coffee beans still covered by their parchment skin have to be separated from the shells (Coste, 2003). The dryness of bean is important during this process as the product has to be dried to an extent that the dry shells crack open or beaks-off. However, the beans should not be too dry since this makes it brittle and cracks.

Hullers in Panchkhal district experience problem with dry cherry with regards to hulling than dry parchment. It is due to the fact that dry cherries are not sufficiently dried by the processors. The dry processor often brought dry cherry with high moisture content. The another fact is that the dry cherries take relatively longer period to dry than dry parchment as it remains in contact with pulp and mucilage for long time. The mucilage is more hygroscopic and absorbs moisture from the surrounding.

Wickramasinghe (2001) in his report mentioned that quality green bean is obtained from hulling if the machine is adjusted properly i.e. adjusting the machine according to the size of dry

parchment or dry cherry. Processing improves the appearance of green beans in terms of colour and size and also cup characteristics. Under-ripe or over-ripe coffee cherries produce inferior coffee beans.

Roasting is the important stage throughout the coffee processing as it contributes to development of flavour profile in coffee cup quality. Electric roasting is modern method in which temperature and time is regulated automatically. In traditional roasting, which is still in practice in the villages of Kavre district, requires more experience and skills in order to make quality roasted beans of desired category.

5.2 Critical control points at coffee processing level

Processors at different stages of postharvest treatment in coffee realize different sub-steps (sorting and grading, fermentation, drying) as CCP. In fact, all the quality parameters (moisture, colour, size, fineness) could be achieved till the stage of green beans. However, if roasting is not done properly, all the quality attributes gained is deteriorated resulting into poor cup quality and low price. Dry processing of coffee has lesser CCP than wet method as it involves fewer handling steps. Hence, the chances of coffee quality deterioration is also more in wet method if critical control limits (for moisture content, temperature, RH%, time) is not established properly.

The CCPs with regards to coffee processing are drying of cherry, parchment and beans, fermentation and roasting. According to coffee technicians from Kavre district, the time duration for fermentation of parchment is 24-72 hours depending on weather conditions. If the surrounding temperature is low, it takes as long as three days to complete fermentation process. Similarly, determining end point of drying is also a critical stage where 11-12% moisture level is the critical limit for optimum storage. Traditional method of finding optimum moisture level in parchment, dry cherry and green bean through biting and shaking in hand is not a relevant way though the farmers and processors in Kavre district commonly practice it.

As roasting is concerned, time and temperature are the critical points that needs to be considered in order to obtain best flavour and aroma to coffee, which ultimately leads to good cup quality. Hicks (2000) claimed that roasting of green beans at 220^{o}C for 10 minutes results it into pleasant aroma in cup quality. This is in accordance with the statement as reported by the local roaster in Kavre district.

5.3 Coffee quality comparison between dry and wet method

5.3.1 Based on moisture content in green bean

It is obvious that dry cherries take longer time to dry than parchment as it remains attached to pulp and mucilage. Processors do not give much attention to drying cherries and also they do not measure the moisture level of cherries. They spread the cherries inside room on the floor without proper drying. The mucilage in the cherry is hygroscopic and absorbs moisture from the periphery if the relative humidity is high. In case of dry parchment, it gets dry quickly even in partial shade as it remains free with pulp and mucilage after pulping and washing. This is the reason that the moisture percentage of green bean obtained from dry cherries is higher than the commercial range.

In general, the quality green bean obtained from wet processing is better fetching higher prices than from dry one as the bean has already received desired level of moisture percentage during drying of parchment in wet method. But further drying of bean is necessary in the dry method as

the moisture percentage remains always high due to insufficient drying of cherries. Hence, wet processing is being popular among the coffee growers, processors and exporters in Nepal (Kattel, 2009).

Wickramasinghe (2001) also claimed that wet method produce better quality green bean than dry processing especially in case of Arabica coffee. This is due to the fact that dry cherry contains pulp and mucilage in contact with beans for longer time than dry parchment which means it needs sufficient drying period with more light intensity in order to reduce the moisture level to 12%. In case of dry parchment, the pulp and mucilage is removed within 24 hours and only parchment cover is remained which dries too fast even in low light intensity. The above statements claimed by two persons also support the researcher's opinion with regards to moisture content of bean processed by two methods.

5.3.2 Based on cup taste test

The wet processor in Kavre district revealed that the coffee gets detached early from the pulp and mucilage during wet processing. The parchments when get dried to an optimum moisture level, are stored safely in the jute sacks until hulling. During roasting, the beans also release original fruity aroma which ultimately results in good cup quality. As far as coffee from dry process is concerned, the mucilage which contains sugar remains in contact with beans even after drying. Therefore, sugar in the mucilage between pulp and parchment penetrates into the bean due to osmotic pressure. After drying, the cherries were packed in plastic bags/sacks and kept or stored for 3-4 months. During the storage, the cherries reabsorb moisture at room temperature where the humidity is slightly high. Due to this, secondary fermentation starts with the presence of sugar in the mucilage. Again the cherries are dried on the cemented floor or straw mat in contact with soil. It then becomes dirty and blotchy resulting into dull aroma and earthy flavour in coffee beverages.

It has been well accepted that green beans produced from wet method yield roasted beans and coffee beverages, respectively, that are characteristically different from the coffee produced from dry method with respect to flavour and aroma (Knopp *et al.*, 2005). There is no doubt that these differences in flavour in part have to be attributed to differences in thorough processes applied during either method of processing and the fact that only fully ripe cherries are used for wet processing, while fruits of all stages of ripeness are utilized in dry processing.

It is agreed that that wet processed coffee gives much better quality than dry one (Bytof *et al.*, 2000). The decisive quality criterion of coffee as cup or beverage is aroma, which composes of more than 800 compounds and only 30 of these contribute significantly to the specific coffee aroma. These aromatic compounds are responsible for estimating objectively the aroma differences resulting from different processing techniques. Since the actual reasons for difference in quality of technologically and distinctively produced coffee has not yet known. In this condition, the physiological and biochemical changes that occur in the coffee green bean during postharvest treatment and related to quality could be taken into consideration (Bytof *et al.*, 2000). The statements given by above two persons pertaining to difference in taste of coffee made from dry and wet method is in line with the view from respondent described in above paragraph.

The processing of same original material (fresh coffee cherries) by both methods (dry and wet) leads to significant differences in the cup quality of the corresponding roasted beans. This difference in quality is mainly based on metabolic changes within the coffee bean that varies depending on the mode of postharvest processing methods. These changes are mainly

associated with the mobilization of starch and sugars within the coffee seed generating low-molecular substances. They are free amino acids with potential aroma precursors which ultimately affect the quality of coffee. Normally total content of amino acids is found to be higher in wet processed green beans than dry processed ones (Selmar *et al.*, 2005). This statement also supports to the findings pertaining to cup difference between two methods.

5.3.3 Perceptions on coffee quality attributes

Moisture content in coffee bean is an important attribute determining its quality. The main objective of lowering the moisture in coffee cherries, parchment and beans is to preserve raw coffee safely to storage. This is normally done by sun drying during, which raw coffees are heated by direct exposure to the sun and by radiation from surface heat. If moisture content of coffee bean is not lowered to an acceptable level of 9-11% due to poor drying that develops fungus and off-flavors ultimately affecting the final taste of coffee (Piechaczek, 2009). This statement supports the perception of majority of respondents who also claimed that moisture content is crucial attribute for coffee bean.

There has been found some contradiction on the optimum moisture range for parchment and green beans. We can find a slight difference in range according to the standards set by various coffee exporting and importing countries. At this condition, one should follow the range recommended by ICO i.e. 9-12 % for export of green beans. Size and color of the bean are also important with regards to sorting and grading of cherries and beans. Grading of green bean according to size leads to obtain uniform roasting of beans otherwise smaller beans get burnt earlier.

Aroma is the fragrance or odour perceived by nose of freshly roasted bean and ground coffee, Aroma in cup is perceived after four minutes of contact with hot water. Flavour is the combination of aroma and taste of coffee. Flavour of coffee can be described in terms of winey, spicy and fragrant. Acidity in coffee develops sharp taste from sweet to fruity/citrus. This opinion is in accordance with the perception given by Wintgens (2004) in his literature.

5.3.4 Perception on coffee processing steps determining quality

The processing method is important for contributing the aroma and flavour in coffee cup quality. Therefore, the quality of coffee is dependent on careful postharvest processing. In primary coffee processing level which starts after harvesting up to drying of parchment, the fermentation of parchment after pulping is the most important stage for maintaining the quality of coffee. If fermentation lasts long, microbial inhibition takes place resulting to pungent flavour and stinker beans and ultimately affects cup quality. The above finding also supports with the findings given by Piechaczek (2009) in his thesis report.

While evaluating the secondary coffee processing stages consisting of hulling, roasting and grinding stages; roasting is the critical stage as this strongly determines the quality attributes in terms of aroma. The release of aroma takes place during coffee roasting that coffee lovers insist on performing themselves. A good roaster must be a part of artist, and part scientist to maintain the quality and consistence (Hicks, 2002). This finding is also supports with the thinking of majority of respondents who scored roasting as a critical stage with respect to coffee quality.

Temperature and time are two important factors that need to be considered during roasting. Deoju and Manandhar (2004) mentioned that coffee beans are roasted at 200-240^{o}C for 10-15 minutes depending on degree of roasting needed to make light, medium and dark coloured

roasted beans. This statement supports the facts given by local roaster in study area in relation to roasting of green beans.

5.3.5 Factors for quality coffee production

Quality coffee production depends on several factors that are social, economic, environmental and technical. Out of these, technical factor has major influence on the production of quality coffee. A good knowledge and skill on coffee production, processing and trading supports the chain actors to maintain the coffee quality throughout the chain allowing consumers to buy coffee without compromising on quality. It also helps to build the capacity of chain actors in their decision making process. The above statement supports the respondents perception who also claimed that knowledge and training as a crucial factor for quality coffee production.

Koirala (2003) in his research work suggested that institutional as well as technology development around quality coffee production and processing system needs substantial amount of financial investment drawn from public funds at least in early stages. Research, extension and development on coffee processing with regards to quality help for the better technology and knowledge dissemination. These statements are mainly concerned with policy on coffee production, processing which is of course responsible for quality coffee production.

Tiwari (2009) recommended that coordination in the coffee supply chain through better information flow among chain actors would lead to development of common understanding of the term quality as well as appropriate quality management system in coffee. This recommendation also supports the respondents perception on factors for quality coffee production.

5.3.6 Reasons behind adopting two processing methods

Coffee is a secondary crop for the farmers and processors in Panchkhal VDC. They are not paying much attention with regards to quality management. They rather give more time on growing food crops. Farmers do not want to waste their times on selling small volume of fresh cherries frequently after harvesting and dry them to make dry cherry. Only those farmers, who produce bulk volume of fresh cherries, bring to the pulping centres for sale after harvest. This is the reason for processors adopting two methods.

Munankami (2004) suggested that coffee processors at farm level needs to increase access to pulping centres. In Nepal, the numbers and capacity of pulping centres established are far lower as compared to quantity of fresh cherries produced based on the distance and numbers farmers a pulping center can cater. Due to this reason, farmers and processors in remote areas are still practicing dry method of processing. The researcher is also in accordance with above statement.

5.4 Benefit cost ratio of dry and wet method

It is obvious that dry method of processing consists of fewer handling steps than wet method. It consists of drying and hulling steps. The cost of drying cherries is low. Hulling cost of dry cherry and parchment is same for both methods. The total gross return in this method is much higher than total costs. Therefore, the B/C ratio is high for dry method. The wet method consists of more handling steps (pulping, drying, hulling). The costs related to these steps are also high. Also the return in this processing is slightly higher. Due to higher handling costs, the B/C ratio is low.

Tiwari (2009) in his report claimed that shifting from dry to wet method of processing has not only improved the quality of coffee but also increased the income of coffee growers. Higher return per unit of the produce (fresh cherry) received by farmers through selling of the fresh cherry at the pulping centres (wet method) has motivated farmers as an incentive to improve production and processing practices to some extent. The researcher agrees on above statement.

5.5 Advantages of dry and wet methods

Dry method of processing being simple and low cost, coffee produced is relatively cheaper in price. Local consumers can easily afford for this. It also saves time and labour. Quality of this coffee is low due to poor management practice.

Wet processing is found more advantageous based on the three key factors i.e. quality, market, and price. Quality, market and price are always interdependent each other and is also related to sustainability of the product. When there is quality product, there is obviously assured market which of course will have certain fixed price. Quality of green bean, cup quality of aroma, flavour, taste, acidity produced from wet method is better than dry. There are also lesser chances of cup quality deterioration. The quality aspects of wet processing are discussed at length under section 5.3. The demand for wet processed coffee is higher for export market. Even in the national market, the higher income groups of people and tourist hotels prefer this coffee. This quality of coffee produced in Nepal has the potential to become a niche product both for the national and international market despite being already in the export market. Given the micro-climatic conditions under which it is produced has greater influences on the quality attributes mentioned above, it also has the potential to develop a unique brand of Nepalese coffee for patent right with certification from ISO in the long run.

The wet processed coffee fetches higher price in the market today. This refers to quality of coffee again as discussed above. Additionally, as only exported coffee from Nepal, quality cannot be comprised and price is directly dependent on quality for profitability and marketability. Also, from the chain perspective, value addition of coffee takes place at various stages, the key quality attributes of coffee come into play.

5.6 Problems in dry and wet methods of processing

5.6.1 Dry method

In dry method of processing, that sorting and grading activity are not practiced by the farmers after harvesting all kind of cherries. As coffee is secondary crop, they do not want to give time for sorting and grading. They simply harvest the cherries and dry on cemented floor or straw mat according to the availability of drying materials. This ultimately resulted into poor quality green beans, which is not suited for the export market. As pulp (thick) and mucilage remains in contact with bean for longer period, the cherries take longer time to dry to an acceptable level of moisture percentage. The mucilage remained with dry cherry is hygroscopic in nature and absorbs water easily from surroundings even the relative humidity is slightly higher, which results to secondary fermentation. The silver skin gets tightly coated with the bean and is difficult to remove through polishing.

5.6.2 Wet method

The wet processing method of coffee consists of more handling steps and adding value at each step (de-pulping, fermentation, washing, drying and hulling). This value addition practices makes it costlier than dry one. The economic status of processors in Kavre district is poor and is unaffordable to buy pulping machine individually. These processors are not able to access loan to buy the machine. Political instability is adding more problems. There is poor relation among coffee processors, traders and finance institutions. Due to difficulty in accessing transportation, the farmers are unable to bring fresh cherries to the pulping centres within same day of harvesting, which ultimately delays pulping hours (>24 hours). Due to lack of knowledge on coffee processing and quality management system, the processors are unable to follow the fermentation techniques properly. Training not only helps in building the capacity of farmers and processors, but also updating their knowledge on processing techniques and quality management. They can also upgrade their skill and attitude through proper training.

Nepal lacks institutions providing training and skills to the coffee processors and technicians with regards to technology transfer focusing on quality coffee production. A research and extension activity on coffee sector with respect to quality management is still inadequate. The researcher strongly supports on this matter in relation to institutional development on coffee sector.

Due to the longer period of drought, there is water scarcity for coffee production in Pachkhal VDC. They are unable to wash the parchment at the right time despite proper fermentation process. Farmers and processors in that area are unaware of water harvesting techniques. The farmers do not dispose the water after washing the parchment in the right place, which (i.e drainage problem) enters into the well thereby polluting the drinking water.

The processors are still practicing the traditional method for finding the optimum stage of drying (i.e. biting of parchment and beans). The digital moisture meter is expensive. Only few processors could afford to buy. They do not have access to this instrument even they are willing to buy.

CHAPTER 6. CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

Based on the findings, the outcome of this research pertaining to quality comparison between dry and wet processing methods of coffee is summarized as under:

Coffee production and processing in Kavre district

The trend of coffee production in Kavre district is increasing with production of 25 mt parchment from 130 hectares of land. The two processing methods coffee processors currently practiced in this district are dry and wet method. Of the 70 percent coffee produced in the district is processed by wet method.

Dry processing of coffee

This method of processing is simple and low cost with few handling steps. It produces low quality coffee fetching lower prices. Drying of fresh cherries after harvesting to an acceptable moisture level of 11-12% and hulling of this to produce the green bean and roasting are the key steps involved. The farmers and processors in Panchkhal VDC do not do sorting and grading of fresh cherries in this method resulted into low quality beans. Their knowledge on dry processing was simple and indigenous that they knew through their own working experiences.

Wet processing

This method consisted of more handling steps than dry method. Sixty seven percent of the processors in Kavre district practiced this method. The pulping was done within 24 hours of harvesting but in the research area, the cherries had to wait for more than 24 hours to get de-pulped during peak season (November-January). In order to obtain good parchment, the optimum duration for fermentation is 24-72 hours depending on the weather conditions. Interview with wet processor in Pachkhal VDC confirmed that drying of the parchment at 11-12% moisture level was found best for storage up to six months based on his experience. Sorting and grading of green beans was an important step after hulling in order to make ready for the export market. Based on the interview with local roaster, roasting of green beans at 200-250^{o}C for 10-15 minutes produced pleasant aroma and imparted good flavour in coffee.

Critical control points (CCP) at coffee processing

During dry processing, drying of cherries is considered as CCP as moisture content is major concern for storage and hulling. Fermentation and drying of parchment are the CCP in wet method whereas sorting and grading of fresh cherries and green beans and roasting were common CCP for both methods. Critical limit for moisture content of dry cherries, parchment and green beans practiced by the processors in study area is 11-12%. The standard commercial range of moisture percentage of green bean for export market is 9-12% for both Arabica and Robusta coffees as recommended by ICO. The optimum duration of 24-72 hours of fermentation depends on the surrounding temperature. Temperature and time were two critical points in roasting (the control limits is mentioned in above section).

Quality parameters of coffee at processing level

Colour and size are the important parameter for fresh cherries whereas size and moisture content are for dry cherries. Similarly, moisture content, size, weight, colour, number of defective beans/parchment, acidity were the desired quality parameters (attributes) for both parchment and green bean coffees whereas acidity, aroma, taste and flavour are the parameters for coffee cup quality. The processors and traders in Kavre district considered moisture content as an important parameter for parchment and green bean. They normally used their indigenous knowledge to determine the dryness by biting and shaking the parchment and cherries in hand to give crackling sound. The local roaster in Panchkhal VDC considered aroma as an important attribute for the roasted bean and cup.

Coffee quality v/s processing method

The moisture content of green bean obtained from dry method was beyond the standard commercial range recommended by International Coffee Organization (ICO) than from dry method. It was due to the fact that drying of cherries took longer time than parchment in order to obtain an acceptable moisture level. Cherries were stored without sufficient drying.

Based on the cup taste test among 30 respondents surveyed, there was significant difference in taste of coffee made form dry and wet method. The main reason for the difference in cup taste was due to aroma and flavour. The cup from wet method gave pleasant aroma with fruity flavour whereas the cup from dry method gave dull aroma with earthy flavour.

Based on the respondents' perception on coffee quality attributes, majority of respondents reported that moisture content and flavour were the major quality determinants for green beans and cup respectively. Similarly, moisture content was the most reliable test attribute to judge the coffee quality. Processing was the important step in coffee value chain functions determining the quality.

It was learned from the cup taste that the more aromatic coffee with higher delicacy and fineness could be obtained by the wet process. Coffee processed through wet method becomes mild. It obtained purer flavour but also less body and acidity as compared to coffee prepared from dry method of processing. The off-flavours, which caused variable, unreliable and lower quality flavours that could be eliminated especially by better drying was important. Wet processing was the only method to produce the desired colour of beans. Further, elimination of defective cherries and beans was easier through wet process than dry process. Dry processing was more delicate and known eliminate inherently good coffee flavour then by wet processing.

Quality control measures in coffee processing

Quality controls measures were applied by the farmers and processors at various steps in coffee processing (harvesting, de-pulping, fermentation, drying, sorting and grading). These control measures were applied as per the perception of the individual actor and objective measurements were done. There was no systematic and uniformity in the application of these controls measures throughout the chain. Most of the actors were unaware of the quality management systems except for the organic certification which was being sought by the importing clients.

Factors responsible for quality coffee production

It was found from the survey that knowledge and training on coffee processing techniques and quality management system had major influence on the production of quality coffee. Similarly, supply of quality inputs to grow healthy coffee plant, coordination among chain actors, influencers and supporters also have influence on quality coffee production.

The main reasons for adopting two methods among coffee producers in Panchkhal district was the inability of some processors to buy pulping machine which was caused by poor economic status of the farmers and processor. Additionally, they did not have access to credit for buying pulping machine.

Economic analysis of dry and wet method

Based on benefit-ratio calculation, the dry method of processing had the higher B/C ratio than wet method as dry method consisted of few handling steps (harvesting, drying, hulling). The total cost incurred in dry method was lower than the wet method.

Advantages and disadvantages of dry and wet method

Dry method of processing was simple and low cost, which needed less time during handling. Wet method of processing was more advantageous than dry method. The pertinent factors in wet method were quality, market and price. These three factors are interdependent and important for sustainable coffee production. The demand for the wet processed coffee was also high in international market. The main disadvantage associated with wet method was water pollution especially when the scale of processing increased suddenly during the peak season; the streams and well become polluted due to mixing of mucilage water with fresh water.

Problems in dry and wet method of processing

The major problem found on the dry method was the variation in quality of coffee due to skipping the sorting and grading of cherries after harvesting which ultimately results in poor green bean and cup quality. The chance of secondary fermentation was high in dry cherries, which was due to the presence of mucilage which is hygroscopic in nature. Similarly, the problems associated with wet method were high processing cost and bad fermentation, which resulted in stinker beans and pungent flavour in cup quality. Water pollution was another problem in wet method as a result of mixing of water used for washing the parchment with the water in well and streams.

6.2 Recommendations

Based on the conclusions drawn as discussed in the previous section, the following recommendations are made to make the coffee sector more competitive by increasing the quality factor through better processing methods (wet) in the coffee supply chain.

On the basis of the quality parameters, view from the respondents and detailed case study with coffee farmers, processors, traders and roaster on coffee processing techniques, wet processing method of coffee is recommended for the processors in order to maintain the better coffee quality that will ultimately fetch higher prices for the export market.

To maintain coffee quality through better processing method (wet), following recommendations are made:

Establish pulping centres

Coffee processors at farm level should have increased access to pulping centres. The number and capacity of pulping centres to be established by the farmers groups should not be only on the quantity of fresh cherries produced, but also on the distance and number of farmers pulping centres can cater. The pulping centres should be established at strategic locations where the farmers can harvest, pulp and ferment fresh cherries within 36 hours of harvest. Due to limited infrastructure for transportation and terrain topographical conditions of the country, it is recommended to establish adequate number of pulping centres with standardized processing method than merely investing on a central processing unit (hulling centre). A mechanism for ownership, management and operation of these pulping centres should be developed collaboratively by the farmers groups and the operators of the pulping centres and should be trained on improved and standardised processing methods.

Increase accessibility to credit for the processors

The economic status of coffee processors in Kavre district is so poor that they are not capable of buying pulping machines. To this juncture, there should be provision for credit from the credit institutions to enable them in buying pulping machines. For this, triangulation of cooperation (value chain finance) among coffee processors, traders and financial institutions need to be developed to improve access to credits. As a condition for loan to be accessed for the processors, the three parties (coffee processors, traders and bank) sign in an agreement. Traders will be the collateral for the Bank. Therefore, coffee traders do no pay the processors directly but through the bank. The bank deducts interest and the loan from the processors and deposits the balance in the processors' account. However, transparency and communication among them is important.

Standardise the processing methods

Though wet processing technique is becoming popular among processors, it has not been standardized yet. It is important to standardize (setting standards with respect to quality) the process from the beginning and disseminate to the small scale processors and pulping centres to ensure uniformity of coffee beans produced. Fermentation of coffee is done in ambient environment in very small batches in sacks. The process of fermentation and drying should be standardised so that the beans are of uniform quality. This can be done by setting critical limits on each critical control point (CCP). Frequent observations on the completeness of fermentation

by feeling with hand and measurement of temperature should be done during fermentation. Regular mixing of the fermentation mass makes sure that the fermentation is uniform (no under or over fermentation) and there is no temperature gradient. These pulping centres should have efficient machineries for coffee processing, packaging and storage. Polishing machines should be used for polishing parchment beans which will reduce the current loss of polishing in the hulling machine.

Increase efficiency of pulping machine

The efficiency of present machine used in pulping the cherries should be increased. Hand operated manual pulping machines (wooden) with an output of 15-20kg parchment per hour is being used currently. The efficiency of pulper can also be increased by proper sorting and grading of fresh cherries before pulping. Feeding uniform size of cherries makes sure that all the cherries are pulped by the machines and adjustment on the pulping machine should be done according to the size of the cherries. The present wooden pulping machine should be replaced with drum pulper (electric) which can be outsourced from other countries and disseminated at the farmer's level. The design of the new machine can be copied by the experts.

Ensure sorting and grading after harvesting

These operations should be done before processing the freshly harvested cherries and also before final packaging. As the ripe cherries are hand-picked, the farmers can also sort the ripe cherries during harvest by using two baskets for separating good and defect ones. When harvesting is done by stripping, sorting and grading is more important to separate unripe and defect cherries as pulper cannot pulp unripe cherries. This operation will also increase the efficiency of any postharvest processes as well as separating the defect cherries will eventually lead to the production of higher quality beans. Size grading of beans will also help to reduce the problem in roasting as roasting cannot be uniform due to difference in bean size. Sorting and grading can be done by spreading the cherries or beans over any clean surface or tarpaulin sheets and manually selecting and picking defect beans and extraneous matters.

Price based on quality

As quality of coffee processed from wet method is far better than dry one, price structure of coffee should be fixed according to quality standards. NTCDB should establish pricing structure of parchment coffee as in the case of dried cherry. Price of green beans produced for wet method should be higher than that of dry method. Premium prices for high quality only encourages the production of high quality beans and all the actors in the coffee chain should be made aware of this price structure.

Research and development

Further research on coffee production and processing methods is needed to improve the quality of coffee which of course requires substantial amount of financial investment drawn from public funds at least in early stages. There should be investment in research and development of coffee cultivation as well as processing methods in order to upgrade its quality.

Coordination in supply chain

There should be increased transparency (in terms of behaviour of chain actors and marketing of product) in the chain during transaction and cooperation among actors. All the actors should

have a common understanding of the term quality and its management. Appropriate quality management system through good processing method (wet method) should be implemented to increase confidence in the chain and assure the buyers on the quality which is indeed possible through better coordination.

Intervention on postharvest

Organizations supporting the coffee sector should focus not only in production of coffee but also on processing methods, increasing the quality and access to market. Intervention of the organizations should focus on development and dissemination of appropriate processing method (wet method) and integration of quality management system in the whole supply chain. There should also be good coordination among organizations to bring synergistic effect in the development of efficient service delivery mechanisms for supporting the coffee sub sector development.

Manage water after washing parchment

The water when washed with fermented parchment contains mucilage and dirty particles which should be managed through proper drainage system so that it will not lead to pollution to other water from streams and well, used for drinking purpose. This water can be used for irrigation on vegetable crops in the kitchen garden or mixing in a compost pit which facilitates formation of compost.

Capacity building of farmers, processors and traders

Building capacities of coffee farmers, processors and traders through training on coffee processing and quality management system should be done so that they can upgrade their knowledge, skill and attitude on wet processing method with regards to quality. I/NGOs, governmental organizations working on coffee sector and producers' organization should organize training campaign. These organizations can hire coffee technicians from National Coffee Board and Ministry of Agriculture to conduct training.

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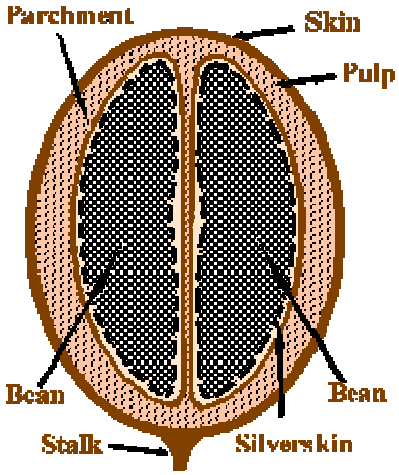
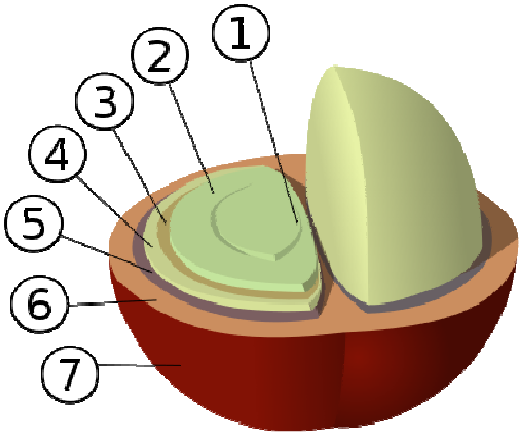
ANNEXES

Annex A. Structure of Coffee cherry/bean

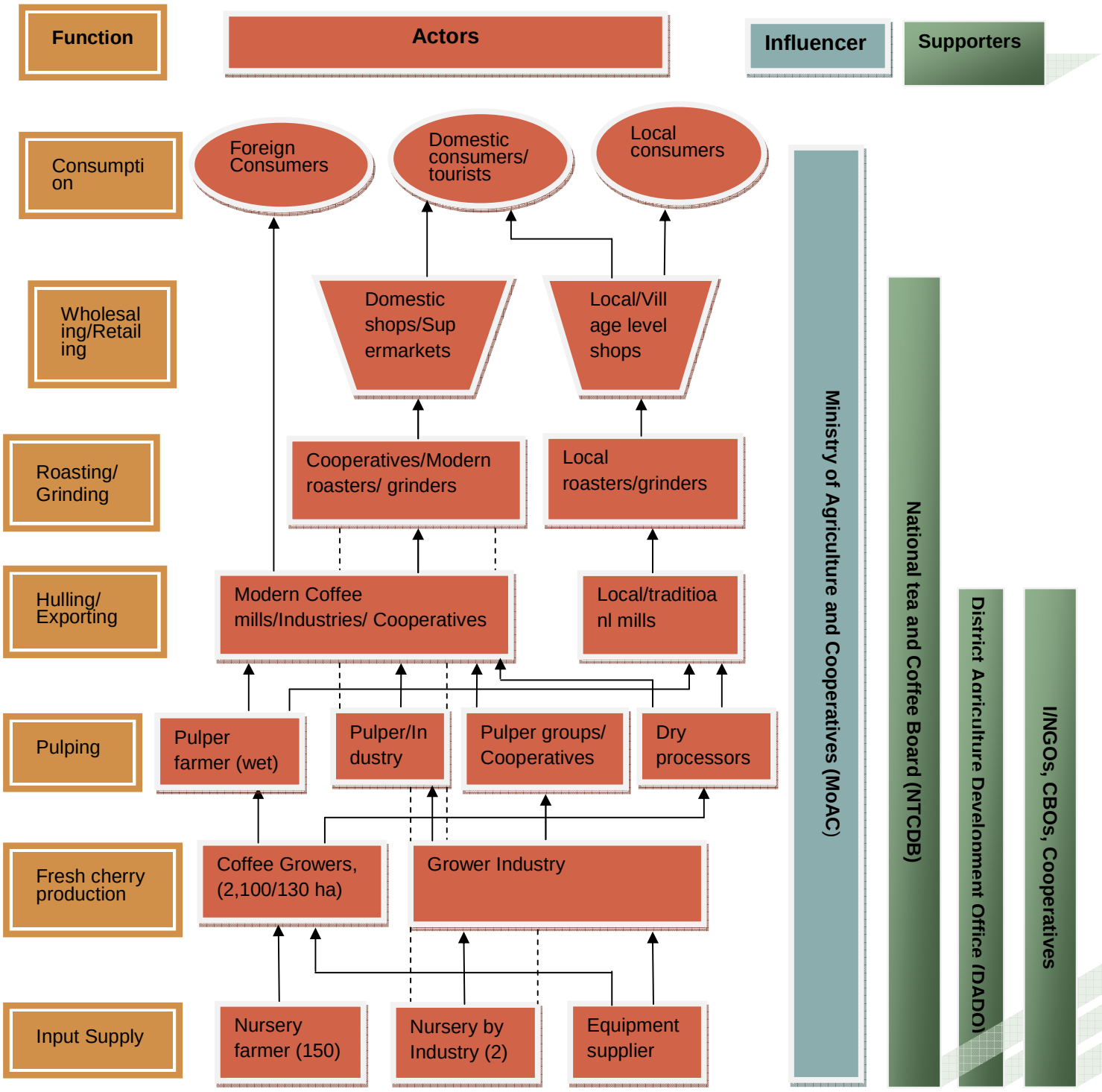




(Source: Wikipedia, 2010)

1. Centre cut
2. Bean (endosperm)
3. Silver skin (testa, epidermis)
4. Parchment (hull, endocarp)
5. Pectin layer (mucilage)
6. Pulp (mesocarp)
7. Outer skin (pericarp, exocarp)

Annex B. Chain map of Coffee in Kavre district



Note: a. Figures in parenthesis indicate the number of actors or area in ha.
: b. Dotted lines between two actors indicate the same actors involved at more than one function.

Annex C. Checklist for farmers

Name of the farmer:
Address:
Size of land:
No of coffee plants:
Position in the group:

1. What is the optimum time for harvesting fresh cherry?
2. How do you observe colour of the fresh cherry during harvesting?
   a. Visual method b. colour matching,
3. What method do you use while harvesting the cherry?
   a. Picking by hands b. shaking coffee bushes c. machine harvesting
4. Do you pulp fresh cherry by yourself? Yes/No
5. If yes, do you have your own pulping machine? Yes/no
6. Do you think method of harvesting affects coffee quality? Yes/no
7. Where do you sell your fresh cherry after harvest?
8. How long time will it take to reach your fresh cherry to the selling point?
9. Do you sell fresh cherry immediately after harvest? Yes/no
10. If no, where do you bring for sale?
    a. Processor in your own village b. other village c. process yourself
11. Do you sell cherry either in fresh or dried form?
12. Do you get cash immediately after shelling fresh/dried cherry?
13. Which is the most important criteria for harvesting quality coffee cherry?
    a. Month (time) of harvest b. size of cherry c. color of cherry d. pulping test
    d. all e. others……..
14. What is the most important thing to maintain the quality of fresh cherry?
    a. Selection of good planting material b. good cultivation practices
    c. Good harvesting d. good processing e. all f. others…….

Annex D. Checklist for primary processors (dry and wet)

Name of processor:
Address:

Dry processing

1. Do you have your own processing plant? Yes/no
2. Why do you choose this dry method?
3. Do you have access for the loan to buy pulping machine?
4. Do you buy cherry from other farmers also? Yes/no
5. Where do you dry your coffee cherry?
   a. Fully sun b. shaded area c. electric drier
6. Do you also have your own hulling machine? Yes/no
7. If no, where do you sell your dry cherry?
8. Do you have easy access for transportation to sale the dry cherry?
9. How much dry cherry do you collect per season (last year)?
10. How do you judge the quality of dry cherry?
11. What is the most important thing to be considered while drying cherry?
12. How do you feel that the cherry has been dried optimally?
13. What is the critical point at this dry processing step of coffee?
14. Have you got any training regarding quality management during processing of coffee? Yes/no
15. If yes, when did you get? And who did organize such training?
16. What kinds of problems do you often face in this method?
17. What are the advantages and disadvantages of this method?

Wet processing

1. When did you start this method of processing?
2. How much coffee did you de-pulp last year?
3. Which criteria do you follow during quality judgment of fresh cherry?
4. Do you have contract with the farmers to buy coffee cherry?
5. Do you sort the fresh cherry before de-pulping? Yes/no
6. If yes, which equipment do you use for sorting and grading of fresh cherry?
7. Till how long times do you store fresh cherry prior to de-pulp it?
8. Do you clean your machine regularly? Yes/no

9. If yes, how often do you clean?
   a. Daily b. weekly c. half monthly e. monthly f. end of season
10. How long do you keep wet parchment for fermentation after de-pulping fresh cherry?
11. What kind of material you use for fermentation?
    a. Special tank b. jute sacs c. plastic bags d. others
12. From which source do you use water for washing the parchment?
    a. Tap water b. water from well c. river-stream d. rainwater collected
13. Do you change water used for washing parchment frequently? Yes/no
14. If yes how often do you change water while washing the parchment?
    a. One b. two c. three d. four e. no change
15. Where do you dry your parchment after washing?
    a. Fully sun shine b. fully shaded area c. partial shaded area d. inside room
16. Do you have specialized structure for drying parchment? Yes/no
17. If yes, what kind of structure do you have?
18. How long do you dry your parchment?
19. How do you know that parchment has received optimum moisture for storage?
20. Do you have special equipment for measuring moisture of dry parchment?
21. Where do you store the dry parchment?
    a. Inside room with cemented floor b. inside cottage c. outside room
    d. open area
22. Do you leave some space between wall and parchment stored inside room?
23. Have you made proper ventilation inside your room?
24. How long do you store dry parchment?
25. When do you sell the parchment to the trader/exporter/huller?
26. Are you satisfied with price that you are getting from sales of parchment? Yes/no
27. If no, what need to be done for getting good price for the parchment?
28. Which is the critical step at primary processing level?
    a. Sorting-grading b. De-pulping c. Fermentation d. washing e. drying f. storage
29. Why have you chosen this processing method?
    a. Higher price b. High profit c. demand from the trader/ huller/exporter
    d. all of above e. others……

30. Which criteria do you consider most important to judge the coffee quality at primary processing level?

    a. Clearance of mucilage from the parchment b. colour of the parchment c. moisture content of dry parchment d. size of parchment e. all of above

31. Do you often face some problems at this processing level? Yes/no
32. If yes, what are they?
33. What solution could be made to remove such constraints?
34. What are the advantages and disadvantages of this method?

Annex E. Checklist for the traders/ hullers

Name of the trader:
Address:

1. When did you start your coffee business?
2. Do you have your own processing (hulling) machine?
3. From whom do you buy dry parchment?
   a. Dry processor b. wet processor (pulper operator) c. both
4. Why you buy coffee from both kinds of processors for hulling?
5. Do you have contract with them?
6. Do you also have your own storage facility for the storage of both dry parchment and green bean before and after hulling?
7. How do you know that the parchment has right time and stage for hulling?
8. What criteria do you usually use to judge the quality of dry parchment?
   a. Color b. size c. weight d. moisture content e. cleanness of parchment
9. What criteria do you mainly use to judge the quality of green bean?
   a. Color b. size c. weight d. moisture content e. cleanness of bean
10. Do you sort the green bean after hulling? Yes/no
11. Do you have special equipment for sorting?
12. How long do you store green bean after hulling?
13. Do you sale your bean for domestic market or export or both?
14. Do you hull the dry parchment and dry cherry separately?
15. Do you mix the green bean obtained from dry parchment and dry cherry? Yes/no
16. If no, do you sell them at different prices? Yes/no
17. If yes, where do you sell them?
18. Have you ever get complain from the clients regarding coffee bean obtained from two processing methods?
19. What need to be done at this stage to get coffee from one processing method?
20. Which processing method do you feel best in your local experience?
21. Have you felt any difference in taste of coffee processed from these two methods?

Annex F. Checklist for local roasters

1. When did you start this business?
2. Which method of roasting do you usually practice?
   a. Manual roasting on firewood b. electric
3. How do you maintain the temperature during roasting?
4. How long time do you roast?
5. Do you have categorized them according to time for roasting? What are they?
6. How do you know that roasting has completed?
7. Do you immediately start grinding after roasting? Yes/no
8. If no, after how long time do you start grinding?
9. Do you roast and grind the green bean processed separately? Yes/no
10. If yes, have you felt any differences in the taste of coffee processed either of two methods?
11. What could be done to obtain coffee bean from one processing method?
12. Do you have packaging facilities? Yes/no
13. If yes, what type of packaging materials do you use?
    a. plastic bags b. glass bottles c. Others……..
14. Where do you sell your product?
15. Are you satisfied with your business?
16. Do you face some constraints at this (secondary) processing level?
17. What need to be done to solve the problems?

Annex G. Questionnaires for survey

(For 30 respondents)
Name of respondent:
Address:
Identity of respondent: farmer/processor/trader/consumers

1) How would you rate the taste of given cup of coffee?
a. Very bad b. bad c. Good d. Very good

If it tastes good, then what is the reason (more/less)?
a) Aroma b) taste c) flavour

If it tastes very good, then what is the reason (more/less)?
a) Aroma b) taste c) flavour

2) What is the most important criteria to judge the coffee quality?
a. Moisture content in coffee bean b. Acidity c. Aroma d. Flavour

3) How do you rate the following quality attributes for coffee in order in your perception?
Give score 1 for least important, 2 for important and 3 for most important

Moisture content
Colour
Size
Acidity
Aroma
Flavor

4) What quality parameters do you look for in determining the price of green bean?
a. Size of the beans b. color of the beans c. moisture content of beans d. freedom from extraneous materials f. all of above g. others please specify……

5) What quality parameters do you look for in determining the price of a cup of coffee?
a. Acidity b. aroma c. taste c. flavour

6) Do you think method of processing affects the cup quality of coffee?
a. yes b. No

7) What is the most important step in coffee value chain to maintain the quality?
a. Selection of good nursery b. harvesting c. transportation
d. processing e. storage

8) What is the most important step during primary processing to maintain the quality of coffee?
a. Sorting and grading of cherry b. De-pulping c. Fermentation d. drying

9) What is the most important step during secondary processing to maintain the quality of coffee?
a. Hulling b. sorting and grading of green beans c. Roasting d. Grinding and packaging

10) Which method is more reliable to judge the quality of coffee bean?
a) Moisture determination b. grading c. Colour inspection d. Laboratory test reports

11) Which factor is more responsible for producing the quality coffee?
a. Knowledge and training for the coffee chain actors
b. Information sharing regarding quality and price among and between the chain actors
c. Supply of quality input
d. Coordination among actors and stakeholders
e. Chain supporters and influencers
f. Any other…….

12) Which is the most hindering factor in producing quality coffee?
a. Small holder farmers are unorganized
b. Lack of access for credit to by inputs
c. Lack of national brand for Nepalese coffee
d. Lack of certification
e. Others…….

13) Which is the restraining factor in retaining quality coffee?
a. Specialty nature of Nepali coffee
b. No use of chemical pesticides (organic)
c. High demand of Nepali coffee in European market
d. Others…….

14) What is the reason behind using two methods of processing by the coffee processors?
a. Lack of proper training on quality management system (QMS) at processing
b. Lack of money to buy the pulping machine
c. Unchanging habit of coffee processors on one type of processing
d. Inadequate backstopping from Government side
e. Others……..

Annex H. Benefit-cost ratio calculation format

Description	Dry method Price/kg (NRs.)	Wet method Price/kg (NRs.)	Remarks
A. Gross returns (GR)			
Farmer			
Sales price of fresh cherry			
Dry processor			
Sales price of dry cherry			
Pulper (wet)			
Sales price of dry parchment			
Huller			
Sales price of green beans			
Total gross return (GR)			
B. Costs			
Farmers			
Production cost of fresh cherry			
Dry processor			
Production cost of dry cherry			
Pulper			
Production cost of dry parchment			
Huller			
Production cost of green bean			
Total costs			
B/C ratio (Total GR/total costs)			

Annex I. Statistical results for cup taste test

How do you rate the cup taste? * Which method of processing?

Crosstabulation

			Which method of processing?		
			Dry method	Wet method	Total
How do you rate the cup taste?	Very good	Count	11	24	35
		Expected Count	17.5	17.5	35.0
	Good	Count	19	6	25
		Expected Count	12.5	12.5	25.0
Total		Count	30	30	60
		Expected Count	30.0	30.0	60.0

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	11.589[a]	1	.001		
Continuity Correction[b]	9.874	1	.002		
Likelihood Ratio	12.050	1	.001		
Fisher's Exact Test				.001	.001
Linear-by-Linear Association	11.395	1	.001		
N of Valid Cases	60				

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 12.50.

b. Computed only for a 2x2 table

Annex J. Quality attributes ranking for coffee

	Respondents (n = 30)																														
Attributes	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	**Total**	**Rank**
	Scores																															
Flavour	3	3	3	3	1	2	3	2	2	2	1	3	3	1	3	2	3	1	3	2	3	2	3	1	3	2	3	1	3	2	**69**	II
Aroma	3	3	2	1	3	3	3	1	2	3	1	3	1	1	1	3	2	1	1	3	2	1	3	3	2	3	3	3	2	2	**65**	III
colour	2	1	3	3	1	2	1	3	2	2	2	3	1	1	1	2	3	1	2	2	3	3	1	1	1	1	1	1	1	1	**52**	VI
Size	3	3	2	2	3	3	1	2	2	1	3	1	2	3	3	1	2	3	1	1	2	1	3	1	1	1	2	2	2	2	**59**	IV
Moisture %	3	2	3	3	2	1	3	3	2	3	3	2	3	3	1	3	3	2	2	3	3	3	3	3	3	3	3	3	3	3	**80**	I
Acidity	1	1	3	2	2	1	2	3	2	1	2	3	3	2	1	2	3	1	2	2	2	2	2	1	2	2	1	2	2	2	**57**	V

Rating: 1= Least important, 2 = Important, 3 = Most important

Annex K. Photographs

(Source: author, 2010)

Picture 1. Digital moisture meter

Picture 2. Green bean

Picture 3. Dry cherry

Picture 4. Dry parchment

Picture 5. Roasted bean

Picture 6. Ground coffee

Picture 7. Pulping machine

Picture 8. Group discussion

Picture 9. Cup tasting

Picture 10. Interview with wet processor

Picture 11. Local roaster and coffee shop at Kavre district