VEGETABLE BASED FARMING SYSTEMS IN KORAMANGALA-CHALLAGHATTA (KC) VALLEY PROJECT AREA: AN ECONOMETRIC ANALYSIS

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DEPARTMENT OF AGRICULTURAL ECONOMICS

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BENGALURU **March, 2022**

AFFECTIONATELY DEDICATED TO

MY FAMILY AND FARMING COMMUNITY

DEPARTMENT OF AGRICULTURAL ECONOMICS
UNIVERSITY OF AGRICULTURAL SCIENCES
BANGALORE

CERTIFICATE

This is to certify that the thesis entitled **"VEGETABLE BASED FARMING SYSYTEMS IN KORAMANGALA-CHALLAGHATTA (KC) VALLEY PROJECT AREA: AN ECONOMETRIC ANALYSIS"** submitted by **Ms. PAVITHRA, K. N., I.D. No. PALB 8005** in partial fulfillment of the requirement for the award of degree of **DOCTOR OF PHILOSOPHY in AGRICULTURAL ECONOMICS** to the University of Agricultural Sciences, Bangalore, is a bonafide record of research work done by her during the period of her study in this University under my guidance and supervision. The thesis has not previously formed the basis for the award of any degree, diploma, associate-ship, fellowship or other similar titles.

Bengaluru
March, 2022

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March, 2022 *(Pavithra, K.N.)*

VEGETABLE BASED FARMING SYSTEMS IN KORAMANGALA-CHALLAGHATTA (KC) VALLEY PROJECT AREA: AN ECONOMETRIC ANALYSIS

PAVITHRA, K.N.,

ABSTRACT

The present study on econometric analysis of selected vegetable based farming systems was undertaken in Koramangala-Chellaghatta Valley Project (KCVP) area using data from a sample of 160 farmers comprising 80 vegetable growers each from KCVP area and NKCVP area. The study was intended to analyze crop diversification, factors affecting crop diversification, economics, resource use efficiency and risk associated with different vegetable based farming systems, externalities associated with KCVP and willingness to pay for the use of treated sewage water in KCVP area. Results on Herfindahl index used to know the crop diversification showed higher diversification in KCVP area (0.42) than NKCVP area (0.68). Four major vegetable based farming systems were selected for indepth analysis. Growing of vegetables gave higher profits and resources were found to be more efficiently used in KCVP area. The results on income variability analyzed using the Co-efficient of Variation (CV) showed higher variability in FS-III (51.15%) followed by FS-II (38.22%), FS-IV (36.88%) and FS-I (32.21%) in KCVP area; similarly the descending order of income variability for NKCVP area included FS-IV (101.83%), FS-II (95.94%), FS-III (92.95%) followed by FS-I (49.46%). FS-I dominated over other farming systems at all levels of risks as revealed by the Stochastic Efficiency with Respect to Function (SERF) analysis based on absolute risk aversion coefficients [$r_a(w)$] in both KCVP and NKCVP areas. Positive externalities were found higher compared to negative externalities due to KC Valley project. The result on willingness to pay for the use of treated sewage water through groundwater recharge was Rs.713.58 per acre per year. Thus study advocated the need for replicating the KCVP model in other feasible areas, development and adoption of risk efficient farming systems for sustained income through demonstrations and effective extension services.

March, 2022

Department of Agricultural Economics	(G.M. Gaddi),
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ಕೋರಮಂಗಲ–ಚಲ್ಲಘಟ್ಟ (ಕೆ.ಸಿ) ಕಣಿವೆ ಯೋಜನೆ ಪ್ರದೇಶದಲ್ಲಿ ತರಕಾರಿ ಬೆಳೆ ಆಧಾರಿತ ಬೇಸಾಯ ಪದ್ದತಿ–ಆರ್ಥಿಕ ವಿಶ್ಲೇಷಣೆ

ಪವಿತ್ರ, ಕೆ.ಎನ್.

ಸಾರಾಂಶ

ಪ್ರಸ್ತುತ ಅಧ್ಯಯನವನ್ನು ಕೋರಮಂಗಲ–ಚೆಲ್ಲಘಟ್ಟ ಕಣಿವೆ ಯೋಜನೆ (ಕೆಸಿವಿಪಿ) ಪ್ರದೇಶದ ಆಯ್ದ ತರಕಾರಿ ಬೆಳೆ ಆಧಾರಿತ ಬೇಸಾಯ ಪದ್ಧತಿಗಳ ವಿಶ್ಲೇಷಣೆಗಾಗಿ ಕೆಸಿವಿಪಿ ಮತ್ತು ಕೆಸಿವಿಪಿ ಅಲ್ಲದ ಪ್ರದೇಶದಿಂದ(ಎನ್‌ಕೆಸಿವಿಪಿ) ತರಕಾರಿಗಳನ್ನು ಬೆಳೆಯುವ ತಲಾ 80 ರೈತರಂತೆ ಒಟ್ಟು 160 ರೈತರಿಂದ ಪಡೆದ ಮಾಹಿತಿಯನ್ನು ಆದರಿಸಿ ಕೈಗೊಳ್ಳಲಾಯಿತು. ಪ್ರಸ್ತುತ ಅದ್ಯಯನದಲ್ಲಿ ಬೆಳೆ ವೈವಿಧ್ಯೀಕರಣ, ಅದರ ಮೇಲೆ ಪರಿಣಾಮ ಬೀರುವ ಅಂಶಗಳು, ಆರ್ಥಿಕತೆ, ಸಂಪನ್ಮೂಲ ಬಳಕೆಯ ದಕ್ಷತೆ ಮತ್ತು ಆಯ್ದ ತರಕಾರಿ ಬೆಳೆ ಆಧಾರಿತ ಕೃಷಿ ಪದ್ಧತಿಗಳಿಗೆ ಸಂಬಂಧಿಸಿದ ಗಂಡಾಂತರಗಳನ್ನು, ಕೆಸಿವಿಪಿ ಪ್ರದೇಶದಲ್ಲಿ ಶುದ್ದೀಕರಿಸಿದ ಕೊಳಚೆನೀರಿನ ಬಳಕೆಯಲ್ಲಿನ ಬಾಹ್ಯತೆಗಳು ಮತ್ತು ಫಲಾನುಭವಿಗಳು ಪಾವತಿಸಲು ಇಚ್ಛಿಸಿದ ಮೊತ್ತ ಮುಂತಾದ ವಿಷಯಗಳ ಆರ್ಥಿಕ ವಿಶ್ಲೇಷಣೆಯನ್ನು ಕೈಗೊಳ್ಳಲಾಯಿತು. ಬೆಳೆ ವೈವಿಧ್ಯತೆಯನ್ನು ತಿಳಿಯಲು ಬಳಸಲಾಗುವ ಹರಫಿಂಡಾಲ್ ವೈವಿದ್ಯತೆಯು ಕೆಸಿವಿಪಿ ಪ್ರದೇಶದಲ್ಲಿ (0.42) ಎನ್‌ಕೆಸಿವಿಪಿ ಪ್ರದೇಶಕ್ಕಿಂತ (0.68) ಹೆಚ್ಚಾಗಿದ್ದುದು ಕಂಡುಬಂದಿದೆ. ನಾಲ್ಕು ಪ್ರಮುಖ ತರಕಾರಿ ಬೆಳೆ ಆಧಾರಿತ ಬೇಸಾಯ ಪದ್ಧತಿಗಳನ್ನು ಸವಿಸ್ತಾರವಾದ ವಿಶ್ಲೇಷಣೆಗಾಗಿ ಆಯ್ಕೆ ಮಾಡಲಾಯಿತು. ಕೆಸಿವಿಪಿ ಪ್ರದೇಶದಲ್ಲಿ ತರಕಾರಿಗಳು ಹೆಚ್ಚು ಲಾಭದಾಯಕವಾಗಿದ್ದು, ಆ ಪ್ರದೇಶದ ರೈತರು ಸಂಪನ್ಮೂಲಗಳನ್ನು ಹೆಚ್ಚು ಪರಿಣಾಮಕಾರಿಯಾಗಿ ಬಳಸಿಕೊಂಡಿದ್ದಾರೆ. ಆದಾಯದಲ್ಲಿನ ವ್ಯತ್ಯಾಸದ ಫಲಿತಾಂಶಗಳನ್ನು ವಿಶ್ಲೇಷಿಸಲು ವ್ಯತ್ಯಾಸದ ಸಹ–ಸಮರ್ಥತೆಯನ್ನು (ಸಿವಿ) ಬಳಸಿದಾಗ, ಕೆಸಿವಿಪಿ ಪ್ರದೇಶದಲ್ಲಿ ಎಫ್‌ಎಸ್–III (51.15%) ನಲ್ಲಿ ಹೆಚ್ಚಿನ ವ್ಯತ್ಯಾಸ ಕಂಡುಬಂದಿರುತ್ತದೆ ನಂತರ ಎಫ್‌ಎಸ್–III (38.22%), ಎಫೆಎಸ್–IV (36.88%) ಮತ್ತು ಎಫ್‌ಎಸ್–I (32.21%) ಗಳಾಗಿದ್ದು, ಎನ್‌ಕೆಸಿವಿಪಿ ಪ್ರದೇಶದಲ್ಲಿ ಆದಾಯದ ಸಹ–ಸಮರ್ಥತೆಯ ಕ್ರಮವು ಎಫ್‌ಎಸ್–IV (101.83%), ಎಫ್‌ಎಸ್–II(95.94%), ಎಫ್‌ಎಸ್–III(92.95%) ನಂತರ ಸ್ಥಾನದಲ್ಲಿ ಎಫ್‌ಎಸ್–I(49.46%) ಇರುವುದು ಕಂಡುಬಂದಿದೆ. ಎಲ್ಲಾ ಹಂತದ ಅಪಾಯ ನಿವಾರಣೆ ಗುಣಾಂಕಗಳಲ್ಲಿ ಕೆಸಿವಿಪಿ ಮತ್ತು ಎನ್‌ಕೆಸಿವಿಪಿ ಪ್ರದೇಶದಲ್ಲಿ ಎಫ್‌ಎಸ್–Iಯು ಇತರ ಬೇಸಾಯ ಪದ್ದತಿ ಯೋಜನೆಗಳಿಗಿಂತ ಪ್ರಬಲವಾಗಿದೆ. ಕೆಸಿವಿಪಿ ಬಗ್ಗೆ ನಕಾರಾತ್ಮಕ ಬಾಹ್ಯತೆಗಳಿಗೆ ಹೋಲಿಸಿದರೆ ಧನಾತ್ಮಕ ಬಾಹ್ಯತೆಗಳು ಹೆಚ್ಚಾಗಿ ಕಂಡುಬಂದಿವೆ. ಅಂತರ್ಜಲ ಮರುಪೂರಣದ ಮೂಲಕ ಸಂಸ್ಕರಿಸಿದ ಕೊಳಚೆನೀರಿನ ಬಳಕೆಗೆ ರೈತರು ವರ್ಷಕ್ಕೆ ಪ್ರತಿ ಎಕರೆಗೆ ರೂ.713.58 ಪಾವತಿಸಲು ಸಿದ್ಧರಿದ್ದಾರೆ. ಆದ್ದರಿಂದ ಈ ಕೆಸಿವಿಪಿ ಮಾದರಿಯನ್ನು ಇತರ ಪ್ರದೇಶಗಳಲ್ಲಿ ಪುನರಾವರ್ತಿಸುವ ಅಗತ್ಯವನ್ನು ಮತ್ತು ಪ್ರಾತ್ಯಕ್ಷಿಕೆಗಳ ಮೂಲಕ ನಿರಂತರ ಆದಾಯವನ್ನು ಗಳಿಸಲು, ಲಾಭದಾಯಕ ಕೃಷಿ ಪದ್ದತಿಗಳನ್ನು ಅಭಿವೃದ್ಧಿಪಡಿಸಿ ಅಳವಡಿಸಿಕೊಳ್ಳಲು ಪರಿಣಾಮಕಾರಿಯಾದ ವಿಸ್ತರಣಾ ಸೇವೆಗಳ ಅವಶ್ಯಕತೆ ಇದೆ ಎಂದು ಅಧ್ಯಯನ ಬಿಂಬಿಸಿದೆ.

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(ಜಿ.ಎಂ. ಗಡ್ಡಿ)
ಪ್ರಧಾನ ಸಲಹೆಗಾರರು

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I INTRODUCTION

Agriculture continues to be the backbone of country's economy and the largest provider of livelihood in India, employing 58 per cent of the total workforce. Agriculture and allied sectors contributed 19.9 per cent to the total gross domestic product of the country during 2020-21 (Anony., 2021). Even with the most diverse agro climatic conditions having possibility of growing a number of crops, farming is said to be like a gamble in monsoon due to its erratic nature over space and time. Around 60 per cent of the agricultural land is under rainfed condition and witnessing a continuous decrease in average farm size over the years.

With ever-increasing population growth, urbanization and per capita income of people, demand is increasing for quality agricultural produce. Food, nutritional, livelihood security and health care have become crucial to human and socio-economic development of the country. Hence, the government of India is focusing its vision towards sustainable agriculture by doubling the farm income by 2022. With not so encouraging position in terms of global food security, human development and other indices of development, it is increasingly being recognized that development and adoption of new technologies in agriculture and horticulture are of crucial importance. So, that horticulture sector would remain an integral component for the strategy to achieve this goal (Jha *et al.*, 2019).

The total foodgrain production in India during the year 2020-21 was around 303.03 million tonnes, which was higher by 5.84 million tonnes than the production during 2019-20 (Anony., 2021). India has unique position in the agriculture map of the world as it leads in production of many crops like spices, pulses production and ranks second in the production of rice, wheat, fruits, vegetables and groundnut. The agriculture and horticultural products have vast demand throughout the world however, agricultural exports constitute just ten per cent of the country's total exports.

Increase in health consciousness and purchasing power of people have spurred the demand for more nutritious and healthy diet including fruits and vegetables. Thus, cultivation and utilization of horticultural crops play a key role in raising prosperity of the nation and in turn, on health and happiness of people. The demand for horticultural produce, especially fruits and vegetables is on the rise and is further expected to increase with growing population, urbanization and rising per capita income (Weinberger and Lumpkin, 2005).

Status of horticulture sector in India

Horticulture is increasingly recognized as a sunrise sector, owing to its potential to raise farm income, provide livelihood and nutrition security and earn foreign exchange through export. The diverse agro-climatic conditions and rich diversity in crops and genetic resources enable India to produce a wide range of horticultural crops round the year. India is the second largest producer of fruits and vegetables in the world after China, with an annual production of 100 million tonnes of fruits and 189 million tonnes of vegetables during 2019-20. Horticultural crops contribute for around 29 per cent to the agricultural GDP from nearly 13 per cent of the total cropped area and support about 20 per cent of the agricultural labour force. Horticulture area and production have grown at a Compound Annual Growth Rate (CAGR) of 2.82 per cent and 4.41 per cent, respectively from 1991-92 to 2019-20 (Appendix I). Horticultural crops comprising fruits, vegetables, flowers, medicinal and aromatic plants and mushrooms play an important role in meeting the livelihood, nutritional security and socio-economic development of farmers. Because of research, technology and policy initiatives in the country, horticulture sector has become a sustainable and viable avocation for small and marginal farmers.

India is the largest producer of mango, banana, coconut, cashew, papaya, pomegranate and bhendi (ladies finger). India is the largest producer and exporter of spices in the world. During the year 2019-20, fruits occupied an area of 6.704 million hectares producing 100.41 million tonnes. Vegetables were grown on 10.316 million hectares of area, producing 189.464 million tonnes. Flowers occupied 0.307 million hectares of area and produced 2.994 million tonnes of flowers. Aromatic and medicinal plants are cultivated on an area of 0.66 million hectares with an output of 0.99 million tonnes. Plantation crops occupy 4.071 million hectares and 16.031 million tonnes of output and spices are grown in 4.138 million hectares and output is 9.754 million tonnes. Horticulture sector is emerging as the potential export earners over the years. During

2019-20, India exported fruits and vegetables worth of Rs.5496 crore and 4617.41 crores, respectively.

Status of vegetable production in India

Vegetables are important constituents of Indian agriculture and nutritional security due to their short duration, high yield and value, nutritional richness, economic viability and ability to generate on-farm and off-farm employment. Vegetables are vital sources of proteins, vitamins, minerals, dietary fiber, micronutrients, antioxidants and phytochemicals in our daily diet. Apart from nutrition, they also contain a wide array of potential phyto-chemicals like anti-carcinogenic elements and anti-oxidants.

India has rich diversity in vegetables and is the primary/secondary center of origin of many vegetables. It is the second largest producer of vegetables in the world after China accounting for 14 per cent of the world's vegetable production. During2019-20, vegetables occupied 10.353 million hectares of area and produced 191.77 million tonnes, with average productivity of 18 tons per ha compared to world average of 19.6 tons per ha. Area and production of vegetables had grown at the compound annual growth rate (CAGR) of 3.19 per cent and 4.98 per cent, respectively from 1987-88 to 2019-20 (Appendix II). Major vegetable crops grown includes potato (19.9% of the total vegetable production), onion (13.8%),tomato (7.88%), brinjal (7.00%), okra (5.17%), cauliflower (4.44 %), cabbage (3.55%) and others (38%). The country has witnessed tremendous progress in vegetable production, especially during the post green revolution period. Development of improved vegetable varieties, hybrids and technologies through systematic research coupled with their adoption by the farmers and developmental policies of the government culminated in tremendous increase in area under vegetables, production and productivity in the country. Compared to area (2.84 million ha), production (16.50 million tonnes) and productivity (5.80 tonnes per ha) in 1950- 51, there had been a phenomenal growth in area (3.31 folds), production (9.87 folds) and productivity (2.98 folds) of vegetables in our country during the last six and a half decades. Seasonal and annual crops like vegetables can contribute to rapid growth which can later be supplemented by perennial fruits and plantation crops.

The major vegetable producing states in the country during 2019-20 are West Bengal (28.11 mt), Uttar Pradesh (26.19 mt), Madhya Pradesh (19.83 mt), Bihar (16.33 mt), Maharashtra (13.64 mt), Gujarat(13.15 mt), Karnataka (7.92 mt) (source: statista). The short duration nature of vegetable crops offers scope for raising three or more crops a year which fits effectively into different cropping systems. Vegetable crops give 5-10 times more yield per unit area than cereals and millets. As they are quick growing and shorter duration, they hold a great promise for accelerating income of the farmers and can provide 3-4 times more cash income per unit area of land compared to cereals, pulses and oilseed crops (Sharma and Dahiya, 2013).

The huge geographical area and myriad of agro climatic niches in the country exert a strong influence on the supply of most of the agricultural commodities. This is particularly true for vegetable crops because of their shorter growth period and wide ecological amplitude. The output variations of vegetable crops could lead to wide fluctuations in their prices exposing the vegetable growers to greater risk than growers of other crops (Sharma, 2011). Thus the vegetable supply in the short run is highly inelastic. As a result, growers are compelled to accept the price during or close to the harvesting period (Vassalos *et al*., 2013) leading to lower incomes.

Vegetable production in Karnataka and Kolar district

Karnataka being one of the major vegetable growing states contribute about five per cent to the total country's production. As the state is epitome of the diversified agro-climatic zones of India, it has diversity in the range of vegetables grown and disparity between the districts in their production. In Karnataka, during 2019-20, vegetables were grown in an area of 418.68 thousand ha. With a production of 7195.06 thousand MT. In Kolar district, vegetable area has increased at Compound annual growth rate of 1.01, production (1.04%) and productivity (1.04%) from 2001-2020. And after implementation of KVCP, since after 2016, area under vegetables has grown at 1.03 percent, production by 1.14 and productivity by 1.11 percent annually.

Farming system

Sustaining house-hold food security has been an issue of prime importance to majority of the small and marginal farmers. These farmers are economically poor, work in diverse, location specific, risk prone environment and invite attention to develop technologies for interdisciplinary enterprises (Dar *et al.*, 2006). During the last five decades, most of the agricultural research emphasized mainly on component and commodity based research involving development of crop varieties, animal breed, farm implements and machinery, fertilizer use, pesticide usage and other production and protection technologies mostly conducted in isolation and at the institute level which enabled the farmers to grow more but at the same time it resulted in over exploitation of the resources. This has resulted in decreasing factor productivity, resource use in-efficiency and ultimately lower farm productivity and profitability. It further coupled with the problems like environmental degradation, groundwater contamination and entry of toxic substances in to the food chain, besides leading to exposure of farmers to various kinds of risk and uncertainty in farming especially price risk.

To address such issues, farming system approach has been recognized and advocated as one of the tools for ensuring harmonious use of scarce farm inputs. The farming systems have compounded response to make the production system more sustainable, as viable solution to address increased food demand, besides achieving stable income and improvement in nutrition, especially small and marginal farmers with limited resources and for sustainability. Integration of agriculturally related enterprises with crop activity as a base will provide ways to recycle produces and waste materials of one component as input through another linked component to bring an improvement in soil health and reduce the cost of production of products which finally raise the total income of the farm. In its broadest sense, the term farming systems research is any research that views the farm in a holistic manner and considers interacting factors in the system.

A farming system is a complex interrelated matrix of soils, plants, animals, implements, labour, capital and other inputs controlled by farming families and influenced to varying degrees by political, economic, institutional and social forces that operate at different levels. Research on farming system has various objectives ranging from increasing the body of knowledge about farming systems to solve different problems of farming system. The farming system conceptually is a set of elements or components that are interrelated which interact among themselves.

Thus, farming system is a resource management strategy to achieve economic and sustained production to meet diverse requirement of household while a system is preserving resource base and maintaining a high level environmental quality (Gill *et al*., 2009). Sustainability is the objective of farming system, where production process is optimized through efficient utilization of inputs without impairing the quality.

Components of vegetable based farming System

Farming enterprise includes crop, livestock, poultry, fish, sericulture, vermi-compost, dairy, goat, *etc*. A combination of one or more enterprises with cropping, when carefully chosen, planned, and executed, gives greater dividends than single enterprise especially for small and marginal farmers. Farm as a unit is to be considered and planned for effective integration of enterprises to be combined with crop production activity. Judicious mix of one or more of these enterprises with crop should complement the farm income and help in recycling the farm residue. The selection of enterprise must be based on the cardinal principle of minimizing the competition and maximizing the complementarity between/among the enterprises.

In the present study, vegetable based farming system is defined as farmers cultivating crops, with vegetables accounting for major portion of their cultivated area along with other enterprise like livestock (dairying) and mulberry cultivation.

K-C valley project

Today, an estimated 80 per cent of global wastewater is being discharged untreated into the world’s waterways. This affects the biological diversity of aquatic ecosystems and disrupts the fundamental web of our life support systems, on which a wide range of sectors from urban development to food production and industry depend. There are approximately 50 cities with a population of more than one million. Furthermore, the total number of cities and towns in India is increasing from 2,250 in

1991 to 5,161 in 2001, and has increased to 7,936 in 2011 (2011 census). Projected municipal and domestic water demand will also double by 2030, to 108 billion m^3 (7% of total demand), while projected demand from industry will quadruple to 196 billion m^3 (13%), pushing overall demand growth close to three per cent per annum (Anon., 2016).

The Bangalore Municipal Corporation is the first largest corporation in Karnataka state to implement Koramangala-Challaghatta Valley project (KCVP), which is deemed to be a unique project in the country. It's a rare Irrigation project and first of its kind in the country. Under this project, treated sewage water is used to fill irrigation tanks in Kolar and Chikkaballapura districts. Bangalore Metropolitan and Karnataka state government authorities have been grappling with the ever growing sewage problem for a long time and a permanent solution was not in sight until KC Valley project took shape. The project turned out to be a panacea to the ever growing problem of Bangalore city's drain and sewage on one hand and on the other hand, rejuvenating the minor irrigation system in rural areas which is facing a slow death. The scheme envisages filling of several tanks in Kolar district with treated water from Bengaluru and strengthening of its ayacut. Mega Engineering and Infrastructure Ltd. (MEIL) has achieved a rare distinction by launching the KC Valley project in Bangalore and adjacent districts of Kolar and Chikkaballapura.

Israel pioneered the technology of using treated sewage water to grow crops through micro irrigation system. Hitherto nowhere in the world such a system exists, except in Israel. However, the KCVP has successfully implemented such a system in the state during November 2016, with first phase yet to complete. Till now nearly 100 tanks have been filled with this treated water. The total cost of this project is Rs.1,342 crores. For ensuring uninterrupted power supply to the project, the MEIL had established six power sub stations of 66 KV capacity, along with six pump houses and a large surge tank to the KCVP. The Government has planned to supply treated sewage water to a total of 126 irrigation tanks situated in different clusters of Kolar district in a phased manner.

Nearly 124 Km's length of pipeline is laid along the major roads, national highways and railway tracks. Special pipes with rust resistance capacity and long-time durability have been used for the purpose. As water is to be supplied to the irrigation tanks against the natural gravity, six pumping stations have been built to serve the purpose. Works for three pumping stations are now completed with which the water is now being supplied. Ninety percent of work is completed for other three pumping stations. Twenty-three motors have been installed with capacity in the range of 160-2800 horse power. Wastewater, if properly managed could be a source of water, energy, fertilizer and other valuable materials and services. Each year, for instance, approximately 330 km^3 of municipal wastewater are generated globally. A recent study showed that resources embedded in this wastewater would be enough to irrigate and fertilize millions of hectares of crops and produce biogas that could supply energy for millions of households. Adequate wastewater collection, treatment, and safe use or disposal can lead to significant environmental and health benefits. From a business perspective, valuation of the costs of no action in wastewater management is necessary to justify suitable investment in this domain. Economic analysis provides the information needed for public policy decisions that support improvements in wastewater management (Anony., 2015).

During the last four decades, groundwater table in Kolar and Chikkabaallapura districts has drastically decreased due to over extraction of groundwater by the farmers resulting in drying up of borewells and openwells. These districts are worst affected with drought for decades forcing people and farmers live in misery. The KC Valley project thus has been designed to fill most of the tanks in Kolar and Chikkaballapura districts. The sewage water from the Bangalore city is being treated and supplied to fill tanks, which helps to recharge the ground water table and support a substantial increase in water bodies to irrigate the parched farms even during the drought. So rejuvenation of bore wells and open wells would be the only way to bring the parched lands back into agriculture operations. Treated sewage water reuse in agriculture is considered an efficient tool for managing scarce water resources with regulated supply that compensates for water shortages caused by rainfall shortage, uneven distribution of the rain throughout the hydrological year.

Kolar district being drought prone from past few years, initially in the region farmers were cultivating ragi, millets, groundnut, vegetable and plantation crops like mango, nilgiri (eucalyptus) etc., but after the implementation of KCVP, the cropping pattern inclined towards vegetables (Appendix-II) as most of the borewells in the region have got recharged. This enabled assured supplemental irrigation throughout the year to cultivate the vegetable crops year round. In recent years, people of this region adopted subsistence and mixed farming system i.e. crop production along with livestock production in different combinations. It has been proved that vegetable production with livestock production is one of the dominant farming systems in the district. However, these arguments do not have any data based scientific proof and there is no clear picture at present about the vegetable based farming system which is considered a dominant system of farming in the district. Major vegetable crops grown in the region are tomato, potato, cabbage, cauliflower, beans, carrot, coriander, cereal crops grown are ragi, fodder maize and some millet crops, few pulse crops as border crops like redgram, fruit crops like mango. These days most of the nilgiri plantations has been replaced by vegetable crops in the region reason being improved irrigation due to KCVP. Thus, keeping the above facts in mind, the present study was conducted in Kolar district of Karnataka with the below stated specific objectives:

Specific objectives and Hypotheses

1. To study the crop diversification and factors determining crop diversification in the study area.

   a) Cropping pattern is more diversified in KC Valley project area, compared to that in Non-KC Valley project area.

   b) Average age, education, irrigated area and farm income are the major factors influencing farmers to diversify their farm fields.

2. To identify and analyze the economics of vegetable based farming system and to find the resource use efficiency associated with it.

   a) Cost of production of vegetables is lower in KC Valley project area, compared to that in Non-KC Valley project area.

b) Cultivating vegetables is more profitable in KCVP area compared to NKCVP area.

c) Farming systems with more number of enterprises/components is profitable compared to farming with only vegetables and livestock in both KCVP and NKCVP area.

d) Resources were efficiently used in KCVP area compared to NKCVP area.

e) Resources were efficiently used in farming systems with more number of components.

3. To estimate the risk in vegetable based farming system and to suggest risk efficient farming system.

a) Farming systems with more number of components is risk efficient or less prone to risk in both KCVP and NKCVP area.

b) Variability of income is more in KCVP area compared to NKCVP area.

4. To estimate the externalities associated with KCVP and to know the willingness to pay for the KCVP in study area.

a) There are more positive externalities than negative externalities in KC Valley Project area.

b) Education, irrigation and crop diversification were the factors influencing willingness to pay for farmers in KCVP area.

II REVIEW OF LITERATURE

A review of past studies would help the researchers in identifying the gaps between conceptual and methodological issues and output of research relevant to the proposed study. This would also enable the researcher to collect relevant data, develop appropriate model for analysis and meaningful interpretation. Keeping in view the objectives of the study, this chapter provides a brief summary of the relevant studies under the following headings.

2.1 Crop diversification and factors affecting crop diversification

2.2 Economics of farming system

2.3 Resource use efficiency of farming system

2.4 Risk in farming systems and risk efficient farming system

2.5 Externalities and willingness to pay

2.1 Crop Diversification and factors affecting crop diversification

The extent of crop diversification at district level in Haryana, using diversification measures *viz.*, crop diversification and entropy indices were analysed by Malik and Singh (2002). Results concluded that more diversion of area towards vegetables, fruits and flowers was observed in Sonepat, Rohtak and Gurgaon districts due to availability of market, increased demand of products and export facilities due to proximity of metropolitan city, Delhi. Crops were diversified in Bhiwani district with introduction of sprinkler-irrigation system. The other districts observed specialization in crops due to absence of proper markets, amount of risks involved and availability of irrigation facilities etc.

In their study, Acharya *et al.* (2011) analysed the nature and extent of crop diversification in Karnataka by collecting secondary data for a period of 26 years from 1982-83 to 2007-08. Composite Entropy Index (CEI) and multiple linear regression analysis have been used to analyze the nature and extent of crop diversification in the state. The CEI for different crop groups have shown that almost all the crop groups have higher crop diversification index during post-WTO (1995-96 to 2007-08) than during pre-WTO (1982-83 to 1994-95) period, except for oilseeds and vegetable crops. The CEI for cereals during pre-WTO and post-WTO was 0.698 and 0.729, respectively. In general, the trend of CEI was almost same within the pulse group with all values lying in the range of 0.704 and 0.722. The overall diversification index for commercial crops was found to be 0.616.

A study on Diversification of cropping pattern: Its determinants and role in flood affected agriculture of Assam plains was conducted by Mandal and Bezbaruah (2013). The Composite Entropy Index was used to know the crop diversification in study area and to know the determinants of diversification, Tobit model was used with censoring on both sides. The prime focus of the study being the connection between crop diversification and flood proneness, it is of interest to note that the coefficient of the dummy (Occasionally flood prone area) F1 had not turned out to be significant whereas the same for Chronically flood prone area F2 (0.21) had been found to be positive and significant. This implies that the given values of the control variables crop diversification was significantly higher in chronically flood prone areas than in flood free areas. Thus, results suggested that farmers in areas where floods were regular have adopted a diverse and intense cropping pattern to extract the most out of their land resources during the period which was free from floods. Farm size (0.03), irrigation (0.02), access to agricultural credit (0.061) have found positive and significantly contributing to diversification in study area.

To know the factors affecting farmers' crop diversification: Evidence from SNNPR, Ethiopia was conducted by Rehima *et al.* (2013). The results of their study revealed that factors that affected crop diversification were gender, education and trade experience, membership in cooperatives, resource ownership, features of the land owned, access to extension services and transaction costs. Based on the findings the following recommendations were forwarded. The government should promote female participations, invest on formal and informal education of the farmers, provide incentive for extension workers and improve the extension system. Furthermore, the government and stakeholder should strengthen agricultural inputs and agricultural research particularly, generating agro-ecology based technologies and disseminates them. Non-crop activities (trade experience) and social organizations underline the need for designing integrated agriculture system (crop-non crop) and improving social organizations as powerful tools to increase diversification capacity of the farmers. Transaction costs need strengthening rural urban infrastructure to link crop diversification with markets.

To know determinants and extent of crop diversification among smallholder farmers in Zambia, study was conducted by Sichoongwe *et al.*(2014). They have used double-hurdle model analysis to know determinants of crop diversification, which indicated that landholding size, fertilizer quantity, distance to market, and the type of tillage mechanism adopted have a strong influence on whether a farmer practices crop diversification.

Satyasai and Premi (2015) evaluated the growth and diversification patterns in Indian agriculture through a district level analysis. They measured the extent of diversification across districts and tested if there was convergence across districts. Covering a 13 year period from 2001-02 to 2013-14, the study observed a significant increase in the average GDP level of a district in absolute terms as well as on per capita basis. The shares of livestock and crop production in agricultural GDP improved over time. There was a decline in diversification levels over time across sectors as well as within the agriculture sector and the decline was statistically significant. The better-off districts had shown a significantly higher level of diversification compared to the resource poor districts.

Basavaraj *et al.* (2016) studied nature, extent and determination of crop diversification in Gadag district of Karnataka. The area under vegetables, fruits and pulse crops had registered a higher (7-11%) growth compared to cereals, oilseeds, fibre and other crop groups (<1%). Gadag taluk was found to be more diversified with entropy index of 0.99 and household crop richness of 3.20 compared to 0.55 and 1.90 in northern transitional zone, respectively. The major factors influencing the crop diversification have been identified as size of land holdings, gross irrigated area and net returns realized per farm.

Structure and nature of cropping pattern, crop diversification, crop concentration, productivity level and inter-districts disparity in the state of Odisha, based on the secondary data was examined by Dinesh (2016) and data was compiled for the period 1980 – 2005 from different published sources. The study revealed that, most of the districts in Odisha were experiencing a lateral movement towards crop specialization. The crop diversification was seen only in tribal-dominated or technologically less-developed districts. The study observed a reduction in inequality during the study period and concluded that districts in Odisha were converging as far as agricultural productivity was concerned.

The impact of crop diversification on dietary diversity of households in different regions of Tamil Nadu was studied by Chinnadurai *et al.* (2016)for which two different types of data set were used: (1) National Sample Survey Organization's (NSSO) consumer expenditure survey data for the years (2004-05) and (2012-13), and (2) Cropping pattern data from Season and Crop report for the years (2004) and (2012-13). The crop diversification influenced positively the dietary diversification, whereas vegetable diversification was negatively related with diet diversification, irrespective of income groups in the state. Also, larger household size, presence of own land, older age and higher education level of household head have been found positively related with dietary diversity of households in Tamil Nadu.

Econometric study of tomato based farming system and risk management in eastern dry zone of Karnataka was studied by Vanitha (2016). She analysed the crop diversification in the study area and the results showed that the highest cropping intensity was in Malur (117.18 %) followed by Mulbagal (111.24 %) and Srinivaspura taluks (108.88%). The highest crop diversification index was seen in Malur (0.85) followed by Mulbagal (0.82) and Srinivaspura taluks (0.78). The highest per cent of sample respondents were having medium crop diversification in all the three study taluks (50%, 40% and 46 %, respectively). As the degree of crop diversification increased, co-efficient of variation of average annual income decreased in all the three taluks. Low diversified farmers had high variation in terms of co-efficient of variation (138 %, 122 % and 102

%) compared to highly diversified farmers (68 %, 110 % and 54 %) in all the three taluks.

Monika *et al.* (2017) conducted a study on identifying the determinants and extent of crop diversification at household level in Ukhrul district, Manipur. The results of their study revealed that education of the household head and access to plough was found to have positive association with the level of crop diversification along with farming experience. Access to fertilizer and availability of irrigation had effect on propensity to diversify crops. Exposure to farming information by the households significantly affected level of diversification. Farmers who attended farming training regularly were more likely to diversify crop. The distance to the nearest market from homestead also positively affected crop diversification level.

A study on Drivers of farmers' income and their role of farm size and diversification was conducted by Das and Kumar (2017) in Mumbai. The study used linear, log linear and panel data models were estimated to understand the nature of relationship between income, farm size and the two forms of diversification (on-farm and off-farm diversification). The study revealed that a U-shaped relationship existed between farm size and farm / farmer’s income. The results also showed that both on-farm and off-farm diversification had an inverted U-shape relationship with farm / farmer’s income. i.e., diversification up to some level helped improve income but excessive diversification might led to misallocation of resources and hence a fall in income.

To know the impact of crop diversification on crop productivity, the study was conducted on crop diversification and productivity in semiarid and sub-humid maize-legume production systems of Ethiopia by Kidane and Zegeye (2018). Two period plot level Panel level data was used to arrive at the results. Results indicated that diversification increased during the study period. Higher diversification occurred in sub-humid, high-potential agro-ecological areas. The association between diversification and productivity was found to be negative, although statistically non-significant. Accordingly, agro-biodiversity being a strategy to mitigate risks, risk-prone environments should be targeted and complemented with relevant institutional services that support smallholders’ diversification objectives. Complementing diversification with research findings could improve crop productivity.

Ravi (2018) studied the role of institutions, technologies, markets and governance in irrigation tank management in central dry zone of Karnataka. He also examined the crop diversification in the study area. The results of the study revealed that majority of the farmers were growing arecanut with coconut as border crop in all the three regimes followed by a combination of arecanut, coconut and banana. The cropping intensity was higher in the farmers managed tank area (275 %) followed by control area (232 %) and MID managed tank area (218 %). The Herfindahl diversity index revealed that, the cropping pattern under MID managed tank area (0.19) was more diversified followed by control area (0.23) and farmers managed tank area (0.25).

Phuge *et al.* (2020) evaluated the farming systems for diversification and sustainability in North Konkan coastal zone of Maharashtra. The analysis revealed that, among selected three farming systems, comparatively higher Sustainable Value Index (SVI) was noticed in the case of horticulture based farming system compared to crop based and livestock based farming systems (LFS). The system wise comparison of SVI indicated that horticulture in combination with field crops (HFS-I) was comparatively more suitable over other farming systems. In kharif season, less crop diversification (Herfindahl Index (HI) > 0.66) was observed in all the farming systems. In Rabi season, more crop diversification (HI < 0.48) was observed in all the farming systems except LFS-I (Livestock+Crop). In summer season, less crop diversification was observed in all farming systems except CFS-II (Crop+Horticulture) followed by HFS-I (Horticulture+Crop).

A study on investment and crop diversity: An empirical evidence from rural-urban interface of Bengaluru, Tobit regression was used to determine the drivers of investment and Herfindahl index to capture the extent of crop diversification was undertaken by Udaykumar and Umesh (2020). The results revealed that per farm investment was relatively higher on water resource and irrigation structure across all the gradients. Around 56, 51 and 45 per cent of farmers have invested on water resource and irrigation structures in transition, urban and rural gradient, respectively followed by animal husbandry (40% in rural gradient) and plantation and horticulture (25% in transition and urban gradients). There had been an investment led crop diversification from food crops to vegetables, flower and fruit crops in rural gradient between 2014 and 2019. Whereas, in transition and urban gradients, diversification was from food and vegetable crops to high value fruit crops during the same period. During 2019, the extent of diversification was more in transition (0.21) and rural (0.25) gradients compared to urban (0.29) gradient. Age of head of family (-1.242), farm income (0.139) and borrowed capital (0.048) were the chief drivers which significantly affected the investment in agriculture. The study concludes that, investment led high value crops cultivation and crop diversification played significant role in augmenting the farm income leading to improvement in farmer's welfare assuring food and livelihood security.

A study on drivers of crop diversification: evidence from smallholder farmers in Delta State Nigeria was conducted by Inoni *et al.* (2021). Authors have used crop diversification index (CDI) to measure crop diversity, descriptive statistics, Heckman two-step model and t-test to analyse the data. The results showed that 62.3 per cent of the farmers were female; farmers' average age was 51years, while farm size ranged between 0.08 and 2.2 ha, with a mean of 0.84 ha. Significant differences existed in farming experience ($p<0.05$), farm income and farm size ($p <0.01$) between crop diversifiers and non-diversifiers. The Heckman model results indicated that age, farm size, credit access, extension contact and farm income had significant positive ($p < 0.01$) effects on farmers' diversification decision; while farm size, credit access, extension contact and attitude to risk exerted positive and significant influence on intensity of crop diversification by smallholder farmers.

It is evident from the above studies that crop diversification in agriculture reduces farm income risk and increases the returns. Diversification of farm enterprises involves cultivation of multiple crops such as field crops (cereals and millets), horticultural crops (fruits, vegetables, flowers and plantation crops) and commercial crops (cotton and sugarcane) etc., along with sericulture (mulberry), livestock and poultry. And it is also important to know the factors which are affecting the Diversification.

2.2 Economics of farming systems

Economics of integrated farming systems at Pariyar in Tamil Nadu was analysed by Kandasamy (1998). His study indicated that among the different farming system practices, dairy-based system was found to be more profitable than others in the study area. The next best system was dairy cum poultry based mixed farming, with a mean annual net income of Rs.5,899 per ha with per day income of Rs.16.16. Poultry based mixed farming system produced net income of Rs.2,287 with per day income of Rs.6.27 over pure cropping system which recorded mean annual net income of Rs.2,219 with per day income of Rs.6.08. Farmer's method of sole cropping gave the least mean annual net income of Rs.1,902 and Rs.5.21 of per day income.

The study on economics of farming systems in Northern transitional zone of Karnataka was conducted by Sachinkumar (2012). The study was based on primary data collected from the 240 sample farmers in peri-urban and rural areas of the zone for the year 2010-11. The sample farmers practiced as many as 24 different farming systems, which included various enterprises like vegetables, flowers, plantations, sericulture, dairy, poultry, sheep and goat rearing activities. The top four farming systems in each of the situation of peri-urban and rural areas based on the highest per cent of farmers practicing were considered for economic analysis. In peri-urban area of Dharwad, the net returns were found to be the highest in crops and dairy system (Rs.33,533.56). In rural area of Dharwad, the highest net returns were from crops, dairy and plantation system (Rs. 57,285.23). Whereas, in the case of Belgaum peri-urban area the net returns were found to be the highest in crops, vegetables, dairy and poultry system (Rs.11,142.62). In rural area the farming system consisting of crops, dairy, goat performed much better (Rs.31,668.41). Dairy was the most common non-crop component included in most of the farming systems and it was found profitable. Vegetable was one of the profitable components of the farming systems in the peri-urban areas.

A study was conducted by Dyavappa (2012) on economic analysis of mulberry cultivation, production and marketing of silk cocoons in north Karnataka. The cost of mulberry cultivation per acre worked out to be Rs.12699.82 for rearing 300 disease free laying (DFL's) of which 77.95 per cent is composed of variable component mainly human labour and the rest is fixed component. The gross returns on selling of mulberry leaves and stalks amounts Rs.9472.91. So it is not profitable to cultivate mulberry for selling leaves instead one could rear the silkworm by purchasing leaves, but availability of mulberry leaves during all times is not assured. The cost of rearing 100 DFL's is worked out to be Rs.33738.84 and returns amounts Rs.38604.96with a marginal net returns of Rs.4866.12. The lower net returns attributed to lower prices due to poor established markets in non-traditional areas and low productivity (cocoon yield per 100 DFL's) i.e., 59.02 kg compared to traditional areas i.e., 90.00 Kg.

Vijaychandra and Mundanamani (2013a) conducted an economic analysis of organic farming systems in Bagalkot district of Karnataka. The study analyzed the cost and returns of major identified organic farming systems *viz.*, organic farming system-I: groundnut + greengram+ wheat + dairy, Organic farming system-II: sesamum+ jowar + dairy and organic farming system-III: maize + groundnut + dairy. Primary data were collected from 95 organic growers for the period 2011-12. The cost and returns of the organic farming systems in the study area revealed that, the net returns realized by the farmers was found to be the highest in organic farming system-III (Rs.40,760.05) compared to other two farming systems. Along with crop enterprises, dairy enterprise was found to be one of the important allied enterprise practiced by the sample farmers, it provided the major income source in the study area. The share of dairy enterprise alone in the organic farming system-I, II and III accounted for 27.83, 39.88 and 32.41 per cent to the gross returns, respectively. This study suggests that efforts should be made through Raitha Samparka Kendra (RSK’s) and Krishi Vigyana Kendra (KVK’s) to popularize these organic farming systems for improvement in productivity and profitability of crops and livestock sector in the study area.

In their study, Vijaychandra and Mundanamani (2013b) on an economic analysis of organic farming systems in Gadag district of Karnataka. The study analyzed the cost and returns of major identified organic farming systems Viz. organic farming system-I: green gram+ sorghum+ dairy, organic farming System-II: groundnut + maize + dairy and organic farming system-III: cotton+ chilli + onion + mango in the study area by collecting primary data from 95 organic farmers for the agricultural year 2011-12. The cost and returns obtained from the identified organic farming systems revealed that, the net returns realized by the farmers was found highest in organic farming system-III (Rs.97,437) as compared to other two farming systems identified in the study area. In addition to crop enterprises, plantation crop i.e., mango cultivation was found as one of the important enterprises associated with dairy as practiced by the sample respondents and it was the one another major source of income in the study area. The share of dairy enterprise contributed 38.83 and 34.77 percent to the gross returns, respectively in organic farming system-I and II. Among six identified farming systems in the study area FS-III of Gadag was found to be profitable with the highest net returns (Rs.97437).

Kavyashree (2016) studied the economics of integrated farming system in Tumkur District, central dry zone of Karnataka. The study was conducted in Madhugiri and Pavgada taluks of Tumkur district. The prominent farming systems identified in the study area include crop+dairy, crop+dairy+small ruminants, crop+dairy+poultry and crop+dairy+small ruminants+poultry. The economic analysis of identified farming systems indicated that irrigated IFS farmers derived more income in all farming systems, while C+D+S system was relatively more profitable (1:2.6) for unirrigated IFS farmers compared to irrigated IFS farmers (1:2.5).

Vanitha (2016) studied the risk management in tomato based farming system with an objective of analyzing different risks involved in tomato production, marketing and different production and management strategies adopted by tomato growers to minimize risks in eastern dry zone of Karnataka. Primary data were collected from 180 sample respondents from the zone. Malur taluk represented cultivation of tomato hybrids, Mulbagal taluk represented HYVs and Srinivaspura taluk represented both. The highest crop diversification index was seen in Malur (0.85) followed by Mulbagal (0.82) and Srinivaspura taluks (0.78). As the degree of crop diversification increased, co-efficient of variation(CV) of average annual income decreased in all the three taluk's. Net profit per acre of tomato cultivated was the highest from hybrids (Rs.1,14,707) than HYV's (Rs.84,287).

Nagappa *et al.* (2017) assessed the yield and economics of vegetables as intercropping system in coconut garden. The study consisted of three different intercropping systems *viz.,* coconut sole cropping, coconut+vegetable cowpea and coconut+french bean with seven replications at farmers' field in a 36 year old coconut garden of Tiptur tall variety. The average results of three year study were recorded. The yield of coconut was found to be higher (9594 nuts/ha/year) under french bean as intercrop followed by intercrop with cowpea (9348 nuts/ha/year) during third year. Whereas, the lowest nut yield was recorded in coconut sole crop. The highest net annual income Rs.99,720/ha and benefit cost ratio of 3.22 was recorded in coconut+french bean intercropping system with more additional income and market demand of beans followed by coconut+vegetable cowpea (net annual income Rs.84,260/ha and benefit cost ratio 3.10) with less market demand of vegetable cowpea, whereas lowest net annual income of Rs.43,107 per ha. and B:C ratio of 2.34 was recorded in coconut sole cropping with no additional income from the farmers practices.

A study was carried out to explore the cost and returns of ragi under rainfed condition and irrigated situation in central dry zone of Karnataka (CDZ) along with its marketable surplus by Bellundagi *et al*. (2017). To analyze cost and returns; and marketable surplus, the techniques such as tabular method with percentage and numbers were used. The study showed that cost structure for rainfed and irrigated ragi were Rs.45,979 and Rs.57,904 respectively. Yield was higher in irrigated (28.50 q./ha) compared with rainfed situation (1700 q/ha). Per hectare gross returns were Rs.41,075 and Rs.64,428 in rainfed and irrigated ragi cultivation, respectively. Rainfed ragi received marginally lesser price (Rs.1850 per quintal) than irrigated ragi (Rs.1,900 per quintal). Marketable surplus of ragi was more in irrigated (43.59 %) situation compared to the rainfed (39.45 %) situation.

A study was conducted by Raghupathi and Kumar (2018) on cabbage production in Kolar district of Karnataka. The findings of the study showed that cost of cultivation of by the small size farms was high (Rs.44671/ha) as followed by medium and large size farms (Rs.42002/ha and Rs.41946/ha). And the cost of production per quintal on different size of farms group was Rs.669.43/ha, respectively. The cabbage price per quintal in market was Rs.1700. The sample average for Cost A_1, Cost A_2, Cost B and Cost C in different farms size groups were Rs.30453 per ha., Rs.33953 per ha. and Rs.37906 per ha. and Rs.42873 per ha., respectively. And farm business income and family labour income in different size of farm group were Rs.75010 per ha. and 755540 per ha. An average of net return obtained from cabbage growers per hectare was Rs.62504 per ha.

Raghavendra *et al.* (2019) studied the major farming systems in Hyderabad-Karnataka region to assess the cost and returns for major farming systems, net income of the farmers from different sources and the influence of area and dairy enterprise in major farming systems. Four major farming systems *viz.*, Crop+Dairy (C+D), Crop+Horticulture (C+H), Horticulture+Dairy (H+D) and Crop+Dairy+Horticulture (C+H+D) were identified based on the preliminary surveys in the area. Primary data from 160 farmers with equal samples under identified farming systems were collected for agricultural year 2016-17. The data were analyzed using descriptive statistics and Gini coefficient. Results of the study revealed that annual net income realized by farm household was higher in Crop+Dairy+Horticulture (Rs.8,62,897.70) farming system, of which 72.42 per cent was from horticulture crops. The least annual net income was observed in Crop+Dairy (Rs.2,17,982.21) farming system 55.49 per cent contribution from livestock enterprise. The inequality was relatively lower in Crop+Dairy (0.45) farm households compared to Crop+Dairy+Horticulture (0.53) farm households.

Kumar (2019) conducted a study to know the production and marketing of carrot in Kolar district of Karnataka. The study revealed that the cost of cultivation per acre was Rs.1,30,466. The average yield per acre was 7.37 tonnes which accrued a gross return of Rs.2,09,748 per acre and net return per acre was Rs.79,282. The return per rupee invested was Rs.1.61. Damage due to diseases and pests, scarcity of skilled labour, expensive inputs, scarcity of farm yard manure, and lack of availability of seeds were the major production constraints.

Singh *et al.* (2019) carried out a study on economic management and analysis of potato cultivation in Agra district (U.P), India. Results showed that cost of cultivation was Rs.140303.7 per farm and Rs.78657.98 per hectare. Among all the inputs, per hectare value of potato seed was 25 percent, the human labour (14%), the total variable cost was 78 percent, the total fixed cost was 22 percent per ha. and the overall total cost of potato cultivation was Rs.154334.07 per farm and Rs.86523.78 per hectare. The gross income received by farms with the overall average of Rs.188370. The overall output per input ratio was 1:2.39, being 1:3.42, 1:2.61 and 1:2.21 on the small, medium and large farms, respectively.

Aiswarya *et al.* (2020) studied the economics of integrated farming systems in Kuttanad region of Kerala, India. The study was under-taken to identify the farming systems followed by small and marginal farmers in the study area, to determine their profitability and to suggest optimal farm plans using linear programming technique. The study revealed that Rice + Fish and Coconut + Banana+ Dairy cow + Poultry+ Goat were the most profitable farming systems with a cost-benefit ratio of 2.63 and 2.86, respectively. The allocation of resources in the existing plan was sub-optimal, hence optimal resource would lead to maximization of net returns and realize higher income. The net returns from rice + fish would increase from Rs.1,81,724 to Rs.2,20,010 in optimal plan. The study also suggested the extent to which net returns can be increased with additional units of constraint resources *viz*., land/labour. Thus, the farmers in study region can increase their income by optimal allocation of resources and by deploying additional units of land or labour.

A study on economic analysis of cumin and coriander cultivation in Rajasthan was conducted by Meena *et al*. (2020). From one hectare of coriander cultivation farmers could harvest a produce of Rs.63479 and earned a benefit of Rs.31943 per ha. and Rs.15422 per ha. over variable and total cost respectively.

The literature reviewed so far under the heading economics of farming system indicated that inclusion of livestock, poultry or any other non-crop farm enterprises combined with field crops and vegetable crops have resulted into earning more income per rupee spent than that from only single crop enterprise.

2.3 Resource use efficiency

The economic analysis of cropping systems under tank irrigation in northern Karnataka showed that except for groundnut, all crops considered in the study made by Suresh(2010) showed decreasing returns to scale in Bagalkot district with R^2 values ranging from 0.53 to 0.97 indicating adequacy of the model. During Kharif season, the

MVP:MFC ratio for sorghum was negative in case of manures and bullock labour indicating their excessive use. The MVP:MFC ratio was negative in the case of manures for sunflower and for machine labour in the case if maize, which indicated the excessive use of these resources.

Khatri and Patel (2011) studied the resource use efficiency of important vegetables in Chorayasi taluka of south Gujarat *viz.,* brinjal and cauliflower. Respondents were randomly selected based on probability proportion. The Cobb-Douglas production function results indicated variation in the production elasticity of inputs among the vegetable crops. In general, nitrogen, potasic fertilizers and other variable cost were positively influencing the output. The comparison of MVP's of inputs with per unit prices indicated the optimum use of nitrogen, potassium and other variables in the production of brinjal, and in case of cauliflower, cropped area, bullock labour, nitrogen and potassium were used optimally.

Energy use efficiency in greenhouse tomato production in Iran was conducted by Pahlavan *et al.* (2011). In the present study, energy use pattern for tomato production in Iran was investigated and a non-parametric data envelopment analysis (DEA) technique was applied to analyze the technical and scale efficiencies of farmers with respect to energy use for crop production. The energy use pattern indicated that diesel, electricity and chemical fertilizers are the major energy consuming inputs for tomato production in the region. Moreover, the results of DEA application revealed that of the average pure technical, technical and scale efficiencies of farmers were 0.94, 0.82 and 0.86, respectively. Also the results revealed that by adopting the recommendations based on the present study, on an average, about 25.15 per cent of the total input energy could be saved without reducing the tomato yield.

Lokapur *et al.* (2014) assessed the resource use efficiency of major vegetables in Belgaum district of Karnataka. The multi-stage random sampling procedure was adopted to choose 120 sample farmers. The results of the Cobb-Douglas production revealed that the regression coefficient for seeds was found to be significant and the co-efficient of multiple determination (R^2) was 74 per cent, 86 per cent, 97 per cent and 96 per cent in case of onion, potato, green chilli and tomato, respectively. In case of onion the MVP and

MFC ratio was found greater than unity for all the inputs(Bullock labour, Human labour and fertilizers) in case of potato except PPC. In case of green chilli, the ratio was negative for the bullock labour, while in case of tomato, the ratio was more than unity except for the human labour and fertilizers.

A study on resource use efficiency and marketing channels for pomegranate was conducted by Kumar *et al*. (2015) in Chitradurga district of Karnataka, India using the Cobb-Douglas production function. The results revealed that expenditure on labour, manures and fertilizers were found to have positive influence on production and were significant. The ratio of marginal value product and marginal factor cost were more than unity for the resource, fertilizer and manures for both Challakere and Hiriyur taluk's. The ratio of marginal value product and marginal factor cost was negative for PPC and labour in both Challakere and Hiriyur taluk's indicating excessive use.

Satashia *et al.* (2017) conducted an economic analysis and resource use efficiency of Bt-Cotton in middle Gujarat. The production function analysis revealed that human labour and bullock labour, plant protection and irrigation exerted significant influence on the yield of Bt-cotton. About 36 per cent of total variation in the gross income from the Bt-cotton cultivation was explained by the explanatory variables included in the function. The sum of regression co-efficient (0.509) indicated decreasing returns to scale. The study has brought to the fore that there is an ample potentiality of the raising Bt-cotton production on the sample farms through adoption of improved technologies along with optimum utilization of resources like human labour, seeds, chemical fertilizers, and irrigation with better management practices.

Ahmadzai (2017) made an attempt to know the crop diversification and technical efficiency in Afghanistan using stochastic frontier analysis. Data from a household level survey conducted in 2013-2004 by the central statistic organization (CSO) is used in the analysis. The results revealed that adoption of a diversified portfolio of crops by the farmers significantly improves technical efficiency. In addition, access to extension services, farm size, cattle, oxen and tractor ownership by the farm households, and regional variables were other important factors that significantly affect technical efficiency. It is evident from the results that the estimated technical efficiency indices from the preferred truncated normal distribution range from 1.5 per cent to 99.29 percent, with a sample mean of 71.9 per cent. The basic SFA model was investigated for potential endogeneity in crop diversification. The results of crop diversification index showed the presence of a relatively low level of crop diversification. Maximum likelihood estimation of translog stochastic frontier model shows that land, labour, and other purchased inputs (fertilizer, seeds, pesticides usage) have positive impact on farm revenues. The results show an evidence of constant returns-to- scale.

Ahmed *et al.* (2018) conducted a stochastic frontier analysis to study the resource use efficiency and to assess the impact of socio-economic factors on sugarcane production in Bihar state. The resource were not being properly utilized. All the resource inputs were found significant at one per cent and five per cent level of probability except machine labour and fertilizers. In inefficiency model, landholding size (-0.0002), age (-0.004) and family size (-0.0072) were estimated negative, indicating positive impact on efficiency in sugarcane production. The effect of education was assessed positive (0.014) indicating increase in formal education raised inefficiency. The mean technical efficiency was estimated to be 0.92 indicated that optimal and sustainable use of resource inputs may raise further the sugarcane production by about eight per cent and boost up the income of the sugarcane growers of the state.

Naik *et al.* (2018) made a study on resource use efficiency of soybean in Belagavi district of Karnataka. The multi-stage random sampling technique was employed to select 60 sample respondents and data were analysed using the Cobb-Douglas type of production function. The results revealed that bullock labour, seed, human labour, FYM and fertilizer were over utilized, while machine labour and plant protection chemicals were under utilised. The MVP to MFC ratio for Bullock labour (-0.23), Seed (-0.59), Human labour (0.13), FYM (0.27), and Fertilizer (- 0.05) were less than unity indicating their excess use while machine labour (3.60) and PPC (2.21) were underutilized, indicating scope to optimize returns using more of FYM and machine labour in the production of soybean.

The study on economics of production, resource use efficiency and constraints in East Champaran district of North Bihar using primary data collected from 68 sugarcane growers was conducted by Singh (2018). The results showed cost of seeds (0.210), tractor (0.762) and plant protection chemicals (2.663) were significantly influenced the sugarcane yield, but were used at sub-optimal and there existed the possibility of enhancing the yield of sugarcane by increasing their use.

Phuge *et al.* (2020) assessed the resource use efficiency in farming systems in North Konkan coastal zone region of Maharashtra. The resource use efficiency in crop based farming systems indicated that, human labour, fertilizers and plant protection chemicals were positively contributing to the production. The sum of regression coefficients indicated decreasing returns to scale. In horticulture based farming system also increasing returns were prevailing and human labour, fertilizers and irrigation were positively influencing production. The results related to livestock based farming system indicated human labour, irrigation and veterinary aid were positive and influencing factors on production and showed constant returns to scale. Thus results indicated great scope for reallocation of resources to increase net income with adoption of recommended package of practices.

Sapkota and Bajracharya (2018) made a study on resource use efficiency analysis for potato production in Nepal. Results of their study revealed that regression coefficients of each inputs using Cobb-Douglas production function were estimated using Stata software. Our results showed that major inputs such as labor, bullock, farm yard manure (FYM) and intercultural operations were overused and need to decrease in terms of cost by 109, 177, 51 and 185 per cent, respectively for its optimum allocation. Similarly, seed was found underused and need to increase its cost by 70 per cent for optimum allocation.

To know the resource use efficiency and economic losses and their implications for sustainable rice production in Vietnam a study was conducted by Tu (2015). The results revealed that returns to scale were decreasing. Rice farmers had high levels of output-oriented and input-oriented technical efficiency with the means of 91.92 per cent and 85.39 per cent, respectively. The mean environmental efficiency was 82.03 per cent. The mean efficiency of normal inputs was 61.20 per cent. Among the bad inputs, pesticide and energy were the least efficient ones with the mean values of 51.39 and 45.53 per cent, respectively, indicating serious overuses of these inputs. As regards normal inputs, capital had the lowest efficiency score at 21.08 per cent, followed by seed quantity at 26.4 per cent. Further, the total economic losses were estimated at 8261 thousand VND (380 USD) per hectare, which is equal to the sales of about 1600 Kg of rice per hectare or the efforts to increase by 20 per cent of output level.

Paled and Guledagudda (2018) made a study on resource use efficiency in hybrid vegetable seed production in northern Karnataka .Results of the study revealed that per acre total cost incurred was Rs.2,30,771, Rs.2,02,044, Rs.2,27,103 and Rs.67,110 respectively in brinjal, cucumber, chilli and watermelon. Per acre gross returns and net returns obtained were Rs.4,47,884 and Rs.2,17,113 in brinjal, Rs.4,29,728 and Rs.2,27,684 in cucumber, Rs.6,06,431 and Rs.3,79,328 in chilli and Rs.1,14,859 and Rs.47,749 in watermelon respectively. MVP to MFC ratio revealed that human labour and irrigation were under-utilized in all four crops. Further, seedlings and FYM are also under-utilized in brinjal and cucumber and are over-utilized in chilli and watermelon. Bullock and machine labour were under-utilized in brinjal and watermelon and are over-utilized in cucumber and chilli. Except watermelon, fertilizers are over-utilized in other three crops. Plant protection chemicals are under-utilized in cucumber and chilli and are over-utilized in brinjal and watermelon.

It is evident from the previous studies that, most of the researchers have used Cobb-Dougal’s production function to know the resource use efficiency, and only few researchers have used frontier production function and Data envelopment analysis. As resource use efficiency for farming system as whole need to be worked out, in the present study DEA has been employed to arrive at the results.

2.4 Risk in farming systems and risk efficient farming system

The application of target MOTAD model to crop production in Zambia: Gwembe Valley as a case study was evaluated by Maleka (1993). The Zambian government encouraged crop production in the Gwembe Valley without taking into consideration the risks involved. These risks mainly originate from the stochastic nature of rainfall. This study identified optimal cropping patterns in the Gwembe Valley using Target MOTAD Model. The results of the Target MOTAD Model indicated an optimal cropping pattern of growing sorghum, rice and soyabean. This was different from the existing cropping pattern of sorghum, sunflower, cotton and maize. The overall policy implication of adopting the cropping pattern obtained from the model solution was that some resources allocated to the production of current crops have to be reallocated to the production of new crops.

Risk efficient farm plans through MOTAD approach for enhancing the development prospects of drought prone farmers of Tumkur district in Karnataka was assessed by Gajanana and Sharma (1994). The results indicated relatively high risk attached with low returns in the existing plans. Among the risk efficient plans, crop, sericulture and dairy enterprise systems were more appropriate in adding stability to farm returns, besides providing higher employment opportunities. It was observed that crop farming in the area was risky and sericulture and dairy were relatively stable.

Farm planning under risk using MOTAD model in the dry farms of Palladam block of Coimbatore district of Tamil Nadu was studied by Sekar and Palanisami (2000). Risk analysis showed that there was a scope to reduce risk at farm level by enterprise mix. The financial institutions should provide the needed capital to the farm sector to raise the income in crops and livestock activities efficiently. The study also revealed that agricultural allied activities such as livestock/ poultry should be encouraged to ensure regular flow of income even in drought conditions.

Umoh (2008) examined the important risk factors and risk management measures as well as optimal farm plans in floodplains farming in AkwaIbom State, Nigeria. Findings of the study showed that the most important risk factors in floodplains farming were flood and drought. Farmers managed these risks through relay/sequential cropping, planting short gestation and flood tolerant crops. Target-MOTAD model showed that farmers were not operating at optimal level of production, a crop combination consisting of cassava, cocoyam, maize and fluted pumpkin was found to be the least risky and the most profitable while all vegetables crop combination was the most risky.

Sachinkumar (2012) studied the economics of farming systems in Northern Transitional Zone of Karnataka. It was based on primary data collected from the 240 sample respondents in peri-urban and rural areas of the zone for the year 2010-11. The sample respondents practiced as many as 24 different farming systems, which included crops, vegetables, flowers, plantations, sericulture, dairy, poultry, sheep and goat rearing activities. The top four farming systems in each of the situation of peri-urban and rural areas based on the highest per cent of farmers practicing were considered for economic analysis. MOTAD was used to quantify the risk and the risk efficient plans in most of the cases had the potential to generate more income and employment. Proper mix of dairy and vegetable components with crops appeared to be more risk efficient in the study area.

Shashi (2013) reported that agriculture is subjected to a wide range of risks due to variable economic and biophysical environment in which farming operates. Agriculture risks arise due to uncertainty over factors determining returns to agricultural production. Author attempted to identify different sources of risk in rainfed maize production in Karnataka. Risk in maize production was assessed by variability in area, production productivity, inputs used and price of maize over the years and also through farmers' opinion on production and price risks in maize. Author also attempted to estimate farmers' WTP the additional premium for crop insurance. The results showed that human and bullock labour and fym used were found to decrease significantly, whereas use of chemical fertilizers and cost of seeds increased significantly. Drought and labour scarcity were the major production risks faced by rainfed maize farmers. Price risk was more in Haveri compared to Shimoga. Varietal selection and crop insurance were the major risk coping strategies followed by farmers. The mean additional WTP for crop insurance premium and new variety of maize was 0.34 per cent and Rs.242.10 per 5 kg packet, respectively. Probability of WTP for the same was 0.53 and 0.58, respectively.

In their study, Vassalos *et al*. (2013) examined the optimal land allocation and production timing for fresh vegetable growers under price and production uncertainty at the United States. Production timing was an essential element in fresh vegetable growers' efforts to maximize profitability and reduce income risks. The study used biophysical simulation modeling coupled with a dual crop (tomatoes, sweet corn) whole-farm economic formulation to analyze the effects of growers' risk aversion levels and price consideration (seasonal or annual price consideration) in expected net returns and production practices. Tomatoes in the examined region were transplanted from early May (spring crop) through early August (fall crop) followed by drip irrigations. A grower who scheduled production with consideration of seasonal price variation enjoyed 3–15 per cent higher expected net returns, depending on risk aversion level, compared with one who disregarded the ability to exploit production timing based on price information. Risk management was defined as the potential to reduce income risk under the two scenarios. Based on this definition, a greater opportunity to manage risk was permitted under the seasonal price trend scenario. Specifically, the CV for this scenario ranged from 17.13 per cent to 24.76 per cent. Under the annual average price scenario, CV had a substantially lower span from 17.34 per cent to 17.76 per cent. A counter intuitive result was that income variability increased as risk aversion increased under the second scenario and that expected net returns were greater for a highly risk averse grower.

Farming systems and cropping pattern in Hassan district of Karnataka to develop efficient farming systems were analyzed by Channaveeregowda and Sureshkumar (2014). The findings of study revealed that regardless of the farm size, the existing farming systems were less efficient as the farming systems developed through normative farm plans exhibited potential for higher income and employment with reduced risk. The transition of existing farming systems from subsistence to commercialization needed emphasis in order to increase and stabilize income from horticulture and other livestock enterprises, as they help in reducing risk of getting lower income on the one hand and generate additional income and employment to farmers on the other. The normative farm plan which would facilitate the increase in net farm income, efficient resource use and minimized risk with minimum working capital can be adopted by all categories of farmers.

A study was carried out by Vijayan and Indira Devi (2016) on a spatio-temporal analysis of agricultural income of Kerala to assess the risk in agriculture. The results of the study showed that the level of agricultural risk in the state, estimated as the instability index was found to be 0.086 at current prices and 0.067 at constant prices. Kasaragod, Alappuzha and Wayanad were the high risk districts. The study recommended that the policy instruments were to be designed taking into consideration the relative importance of districts in the state’s agricultural performance and risk factors.

Vanitha (2016) conducted an econometric study on tomato based farming system and risk management in Eastern Dry Zone of Karnataka in which the researcher analysed the risk associated with the farming system. The results of the study showed that the least variability (CV) in income was in sericulture and livestock in Mulbagal (58 % and 45% respectively) and Srinivaspura (78 %) taluks. Variability in farm income (75, 110 and 134 %) was more than non-farm income (74, 72 and 131 %) in all the three taluk's. Results of quantile regression showed that diversification led to decrease in variability in total annual income at all quantile. The game theory analysis with nature and tomato growers as two players showed that continuous planting and early planting were feasible among the production strategies adopted by tomato growers for 40 and 60 per cent of time. The final game value which was the net returns over variable cost of growing tomato was Rs.53,916 per acre grown either in kharif or summer season.

Ishag (2016) made an attempt to know the economic performance of goat breeds farming sustainability and policy analysis in Oman can be classified to three production systems i.e. traditional mounting pasture system, goat and sheep husbandry at farms located at costal area and modern goat production systems at new established farms. The study used Stochastic efficiency with Respect to Function (SERF) techniques to investigate the effect of new policies on goat farming viability and aims to identify the most sustainable goat farming system. The modern goat farming found as the most risk efficient goat farming system and preferred to other systems. Risk premium price of RO 35.930 per Does is required to persuade farmers to shift from traditional goat farming to high yield breed and modern goat farming system. Policy Makers need to pay RO 25.290 per Does to compensate farmers at semi-intensive coastal goat farming system to stop growing Rhodes Grass and improve ecosystem resilience and economic viability.

These above mentioned studies reflect various measures of risk like co-efficient of variation (CV), minimization of total absolute deviation (MOTAD), Game theory, certainty equivalent. They also throw light on different strategies that the farmers adopt in terms of new technologies, diversification, crop insurance etc. to minimize risk in farming. Most of the previous studies used linear approximation technique i.e., MOTAD to estimate the risk but due to constraints associated with model to be used for cross sectional data, certainty equivalent was calculated to know the risk in the farming systems in the present study.

2.5 Externalities and willingness to pay

The negative externality in borewell irrigation in Bangalore and Kolar districts of Karnataka was evaluated by Chandrakanth and Arun (1997). Snowball sampling was followed in selection of sample farmers, whose borewells were interfered. The Logit model measured the conditional probability of drilling additional wells as a response to negative externality. Tobit model measured the willingness to pay for additional well. The results indicated that the probability of farmers investing on additional well increased significantly with the size of land holding, ratio of gross irrigated area under vegetables in post interference period to gross irrigated area under all crops in pre interference period and ratio of net irrigated area affected by well interference to total irrigated area, while it reduced with ratio of gross irrigated area under mulberry in post interference period to gross irrigated area under all crops in the pre interference period. The overall probability of drilling additional well was 0.87 and the odds ratio accordingly was 6.69 which implied seven chances in favor of drilling additional well to one chance of not drilling additional well. The results of tobit analysis indicated that the willingness to pay for additional well (WTPAW) was Rs.48,370. For every one acre increase in the size of holding, WTPAW was estimated to be Rs.14,122. The WTPAW to mitigate externality was Rs.48,370, an indicator of magnitude of negative externality for the farmers, which was uncompensated.

The methodologies for appraisal of economic and environmental insinuations of groundwater depletion and quality degradation effects in Tumkur district (Karnataka) was analysed by Nagaraj and Chandrashekar (2001). The study revealed that use of contaminated groundwater resulted in allergic dermatitis, skin irritation and gastrointestinal problems which led to extra health care expenditure of Rs.2,616 per year per family. Also, livestock grieved from skin rashes and edema. They also reported employment loss in agricultural activities to the extent of 40 man-days valued at Rs.2,327 per year.

The negative externalities on human and animal health in Coimbatore district of Tamil Nadu was studied by Sekar (2001) and the study revealed that due to polluted water several human health defects such as fever, dysentery, headache, jaundice, allergies and skin rashes, etc., were identified. Livestock, also reported premature delivery or abortion, decreased milk yield, poor health status and reduction in animal population. His study concluded that Rs.382.9 was the extra expenditure incurred per family for a year towards human and animal health.

In a study by Madi *et al.* (2008) on perceptions of farmers and public towards irrigation with reclaimed wastewater in Jordan and Tunisia, reported reasonably high levels of farmers' acceptance to use reclaimed wastewater and public acceptance to consume crops irrigated with this water. The study analyzed the factors that influence decisions of farmers and public to accept or reject irrigation with the reclaimed wastewater and related crops, respectively. The results also identified the major factors that might be influential in changing the perceptions and attitudes of farmers' and public.

Rajendra *et al*. (2009) analysed the status of municipal waste water treatment in some cities of India. The study covered cities of Indore, Delhi, Kanpur, Tiruchirappalli and Pune. They stated that sewage discharge created a serious environmental pollution in water resources. The rapid growth in the population, technological and industrial boom had brought enormous problems and degradation of the environment. Nearly 75 per cent of domestic water supply was discharged into sewers. They suggested for utilizing the treated sewage waste water for agriculture, growing greens.

Muhammad (2015) in his study on economic impacts of wastewater irrigation in Punjab found that, the average per capita health expenditure in the study area was Rs.3848. While, in case of wastewater use in agriculture per person health expenditure was higher (Rs.4178) compared to fresh water used areas (Rs.3537). The expenditure on health was 18 per cent more in case of respondents living in wastewater use areas than their counterparts in areas living in fresh water.

A study made by Kolawole and Kan (2016) on analysis and modeling of wastewater reuse externalities in African agriculture. The study used cost-benefit analysis (CBA) and stochastic frontier cost functions were modeled for estimating the economic/environmental trade-offs of wastewater reuse and costs of wastewater treatment. The descriptive results indicated that Northern Africa, which is the most vulnerable region, has the greatest potentials of wastewater reuse. Correlation analysis results show that "area of land salinized" had a highly positive significant correlation with the quantity of treated wastewater used (r=0.69). CBA was modeled to account for treatment cost, health cost, cost of soil reclamation, aquifer damage cost, increased crop yield and aquifer recharge. A conceptual Stochastic Frontier Model (SFM) was also developed in this research as no previous studies took into account inefficiency parameters (negative externalities) accompanied with wastewater reuse. African regions living above water-poverty line must however not wait till when freshwater will become a limiting resource. The significance of salinity in this study calls for the use of appropriate agronomic practices to remediate saline soils.

An economic analysis was conducted by Ravi (2018) on role of institutions, technologies, markets and governance in irrigation tank management in Central Dry Zone of Karnataka. In the study, researcher had analysed the positive externality using contingent evaluation method and logistic regression. The results of the study found that the mean willingness to pay for assured irrigation and equity in distribution of water was Rs.894, Rs.809 and Rs.895 per acre per year by the farmers in farmers managed tank, MID managed tank and control area, respectively.

Ramesh (2020) conducted an economic impact assessment of supplying treated sewage water to irrigation tanks for farming in Kolar district under K-C valley project. He used composite externality index to know the externalities associated with the treated sewage water. The composite index for positive externalities (PE) and negative externalities (NE) was computed by using the parameters. It revealed the mean index of 0.709 and S.D of 0.312 for positive externalities and mean index of 0.29 of negative externality and S.D of 0.156 for negative externalities. Further externalities were classified into two categories based on the mean and S.D about (65 %) of the respondents fell under the high PE composite index and rest of them fell under the low PE. Whilst (72 %) were in the high negative externality composite index and only (28 %) fell under the low NE composite index.

From the above studies, it is summarized that most of the researchers in previous years have found out negative externalities of waste water or polluted water and its effects on agriculture and livestock. And some studies have also estimated willingness to pay for waste water for farming in other regions along with factors which have influenced them to pay. And in the present study, CVM is used to know the willingness to pay by the farmers for the KCVP and tobit model is used to estimate factors influencing them to pay.

III METHODOLOGY

This chapter deals with the description of the study area, adoption of sampling techniques, the method of data collection, the nature and sources of data and the various tools and techniques employed in analyzing the data and evaluating the objectives of the study. The methodology adopted has been presented under the following major heads:

3.1 Selection and description of the study area

3.2 Sampling framework

3.3 Nature and sources of data

3.4 Analytical tools and techniques employed

3.1 Selection and description of the study area

Karnataka is the sixth largest state in India, with an area of 191 lakh ha and the eighth largest state in terms of population of 611 lakh according to 2011 census. The state is situated in south western region of India between 11.5° and 19.0° N latitude and between 74° and 78° E longitude in the southern plateau. The state receives an average annual rainfall of about 1139 mm both from south-west and north-east monsoons. The important crops grown in the state are paddy, jowar, ragi, maize and bajra among cereals; red gram, green gram and bengal gram among pulses; groundnut, sunflower and safflower among oilseed crops and cotton; sugarcane and tobacco among commercial crops. Major horticultural crops grown in Karnataka are banana, lemon, grapes, mango, sapota, tomato, potato and onion. Karnataka is the second largest producer of vegetables from an area of 381.27 thousand hectares. There are ten agro climatic zones in Karnataka classified based on different agro-climatic parameters. The fifth zone is the Eastern Dry Zone (EDZ) where the present study was conducted comprised of four taluks in Bengaluru rural, three taluks of Bengaluru urban, four taluk's of Ramanagara, five taluks of Kolar, six taluks of Chikkaballapur and two taluks of Tumkur district. The Kolar district being one of the drought prone districts was selected for the present study, which receive annually about 700 mm rainfall. The district was initially cultivating millets, groundnut, ragi, plantation crops like mango and few vegetable crops due to ground water scarcity in the region. With the implementation of

KC valley project in the district, most of the dry patches of land turned into irrigated lands due to water availability throughout the year. Hence study was undertaken to know the extent of changes in cropping pattern and to know the impact of KCVP in the dry region.

3.1.1 Kolar district

3.1.1.1 Location

Kolar district lies in southern part of the state between 77° 21' to 78° 35' east longitude and 20° 46' to 130° 58' north latitude, extending over an area of 3979 km². The district is bounded by Bengaluru Rural district in the west, Chikkaballapur district in the north, Chittoor district of Andhra Pradesh in the east and in the south it is surrounded by Krishnagiri district of Tamil Nadu.

3.1.1.2 Demographic features

The population of the Kolar district according to 2011 census was 1536401 (Table 3.1) with 979 females per 1000 males. Of the total population in the district, 68.75 per cent lives rural areas spread over 1797 villages and the rest live in urban and semi urban areas in seven towns. The population density of the district was 386 per sq. Km. The literacy rate of the district was 74.39 per cent.

3.1.1.3 Climate and rainfall

The climate and rainfall are very crucial factors in farming. There are three distinguishable agricultural seasons in the district, viz. *Kharif* (June to September), *Rabi* (October to January) and summer (February to May). The southwest monsoon, which usually commences by the end of May or early June, continues intermittently till the end of September.

The average annual rainfall in the district is 724 mm with the major portion of it received from southwest monsoon. The average annual number of rainy days varies from 38 (Bangarpet taluk) to 55 days (Kolar taluk). There existed wide variation in the pattern and distribution of rainfall over the years in the district.

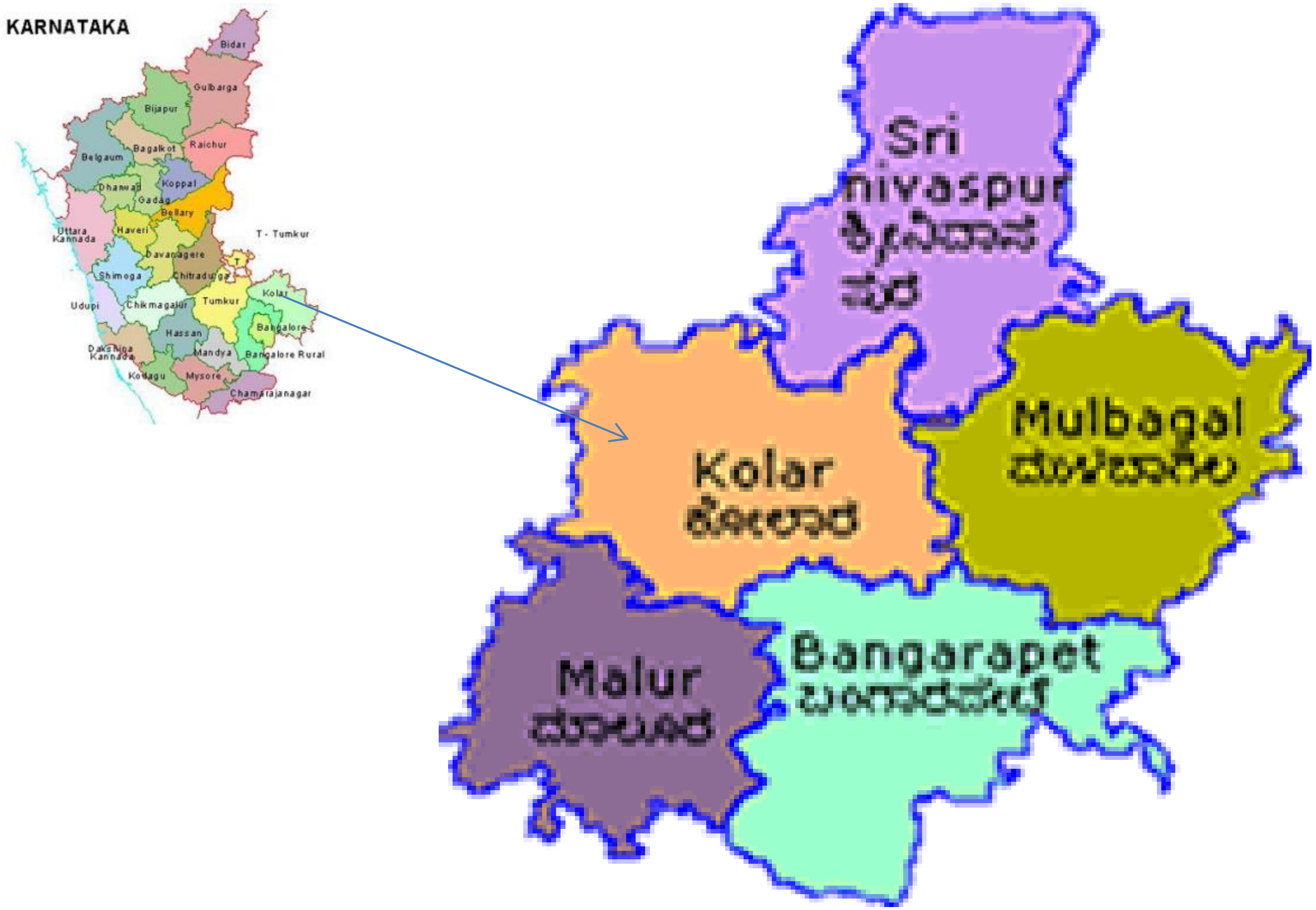

Plate 1: Map showing study area

3.1.1.4 Soils

The soils in the district are mostly red loamy soils, which are shallow in depth, well drained but with medium level of plant nutrient content. The district also possess laterite soils as well.

3.1.1.5 Land utilization

Land utilization is an important indicator of agricultural conditions as it gives a broad picture of land use, available fallows and net area sown as well as consequent economic contributions for the growth of the area. Land utilization details (Table 3.3) pertaining to the year 2019-20 are as follows. The total geographical area of Kolar district is 374916 ha. of which 20620 ha is forest cover, 47503 ha.is non-agricultural area, 28870 ha.is barren and uncultivated land. The cultivable waste land is 6397 ha. permanent pasture area is 37418 ha.; area under trees and groves is 7009 ha.. The district has a net area sown of 203169 ha. 42719 ha. area under vegetable crops. Apart from cereals and pulses, the major horticultural crops cultivated in the district include potato, tomato, onion, beans, cole crops, carrot, radish, beetroot, mango, banana, guava, sapota, grapes, marigold, jasmine, chrysanthemum and rose.

3.1.1.6 Socio-economic and demographic features of the study taluks

The Kolar district consists of five taluks – Kolar, Bangarpet, Srinivaspura, Malur and Mulbagal in the south eastern part of the state. The population of district was 1536401 with literacy rate of 74.39 per cent. The per-capita income of the district was Rs.128439. The major vegetable crops grown in the study area included tomato, potato, onion, beans and many other vegetable crops. The net sown area of the district was 203169 hectares, of which 40 per cent was irrigated. Among the major crops grown in the district, finger millet occupies major portion of the total cultivated area. The irrigated crops are mulberry and vegetables. The vegetables were grown on 42174 ha., with annual production of 13,37,226 tonnes during the year 2019-20. The important commercial fruit crops grown in the district were mango and grapes. The area irrigated by wells constitutes 99 per cent of the total irrigated area. Dug well irrigation practice is largely replaced by bore-well irrigation.

Table 3.1: Taluk-wise population of Kolar district (2011 Census)

Name of the taluk	Female	Male	Rural	Urban	Total	Rural %	Urban %
Bangarpet	225211	227621	235340	217492	452832	51.97	48.03
Kolar	190281	195129	246948	138462	385410	64.07	35.93
Malur	115837	121083	196870	40050	236920	83.10	16.90
Mulbagal	128447	130488	201659	57276	258935	77.88	22.12
Srinivasapura	100229	102075	175511	26793	202304	86.76	13.24
District Total	**760005**	**776396**	**1056328**	**480073**	**1536401**	**68.75**	**31.25**

Source: Kolar District at a Glance 2019-20.

Table 3.2: Socio-economic features of the study area

Sl. No.	Particulars	Unit	Kolar district
1	Geographical area	ha	3,74,916.00
2	Taluk's	No.	5.00
3	Hoblies	No.	27.00
4	Villages		
a)	Inhabited	No.	1,599.00
b)	Un-inhabited	No.	199.00
5	Population	No.	15,36,401.00
6	Density of population	per sq.km	386.00
7	Decadal growth of population	%	10.77
8	Annual average rainfall	mm	896.40
9	Number of rainy day per year	days	46.20
10	Temperature	ºC	
a)	Minimum		21.00
b)	Maximum		33.00

Source: Kolar District at a Glance 2019-20.

Table 3.3: Land use pattern in study area (in ha)

Taluk	TGA	Area under agriculture				FA	WL	OU
		GCA	NSA	Area sown area>one	C.I. (%)			
Bangarpet	74520	30064	28527	1537	105.39	2758	16417	19505
Kolar	69210	34617	32852	1765	105.37	4633	14704	12674
Malur	63166	26728	25365	1363	105.37	1560	10165	12193
Mulbagal	82246	44636	42361	2275	105.37	2122	15406	7624
Srinivasapura	85824	40630	38561	2069	105.37	9547	17855	7263
District total	**374916**	**176675**	**167666**	**9009**	**105.39**	**20620**	**74547**	**59259**

Source: Kolar District at a Glance 2019-20.

Note: TGA-Total Geographical Area; GCA-Gross-cropped Area; NSA-Net Sown Area; C.I- Cropping Intensity; FA-Forest Area; WL- Waste land; OU-Area under other uses.

3.1.1.7 District water profile

Kolar district has 26,144 hectares gross irrigated area, of which 17,135 (10.22%) hectares was net irrigated and remaining area was rainfed. Total number of wells in the district was29,936, groundwater availability with the depth of 1,150 feet. Major irrigation sources include wells, bore wells and ponds etc. during the year 2012.

A) Water availability

a) Status of water availability

The cumulative potential of annual water availability is about 1.4409 BCM. Of which, majority (80%) of the water availability is from surface irrigation tanks (1.1495 BCM) which is dependent on run-off induced rainfall and the cumulative command area is 34870.37 ha. Groundwater is the dependable source of irrigation with an area of 17,135 ha. The net groundwater availability is 0.2914 BCM and its usage has been 0.5265 BCM as per the (CGWB report, 2012). The potential availability of water for irrigation is given in table 3.4. The gross irrigated area during 2018-19 has been 26,144 ha. During rabi, maximum area was irrigated to the tune of 10,671 ha, 8,761 ha was irrigated during kharif and during rabi an area of 6,712 ha was irrigated.

Table 3.4: Details of potential water availability (BCM per annum)

Sl. No	Sources	Total
1	**Surface irrigation**	**1.1495**
(i)	Canal (major & medium irrigation)	0
(ii)	Minor irrigation tanks (Including ZP tanks)	1.1495
(iii)	Lift irrigation/ diversion	0
(iv)	Various water bodies including rain water harvesting	0.0015
(v)	Treated effluent received from STP (KC valley & STPs)	0.1294
(vi)	Untreated effluent	0
(vii)	Perennial sources of water (Yettinahole)	0.1391
2	**Ground water**	**0.2914**
(i)	Open well	0
(ii)	Deep tube well	0.2914
(iii)	Medium tube well	0
(iv)	Shallow tube well	0
	Total	**1.4409**

Source: Kolar District at a Glance 2010-11, District Statistical Office, Kolar

b) Status of ground water availability

The Central Ground Water Board (CGWB) assessment team reported the about the groundwater situation of Kolar district. During 2016, the Kolar district falls in over exploited category across all blocks. It can be observed that Bangarpet was found to be in the most over exploited stage of groundwater development with 211.16 percent and the lowest being 164.75 per cent in Kolar taluk.

Table 3.5: Status of groundwater availability across Kolar district (2009-2010)

Name of the block	Status of block as per central ground water board notification	Wells in use		Wells dried up	
		Dug wells	Shallow BW	Dug wells	Shallow BW
Bangarpete	over exploited	1974[32.65]	5262[18.94]	188[40.43]	144[21.98]
Kolar	over exploited	231[3.82]	7906[28.46]	81[17.41]	128[19.54]
Malur	over exploited	477[7.89]	5594[20.14]	163[35.05]	231[35.26]
Mulbagal	over exploited	3071[50.80]	3781[13.61]	14[3.01]	45[6.87]
Srinivasapura	over exploited	292[4.83]	5230[18.83]	19[4.08]	107[16.33]
Total	over exploited	6045[100.00]	27773[100.00]	465[100.00]	655[100.00]

Source: Groundwater year book of Karnataka state, 2009.

Note: Figures in parentheses indicate the per cent to the respective totals

Considering the significance of waste water on production and productivity of agriculture, Government of Karnataka had taken an initiative to implement Koramangala-Challaghatta Valley Project (KCVP) which is considered to be an unique project in the country. The scheme envisages filling of tanks in Kolar and Chikkaballapur districts with treated sewage water from Bengaluru. The KCVP was initiated during November 2016 to supply treated sewage water to a total of 126 irrigation tanks situated in different clusters of Kolar and Chikkaballapur districts in a phased manner. Bengaluru Metropolitan and Karnataka state government authorities have been grappling with the ever growing sewage problems. The KCVP thus has been designed to attain double benefits to address the ever growing problem of Bangalore city's drain and sewage water problems on one hand and on the other to rejuvenate the steadily declining groundwater table in the surroundings of the irrigation tanks in rural areas.

Project works were initiated in November 2016. The total cost of this project was Rs.1,342 crores. For ensuring un-interrupted power supply, Megha Engineering and

Infrastructures Limited (MEIL) has made efforts to establish 6 power Sub Stations of 66 KV capacity, along with 6 pump houses and a large surge tank for this KC Valley Project.

There is a possibility to improve area under irrigation by augmenting groundwater recharge in all taluks as these blocks have exceeded the safer limits and fall in over-exploited category, as briefed in the previous section. These bore wells will get recharged due to supply of treated water from KC Valley project as the water that will be stored in minor irrigation tanks. There will be improvement in yields of the borewells and would lead to increase in the gross irrigated area from the present level of 26,144 ha.

Table 3.6: Groundwater level status in Kolar district

Year	No. of wells analyzed	No. of wells recorded rise	No. of wells recorded fall
May-Nov 2019	35	31	4
May-Jan2020	32	30	2

Source: Groundwater year book of Karnataka state (2019-2020)

3.2. Nature and sources of data

The study was carried out in the Kolar district of Karnataka. The main objective of the study was to identify and evaluate the economics of major farming systems practiced in the study zone. Therefore, the study primarily relies upon primary data collected from randomly selected sample farmers in the zone. The study also utilizes the secondary data on various aspects to understand and analyze the demographic, crop, animal husbandry, irrigation and other conditions influencing the farming systems followed in the zone. The relevant statistics on crops, livestock, irrigation facilities etc., were collected from the District Statistical Office of the respective district.

It was learnt from previous studies and discussion with the experts in the field that that, the farming systems practiced are greatly going to be influenced by the proximity of the farmers to the urban centers. The study used the data from two distinct categories of farmers from Koramangala-Chellaghatta Valley Project (KCVP) and area other than

Plate 2: Primary data collection

Koramangala-Chellaghatta Valley Project (NKCVP) within the district. The region in which irrigation tanks filled from treated sewage water, lifted from Bangalore are considered as KCVP region and other region in which irrigation tanks are not filled with treated sewage water but poses borewell to supplement the irrigation are considered as NKCVP region.

The sample villages surveyed to meet the primary data requirement of the study included Chowdadenahalli, Doddavallabbi, Singenahalli, Dinnehosalli, Uddapanahalli, Lakshmisagara and Narasapura in KCVP area, while Imarakunte, Dasarathimmanahalli, Baipanahalli, Nukkanahalli, Hoodali, Bangarpete, Mulbagal and Mallasandra villages in NKCVP area.

Purposive random sampling design was employed for the selection of respondents. The primary datawere collected from 160 farm households, consisting of 80 farm households in KCVP area and 80 from NKCVP area, i.e., area outside the KCVP area. The distinction between two categories of respondents was on the basis of implementation of KC Valley Project (KCVP) implementation (village tanks filled) in the district. The data were collected from the respondents through personal interview method using pre-tested, well-structured schedules. The villages were selected randomly based on the area in which tanks were filled under the project in the district. The required information regarding age, education level, average land holdings, cropping pattern, marketing practices pertained to the agricultural year 2020-21and farm income pertaining to previous year were collected.

Among the various farming system, it was decided to consider four major farming systems in each of the areas for detailed economic analysis. A detailed information on crops grown, inputs used, output obtained, input output aspects of animal husbandry activities taken up by the sample farmers was elicited. The data pertained to the agricultural year 2020-21. Further the study also attempted to determine the risk efficient farming systems in the zone.

3.3 Analytical techniques employed

The important analytical tools and techniques used in the study are explained in this section**.**

3.3.1 Crop diversification and factors affecting crop diversification

3.3.1 Herfindahl Index (HI)- It is the sum of square of the proportion of area under each crop to the total cropped area and is given by the equation:

$$HI= \sum_{i=1}^{N} P_i^2 \quad \ldots\ldots(1)$$

Where,

P_i is the proportion of area under i^{th} crop in the net sown area.

The index value nearer to one indicates the region is specialized in growing of particular crop, if index approaches zero, it indicates that the area is towards diversification.

3.3.2. Simpson Index (SI): This measure of index is most suitable for measuring diversification of crops in a given particular geographical region using the following equation:

$$SI=1-\sum_{i=1}^{N} P_i^2 \quad \ldots\ldots(2)$$

Where,

$p_i=\frac{Ai}{\sum Ai}$ is the proportion of the i^{th} activity in acreage.

The value of Simpson index nearer to zero indicates that the area is specialized in growing of a particular crop and if it is close to one indicates diversity in crops grown.

3.3.3.a Fractional Probit model:

The fractional probit has been introduced by Papke and Wooldridge (1996) and has been extended to panel data by them during 2008.

Fractional probit model was used to identify the factors influencing crop diversification. The Simpson Index of Crop Diversification (SICD) which ranges from 0 to 1 was used as dependent variable.

The general form of the Fractional probit regression can be written as:

$E(\psi / \xi) = \phi(\xi\beta)$

The following fractional probit regression model as specified below was used in the present study:

$$\Psi = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 D_1 + \beta_8 D_2 + \mu \quad \text{..........................(3)}$$

Where,

Y= SICD score

X_1 = Age (years)

X_2= Education (No. of formal years of education)

X_3 = Farm income (Rs.)

X4=Average size of land holdings (acres)

X5=Distance to market (Kms)

X_6= Human labour (Man-days)

D1 = Region dummy (1 for Irrigated area and ‘0’ otherwise)

D_2= Access to Extension services (1 for Yes and ‘0’ otherwise)

3.3.3.b Output elasticities

Marginal effects of the explanatory variables at the mean could be obtained by:

$$\text{Marginal effect of } X_i = \frac{dy}{dXi} * \frac{\overline{Xi}}{\bar{Y}} \text{ (or) } b_i * \frac{\overline{Xi}}{\bar{Y}} \text{...(4)}$$

Where,

b = Partial elasticity estimated for each independent variable),

$\bar{x}$ = Mean of independent variable,

$\bar{y}$ = Mean of dependent variable.

3.3.4. Stochastic frontier analysis

The translog stochastic frontier model initially developed by Aigner *et al*. (1977) and Meeusen and Van den Broeck (1977). The translog production function can be used to know the impact of crop diversification on Crop productivity.

The functional form of model can be written as

$$\ln Yi=\sum_{K=1}^{n} \beta k \ln Xik + \frac{1}{2}\sum_{K=1}^{n}\sum_{J=1}^{n} \beta jk \ln Xik \ln Xij \ldots\ldots\ldots.. +Vi-Ui \ldots\ldots\ldots.(5)$$

Where,

Y_i- Crop Productivity of i^th^ producer,

k-Number of inputs used,

X_{ij} represents a set of four input categories (mainly fertilizer (kg), pesticides (kg/ltr), FYM (tonnes), and Human labour (man-days) used by the i^{th} farmer, and β is a vector that collects unknown parameters to be estimated.

In addition, ε_I is the composed error term, where $\varepsilon_i=v_i-u_i$ with $u_i\geq0$. The random error v_i accounts for the stochastic effects beyond the producers control, measurement errors as well as other statistical noise, and u_i captures production inefficiency due to factors that are in the control of the producer.

The error terms in model assumes Half-Normal Distribution

$vi=iid\ (0, \sigma_u^2)$

$ui=iidN^{+}(0,\sigma_u^2)$

*vi*and *ui* are distributed independently of each other and of the regressors

Variables used in the model:

Y=Composite Farm productivity (kg/acre)

X_1=Fertilizer (50 kg bags)

X_2=Pesticides (kg/litre)

X_3=Farm Yard Manure (tonnes)

X_4: Human Labour(Man-days)

Exogenous Variables

D1=Crop diversification index

D2=Region dummy(KC irrigated area=1, other wise=0)

D3=Extension services(Yes=1,otherwise=0)

3.3.5 Estimation of costs and returns

The total costs was comprised of variable cost and fixed cost. Variable cost includes cost on seedlings, farmyard manure, fertilizers, pesticides, labour cost and interest on working capital, while fixed cost include depreciation on farm implements, rental value of land, managerial cost and interest on fixed cost.

A. Recurring cost or Variable cost

The costs which vary with the level of production are included under this category. The components included under the variable items of cost are:

a) Labour cost

The cost on human labour was calculated by multiplying the man-days with prevailing wage rate. The women working days were converted into man days by multiplying it with the ratio of wages given to women labour compared to men labour (0.75). The cost on family labour was imputed by multiplying man days with the prevailing wage rate. The bullock labour was taken in pair days and the cost towards it was estimated by multiplying pair days with hiring rate. Machine labour was measured in hours and valued at prevailing hourly rates in the study area.

b) Cost of inputs

Cost of various inputs like seeds, fertilizers, and manures, pesticides were included in this cost. The purchased inputs were valued at the actual price paid by the respondents while owned farm inputs were imputed at current prices.

c) Marketing cost

The cost involved in marketing of produce i.e., from farm gate to the place where the produce is sold is included in this category.

d) Interest on working capital

The prevailing bank rate of seven per cent which the commercial bank lend to crop production was taken to work out the interest on working capital for the duration of the crop.

B. Fixed cost

These costs which do not vary with the level of production and various components considered under fixed costs are detailed below.

a) **Rental value of land;** The rental value of land was considered at the actual rates prevailing in the study area per annum and later considered for the duration of the crop, while and was imputed at the prevailing rent rates for the owned land .

b) **Depreciation;** Depreciation on every owned capital equipment and machinery was calculated using the straight line method by taking into consideration, purchase price, economic life, terminal value of the assets. The total depreciation was apportioned to each crop area considering the total land holding operated. .

$$\text{Depreciation} = \frac{\text{Purchase price} - \text{junk value at life end of the asset}}{\text{Average Life (in years) of the Asset}}$$

c) **Interest on fixed capital:** Interest on fixed capital was computed at the rate of ten per cent per annum. Interest on fixed cost is only for land revenue, rent and depreciation but not for values of assets otherwise overestimated.

d) **Establishment cost:** It is the cost incurred on the establishment of any perennial crop like mango, mulberry on the sample farms. This comprises again both the fixed cost and variable items of cost like land Revenue, expenditure towards land preparation, seedling, irrigation infrastructure, fertilizer and manure, etc.

e) **Amortized establishment cost**; The total establishment cost was apportioned over life span of the study crop.

C. Total cost: It is the summation of total variable/recurring cost and total fixed cost.

D. Returns

a) **Gross returns:** Include the total value of quantity of main and bye product from each of the crop / livestock enterprises raised valued at the price realized for the main / bye product sold and including value of the quantity retained for the own/family use.

b) **Net Returns (NR);** Net returns were obtained by deducting the total cost from the gross returns.

c) **Returns per rupee of expenditure;** Returns per rupee of expenditure was calculated by dividing the gross returns with the total cost.

3.3.6 Data Envelopment analysis

The Data Envelopment Analysis (DEA) is a nonparametric mathematical programming technique first used by Farrell (1957) as a piecewise linear convex hull approach to frontier estimation. The DEA technique is used to estimate efficiency scores or levels of inputs or outputs from either an input or output orientation, either using constant returns to scale (CRS) or variable returns to scale (VRS) models. Following from coelli *et al.* (1998) the linear programming models for the input oriented measure of technical efficiency under the assumption of VRS, the envelopment from of the input-oriented VRS, DEA model can be specified as:

$Min_{\theta\,\lambda}\theta$……………………………………….(6)

Subject to

$y_1 + Y_\lambda \geq 0,$

$\theta_{Xi} - X_\lambda \geq 0,$

$N^1 \lambda = 1$

$\lambda \geq 0.$

Where,

θ_1 is the i^{th} firm's Technical Efficiency (TE) score relative to the other firms in the sample ranging from zero to one. The θ value of 1 indicates a point on the frontier (100% efficiency) otherwise; the firm is operating below the frontier, with various degrees of inefficiency, with zero indicating 100% inefficiency. The analysis was done using R software.

In the analysis of efficient and inefficient decision making units, the resource saving target ratio index was calculated for farming system and is given by (Sadiq, *et al.*, 2015)

$$RSTR(\%) = \frac{Resource\ saving\ target}{Actual\ resource\ input} \times 100 \quad \text{.................................(7)}$$

Where, resource saving target is the total amount of input that could be saved without decreasing output level. RSTR represents each inefficiency level of resource usage. The value of RSTR is between zero and unity. A higher RSTR implies higher resource use inefficiency, and thus, a higher resource saving amount.

Here in the model, composite crop yield from all the enterprises are taken as dependent variable and inputs from all the enterprises (Seedlings/seed cost, cost on manures, cost on pesticides and fertilizers, cost on labour and other costs) were added together along with the technical efficiency of dairy and mulberry enterprises as one of the input variable, as output of dairy i.e., cow-dung acts as one of the input variable to find the resource use efficiency of farming system. Technical efficiency (variable returns to scale) for dairy was found out separately because the input used in the dairy enterprise varies with crop production and even the output of dairy component cannot be taken in common terms.

3.3.7. Standard deviation, co-efficient of variation and Stochastic efficiency with respect to function (SERF)

3.3.7.a Standard deviation (S.D.) and Co-efficient of variation (C.V.)

To know the risk associated with the farming systems in the study area, standard deviation and coefficient of variation of net returns were found out. The formula for standard deviation (S.D.) and co-efficient of variation (C.V.) are given as follows:

Standard deviation=$\sum(X-\bar{X})^2$divided by n-1

Where, X-samples

$\bar{X}$- mean of samples

n-number of samples/ sample size

Co-efficient of Variation (C.V.) =$\frac{Standard\ deviation}{Mean}\times 100$……………(8)

3.3.7.b. Stochastic efficiency Analysis:

The study performed Stochastic Efficiency with Respect to a Function (SERF) analysis to evaluate different farming systems and generates Certainty Equivalent (CEs) and ranking risky alternatives within different risk aversion level. The Certainty Equivalent (CEs) value used to calculate risk premium need to be paid to farmers to move to risk efficient farming systems to get higher returns and to remain on higher utility level.

Model structure:

The modeling process began by defining inputs and parameters effecting returns from farming system. The qualitative risk analysis used in this study to provide a high level of understanding of risks of farming system. In this analysis, we have investigated the economic viability of four major farming systems under different risk aversion level in both KCVP and NKCVP area. According to Hardaker *et al.* (2004a), SERF ranks the farming systems options using CE over a range of values of risk aversion. The CE for each risky alternative relies on the particular utility functional form specified. Negative exponential utility function was used to arrive at CE's and Risk aversion Coefficients (RAC's).

The main farming systems considered in both KCVP and NKCVP area are presented below:

FS-I: V+C+M+L

FS-II: V+M+L

FS-III: V+C+L

FS-IV: V+L

(V-Vegetables, C-crops, M-Mulberry and L-Livestock component)

In this study, we assume the annual net farm income reflects farmer's wealth. The stochastic simulation model employed to evaluate the probability distribution for annual net farm income that incorporates certainty equivalents obtained from the negative exponential utility function along with absolute risk aversion co-efficients for each farming system can be described as follows

The simulation model is presented below:

$$NR=(Y_a*P_a+Y_b*P_b............+Y_n*P_n) -FC-VC..............................(9)$$

NR=Probability distribution of Net returns from farming system

Ya Stochastic yield of crop 1

P_a stochastic price of crop1

Yb Stochastic yield of crop 2

P_b Stochastic price of crop2

Y_e Stochastic yield of dairy enterprise

P_e stochastic price of milk

FC-Fixed cost involved in farming system (Land revenue, cost on cattle-shed, depreciation, amortization, medicines etc.,)

VC- Stochastic variable cost involved in farming system(Labour cost, seed, fertilizers, manures, pesticides, feed concentrates, fodder etc.)

Stochastic Efficiency with Respect to a Function (SERF)

A stochastic efficiency model performed to compare the Net returns (NR) of four major farming systems. Stochastic efficiency with respect to a function (SERF) is used to rank the risky alternatives simultaneously with different risk aversion preferences. Risk Premium is also calculated by subtracting CE Certainty equivalent for less preferred farming system from dominant alternative. Given a utility function u(x), a random wealth variable X, and an initial level of wealth w_0, the certainty equivalent is :

$$CE = u{-}1\{E[u(X + w0)]\} - w_0 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (10)$$

The risk premium measure the minimum amount need to be paid to farmers and decision maker to justify a switch from present farming system to other less risky alternative. The model simulated the costs and returns for one acre of land and 2 dairy animals in both KCVP and NKCVP area. The Net Return is calculated and probability distributions generated by the simulation model. The model used to rank the best alternative farming systems across a full range of RACs. The study finally performed CE analysis to estimate premium price or amount should be given to farmers to keep their farming systems at a less risky farming system; to remain on same utility level and utilize farm resources in a sustainable manner.

3.3.8 Double bounded dichotomous Contingent Valuation Method (CVM)

In order to estimate the farmers' willingness to pay for assured irrigation and equitable water distribution, double bounded dichotomous Contingent Valuation Method (CVM) was employed. The CVM is a survey method which rests in the creation of imaginary (hypothetical) market situation to elicit the preferences of the respondents towards the environmental goods and services. Irrigation water in many cases are undervalued or not at all valued. In this particular study, use value of KCVP is elicited by CVM as used by Durba and Venkatachalam, (2015).

The steps followed in the present while using the Contingent valuation method to overcome biases associated with CVM (*viz.,* strategic bias, starting point bias, hypothecation bias and vehicle bias). To avoid the starting point bias, the water rate charged per acre was Rs.1000/acre taken as the initial bid amount based on the pilot survey made to study area. The format of CVM is depicted in Fig. 3.1.

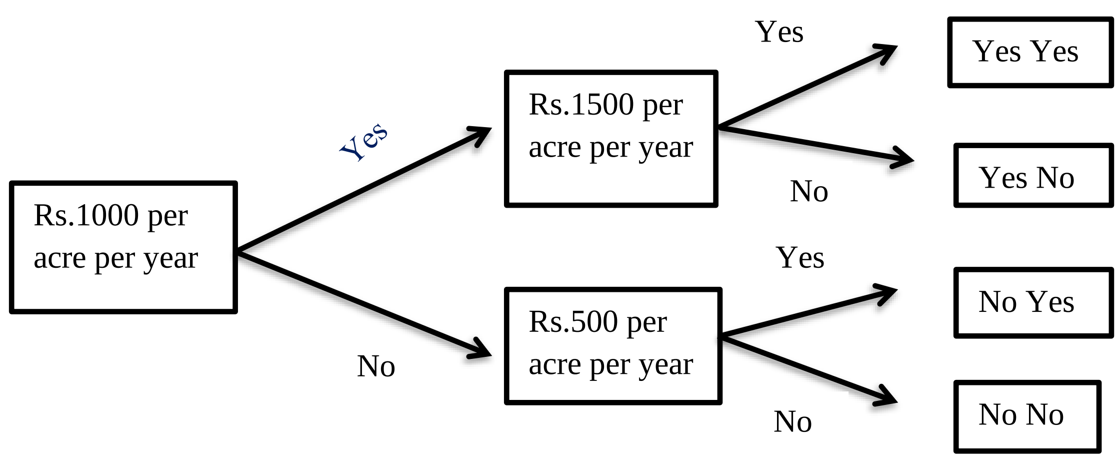

Fig. 3.1: Double bounded dichotomous Contingent valuation method

Based on the response, the farmers were grouped into four categories *viz.,* YY (Yes for first bid and Yes for second bid), YN (Yes for first bid and No for second bid), NY (No for first bid and Yes for second bid) and NN (No for first bid and No for second bid). Along with this, their actual willingness to pay (Rs. per acre per year) for the assured and equity in distribution of water was also collected. These four different categories were used as endogenous variables. While age, education attainment, area under irrigation and scarcity of water , gross farm income and crop diversification index were considered as exogenous variables to figure out the factors affecting the farmers willingness to pay. Multinomial logistic regression was used to elucidate the factors affecting the willingness to pay by the farmers in KCVP area.

3.3.8.1. Logistic regression/ Multinomial logistic regression

To elucidate the factors affecting the willingness to pay for assured irrigation through borewell recharge and equity in filling up of village tanks with treated sewage water through K-C valley project, logistic regression was employed.

The regression was run with YY=1, YN=2, NY=3 and NN=4 as dependent variable in case of multinomial logistic regression (KCVP). The base category was YY in case of multinomial logistic regression.

The form of the logistic regression used was of the following form.

$$P_i = P_i\left(Y = \frac{1}{X_1, X_2, X_3, X_4, \ldots.. X_k}\right) = \frac{e^Z}{1+e^Z} = \frac{\exp(Z)}{1+\exp(Z)} \ldots\ldots\ldots\ldots\ldots \text{(11)}$$

Where, Z= $\beta_0 + \beta_i X_i$ and X_i are set of predictor variables.

$$\frac{P_i}{1-P_i} = e^{Z_i} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(12)}$$

$$L_i = \ln\left(\frac{P_i}{1-P_i}\right) = Z_i = \beta_0 + \beta_i X_i \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(13)}$$

The quantity $\frac{P_i}{1-P_i}$ is called the odds and hence, $\ln\left(\frac{P_i}{1-P_i}\right)$is logit. The coefficients β_i are logit regression coefficients. Odds ratio were computed using these coefficients. In the case of a dichotomous independent variable, the odds ratio can be interpreted as the increased odds of a positive outcome on the dependent variable for the affirmative category (X=1) over the negative one (X=0). Logistic regression commands in the Stata 14.2 version software was used to analyze the data.

3.3.8.2. Tobit regression analysis

A sample in which information on the dependent variables are available only for some observations is known as a censored sample and in such cases tobit is used (Gujarati, 2004). In view of the fact that the actual willingness to pay was zero for few farmers, tobit model was estimated to find the factors affecting the actual WTP. Censored tobit regression commands in the Stata 14.2 version software were used to find the maximum likelihood estimation of the independent variables.

$Y_i = \beta_0 + \beta_i X_i + u_i$,if RHS>0 and $Y_i = 0$, otherwise………………………. (14)

The following model was used for respondents of KCVP area

WTP (Rs.) = $\beta_0 + \beta_1$ (X_1) + β_2 (X_2) + β_3 (X_3)+β_4 (X_4) + $\beta_5 X_6$…… . (15)

Where,

X_1= Age (years)

X_2= Education attainment (years of schooling)

X_3= Area under irrigation (acres)

X_4= Gross annual farm income (Rs.)

X_5=Scarcity of water

X_6=Crop diversification index

IV RESULTS AND DISCUSSION

The results from the analysis of data collected using the suitable tools and techniques presented in methodology chapter in achieving the objectives of the study are presented in this chapter under the following sub-sections.

4.1 Socio-economic characteristics of sample farmers

4.2 Crop diversification and factors affecting crop diversification

4.3 Impact of crop diversification on composite crop productivity

4.4 Economics of major farming systems and Resource use efficiency of major farming systems

4.5 Risk associated with farming system and risk efficient farming system.

4.6 Externalities associated with KCVP and willingness to Pay for KCVP

4.1 **Socio-economic characteristics of the respondent farmers**

Socio- economic characteristics are going to influence the decision making behavior of farmers. The study area consisted into two regions *viz.*, KCVP (Koramangala-Challaghatta Valley Project) and Non-KCVP (Non-Koramangala-Challaghatta Valley Project) area. From each region, 80 farmers were selected so to make a total sample size of 160 farmers to study economics, resource use efficiency and suggest risk efficient system among different vegetable based farming systems followed. As the decisions and practices of farmers are going to greatly influenced by the characters of the respondents and hence it was attempt to study socio-economic characters of the respondents and results are presented in Table-4.1.

4.1.1 Socio-economic characters of the sample respondents

Average age of the sample respondents was 47.16 years and 46.54 years in KCVP and NKCVP area, respectively. Age of the respondents ranged from the lowest 23 years to as old as 75 years in KCVP area and 28 to 70 years in NKCVP area (Table 4.1). Majority of the respondents were in the middle age group of 36-50 in both KCVP (48.75

%) and NKCVP area (55%). However, the mean difference in age between the two categories of farms was not significant.

Table 4.1: Socio-economic characteristics of respondents in KCVP and NKCVP

Sl. No.	Particulars	KCVP(n=80)	NKCVP(n=80)
1	**Age**		
a.	No. of respondents below<35 years	13(16.25)	14(17.5)
b.	No. of respondents between age 36-50 years	39(48.75)	44(55.00)
c.	No. of respondents aged 50 and above	28(35.00)	22(27.50)
d	Average Age (Years)	47.16	46.54
	Chi-square value	**0.593**	
	Range(Years)	23-75	28-70
2.	**Family Size**		
a.	Adults (number)	5	5
i.	Male	3	3
ii.	Female	2	2
b.	Children (number)	2	1
	Chi-square value	**0.946**	
3.	**Education**		
a.	No. of Illiterates	1(1.25)	9(14.51)
b.	Primary education(Number)	30(37.5)	11(17.74)
c.	Secondary Education(Number)	34(42.5)	28(45.16)
d.	PUC(Number)	11(13.75)	6(9.67)
e.	Degree(Number)	4(5.00)	8(12.90)
	Chi-square value	**0.0023***	

Note: *Indicates significance at one per cent probability level

The average family size was 5 adult members along with 2 and 1 children in KCVP and NKCVP area and it was found statistically non-significant. Analysis of education level of the respondents revealed that there was one illiterate and nine illiterates in KCVP and NKCVP area, respectively. Majority of the respondents had secondary education followed by primary school education, PUC and graduation. Only one and fourteen percent of respondents were illiterates in KCVP area and same trend was observed with respect to number of literates, except the less number of PUC holders (9.67%) than graduates (12.90%) NKCVP area(Table 4.1). The Chi-square test showed significant difference with respect to education level between KCVP and NKCVP area.

Thus there was no significant divergence between the groups with respect to the socio-economic characteristics in study area, except education indicating that the samples were almost homogeneous and hence they can be meaningfully compared.

4.1.2 Land holdings of the sample respondents

The sample farmers possessed 0.49 acres and 1.12 acres of rainfed land, while irrigated land was 3.15 acres and 2.94 acres in the case of KCVP area and NKCVP area, respectively. The total landholding was relatively more (4.06acres) in NKCVP area compared to KCVP area (3.63 acres) (Table 4.2).Sample farmers are classified into three categories based on the average size of land holding, *viz.*, Large farmers those who possessed more than 5 acres of agricultural land, Medium category farmers. Those farmers having the land holding size of 2.5 to 5 acres of agricultural land and farmers with land holding size of less than 2.5 acres of agricultural land were classified as small farmers (Table 4.3).

Table 4.2: Land holding details of sample respondents (acres)

Landholdings	KCVP (n=80)	NKCVP (n=80)
Rain-fed	0.49 (13.46)	1.12 (27.59)
Irrigated	3.15 (86.54)	2.94 (72.41)
Total land holding	**3.64**	**4.06**

Note: Figures in parentheses indicate per cent to the respective totals

The farm size category-wise distribution of farmers revealed that the highest percentage of sample farmers were medium size category farmers accounting for 55 per cent and 43.75 per cent in KCVP and NKCVP area, respectively. Small farmers accounted for 32.50 per cent and 40 per cent of respondents followed by 12.50 per cent and 16.25 per cent of large farm size category farmers in KCVP and NKCVP area, respectively (Table 4.3) (Fig. 4.2).

Table 4.3: Classification of farmers based on Size of land holdings

Classification	**KCVP(No.)**	**Percent**	**NKCVP(No.)**	**Percent**
Large	10	12.50	13	16.25
Medium	44	55.00	35	43.75
Small	26	32.50	29	40.00
Total	**80**	**100.00**	**80**	**100**

Note: Large farmers - >5 acres of agricultural land, Medium farmers-2.5 to 5.0 acres of agricultural land and Small farmers - <2.5 acres of agricultural land.

4.1.3. Farm assets and farm buildings

Different types of farm assets were owned by sample farmers for performing various farm operations. Among the machineries and equipment's, around 35 and 21 per cent of the sample farmers owned tractors, 12 and 1 per cent of them owned power tiller and 67 and 36 per cent of them owned power sprayers in KCVP and NKCVP area, respectively. Cent per cent of the sample respondents had hand sprayers in both KCVP and NKCVP area. 13.75 percent and 2.50 per cent of respondents have bullock cart and 36.25 percent and 53.75 percent of respondents had other implements like spade, varvari, Harrow and other implements. The average age of the asset and its value is given in Table 4.4 in detail for KCVP and NKCVP area. Farm buildings such as cattle shed were owned by 57.50 per cent and 40 per cent of the sample respondents, pump sheds were owned by 61 and 51 per cent of the sample farmers with the average value of farm buildings were Rs.11209 and Rs.10990 and 22 per cent and 11.25 per cent of respondents

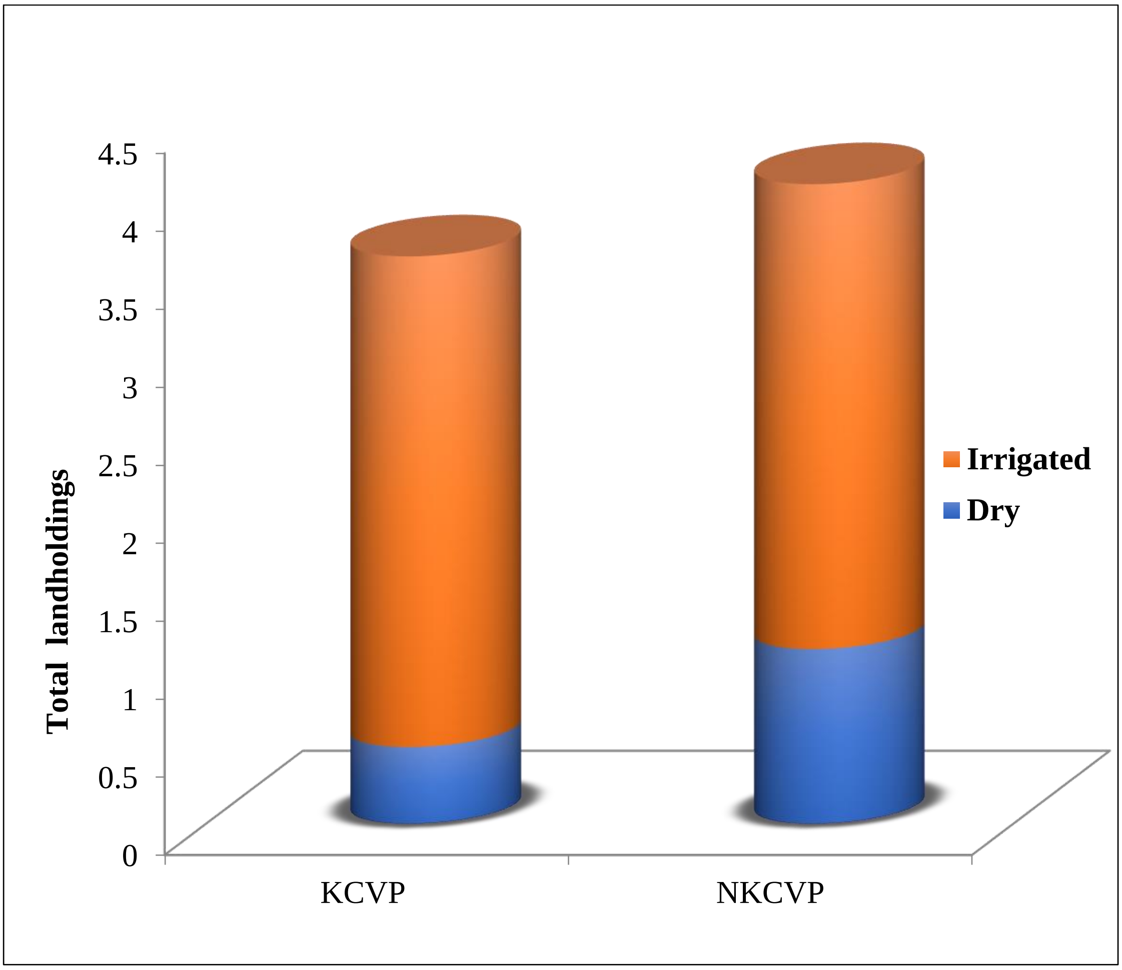

Fig. 4.1: Rain-fed and Irrigated landholdings in KCVP and NKCVP area

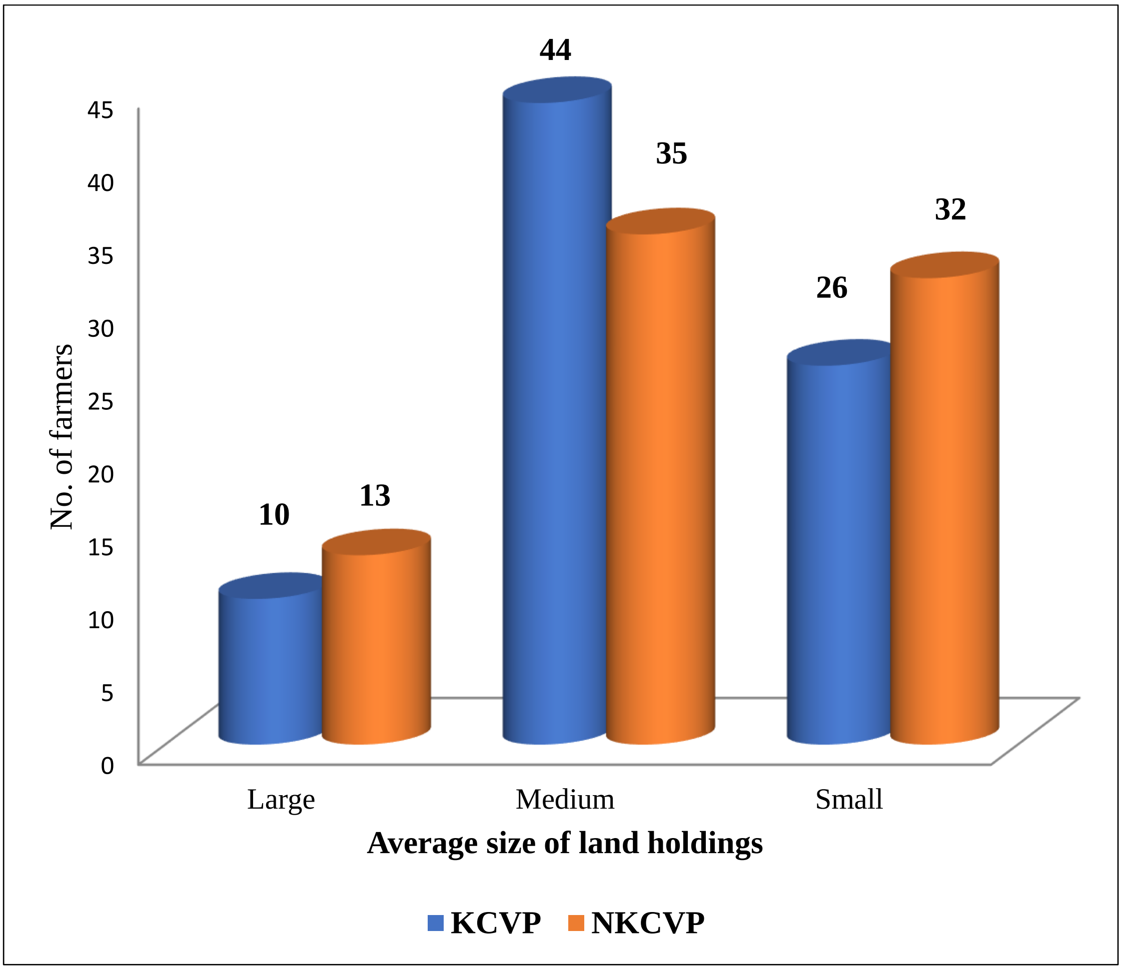

Fig. 4.2: Distribution of respondents based on size of landholdings

had poultry shed, valuing Rs.20890 and Rs.19980 respectively in KCVP and NKCVP area (Table 4.4). T-test was applied to know significant difference between the two areas but it was found non-significant indicating there was no difference between the groups.

Table 4.4: Details of farm assets & buildings owned by sample households

Sl. No	Farm Assets	KCVP(n=80)		NKCVP(n=80)	
		Number	Value (Rs.)	Number	Value (Rs.)
I.	**Machineries and equipment**				
	a. Tractor	28(35.00)	467441	17(21.25)	388824
	b. Power tiller	10(12.50)	177500	1(1.25)	102500
	c. Power sprayer	54(67.50)	5002.82	29(36.25)	4388
	d. Hand sprayer	98 (100)	2546.18	82 (100)	2343.25
	e. Bullock cart	11(13.75)	9125	2(2.50)	6750
	f. Others #	29(36.25)	689	43(53.75)	632
	Sub total		662304 [93.57]		505437 [92.00]
II.	**Farm buildings**				
	a. Cattle-shed	46(57.50)	13450	32(40.00)	12980
	b. Pump-house	49(61.25)	11209	41(51.25)	10990
	c. Poultry shed	18(22.5)	20890	9(11.25)	19980
	Sub total		45549 [6.43]		43950 [8.00]
	Total value	**705308**		**547044**	

Note: Figures in parentheses indicate percentage of farmers owning

Figures in square brackets indicate per cent to the total asset value

T-test was applied and found non-significant in both the situations.

Spade, Varvari, Harrow, and other implements, etc.

4.1.4 Household assets

Most of the households had houses inherited as the ancestral property. About 77 per cent and 71 per cent of sample respondents owned TV, 16 per cent and 11 per cent of respondents possessed refrigerator, 33 per cent and 41 per cent of respondents owned bicycle, 73 per cent and 65 per cent had car and cent per cent of respondents possessed mobile phones in KCVP and NKCVP area, respectively. The details of expenditure on these assets are given in the Table 4.5 for respondents in both the KCVP and NKCVP area.

Table 4.5: Household assets owned by the respondents

Household assets	KCVP(n=80)		NKCVP(n=80)	
	No of farmers	Purchase price (Rs.)	No of farmers	Purchase price (Rs.)
TV	62(77.5)	108672	57(71.25)	98709
Refrigerator	13(16.25)	54609	9(11.25)	66908
Bicycle	27(33.75)	1099	33(41.25)	879
Two wheeler	59(73.75)	42309	52(65.00)	47567
Car	11(13.75)	489099	6(7.50)	512390
Mobile phone	80(100.00)	3870	80(100.00)	4897

Note: Figures in the parentheses indicates percentage to sample

Table 4.6: Livestock inventory of sample farmers in KCVP and NKCVP area

Sl. No.	Particulars	KCVP(n=80)		NKCVP(n=80)	
		Ave. No.	No. of farmers	Ave. No.	No. of farmer
1	Drought animals	2	6(7.50)	1	9(11.25)
2	Cows	3	39(48.75)	1	28(35.00)
3	Cross bred cows	2	57(71.25)	2	61(76.25)
4	Buffaloes	1	29(36.25)	1	23(28.75)
5	Sheep	5	23(28.75)	7	19(23.75)
6	Goats	2	19(23.75)	3	13(16.25)
7	Poultry birds	5	34(42.50)	3	41(51.25)

Note: Figures in parentheses indicate percentage to total sample

4.1.5 Livestock inventory

The livestock inventory of the farmers in the study area revealed that relatively lower percent i.e., 7.50 percent and 11.25 percent of farmers had an average of two drought animals, 48.75 and 35.00 percent of farmers had average of 3 cows, 71.25 per cent and 76.25 per cent of farmers had crossbred cows in KCVP and NKCVP area (Table 4.6), respectively. 36.25 percent and 28.75 per cent of farmers had an average of one buffalo,28.75 and 23.75 percent of farmers had average of 5 sheep's, 2 and 3 goats (23.75 % and 16.25% of farmers) and 42.50 and 51.25 percent of farmers possessed 5 and 3 poultry birds respectively, in KCVP and NKCVP area.

4.1.6 Cropping pattern of the respondent farmers

Since, study followed purposive sampling of vegetable growers, all the respondents were growing vegetables in all the three agriculture seasons in both KCVP and NKCVP area. The area under vegetables was 353.87 acres in KCVP area as against 155.5 acres in NKCVP area in Kharif and Rabi seasons. The major vegetable crops grown in kharif season under KCVP area included Tomato (55.5 ac.), potato (26.5 ac.), cabbage (17.5 ac.), beans (17 ac.), carrot (28.2 ac.), coriander (8 ac.), chilli (6.5 ac.) and other vegetables crops like brinjal, ridge-guard, cauliflower, radish, capsicum, green-leafy vegetables on an acreage of 26.5 in KCVP area. In rabi, vegetables grown are Tomato(75 ac.),potato(5 ac.),cabbage(33 ac.), carrot(15 ac.), chilli(5 ac.,) and other vegetables included in an area of 9.52 acres. And in summer, major vegetables are grown in area of 25 acres, tomato (32 ac.), potato (39 ac.) and other vegetables are grown in acreage of 25 acres.

In NKCVP area, farmers in kharif were majorly involved in cultivating vegetables like Tomato (38 ac.), Potato (41 ac.), beans (8.5 ac.), carrot (4.5 ac.), chilli (4.5 ac.) and other vegetables like brinjal, radish, cauliflower, capsicum, green leafy vegetables on an area of 5.5 acres and in rabi season, tomato is grown in area of 8 acres, potato (5 ac.), carrot (15 ac.) and other vegetables in an area of 2 acres. Ragi occupied 34.5 acres and 44.5 acres in Kharif in KCVP and NKCVP area. Marigold was grown on an area of 25 acres and 9 acres in KCVP and NKCVP area, respectively.

Table 4.7: Cropping pattern of sample respondents in KCVP and NKCVP area

SL. No.	Crops	KCVP		NKCVP	
		Area(ac.)	**% to GCA**	**Area(ac.)**	**% to GCA**
I.	Kharif				
A.	Cereals				
1	Ragi	34.5	5.93	45.5	8.70
2	Fodder maize	1.78	0.31	6.1	1.17
	Sub-total	36.28	6.23	51.6	9.87
B.	Vegetables				
1	Tomato	55.5	9.53	38	7.27
2	Potato	26.5	4.55	41	7.84
3	Cabbage	17.15	2.95	-	-
4	Beans	17	2.92	8.5	1.63
5	Carrot	29.2	5.02	4.5	0.86
6	Coriander	8	1.37	0.5	0.10
7	Chilli	6.5	1.12	4.5	0.86
8	Others#	26.5	4.55	5.5	1.05
	Sub-total	186.35	32.01	102.5	19.60
C.	Flower crop				
1	Marigold	25	4.29	9	1.72
	Subtotal- Kharif	**247.63**	42.54	**163.1**	31.19
II.	Rabi				
A.	Cereals				
1	Fodder maize	11	1.89	15.5	2.96
B.	Vegetables				
1	Tomato	75	12.88	8	1.53
2	Potato	5	0.86	5	0.96
3	Cabbage	33	5.67	-	
4	Carrot	15	2.58	15	2.87
5	Chilli	5	0.86	8	1.53

6	Other vegetables	9.52	1.64	2	0.38
	Sub total	**142.52**	24.48	**38**	7.27
	Rabi subtotal	**153.52**	26.37	**53.5**	10.23
III	Summer				
	Vegetables				
1	Tomato	**32**	5.50	**25**	4.78
2	Potato	**39**	6.70	**35**	6.69
3	Other vegetables	**25**	4.29	**15**	2.87
	Summer-sub total	**96**	16.49	**75**	14.34
D.	Perennials				
1	Mango	7.5	1.29	77.4	14.80
2	Mulberry	28.5	4.90	13.8	2.64
3	Nilgiri	6.5	1.12	15.5	2.96
4	Papaya	-		9	1.72
	Sub-total	**42.5**	7.30	**115.7**	22.12
III.	Gross cropped Area (ac.)	582.15		523	
IV.	Net cropped area (ac.)	294.4		324.8	
V.	Cropping Intensity (%)	197.74		161.02	
VI.	Herfindahl Index (HI)	**0.42**		**0.69**	
VII.	Simpson index	0.58		0.31	

Note: #- includes Brinjal, ridgeguard, raddish, cauliflower, capsicum, Green leafy vegetables

As district is known for growing mangoes, the acreage under mango in NKCVP was 77.4 acres and in KCVP it cultivated on 7.5 acres (Table 4.7). Mulberry being another major crop grown in the study area, it was grown on area of 28.5 acres in KCVP as against 13.8 acres in NKCVP area.

The gross cropped area was 582.15 acres and 523 acres and net cropped area was 294.4 acres and 324.8 acres in the case of farmers in KCVP and NKCVP area, respectively. Cropping intensity was comparatively more in KCVP area (197.74 %) than in NKCVP area (161.02%) as indicated in Table 4.7. Due to availability of water in the

KCVP region after implementation of project, there is an increased water availability, which made farmers to cultivate more number of vegetable crop compared to NKCVP region. Thus there was an increased cropping intensity by 30 per cent in KCVP area compared to NKCVP area. The diversification was also tested using the Herfindahl index and it worked to be 0.42 in KCVP area and 0.68 for NKCVP area (Table 4.7). The Simpson index for knowing the crop diversification was also worked out the index was 0.576 for KCVP area thereby indicating that the region showed more diversified compared to NKCVP area which showed relatively lower index value of 0.314 and hence hypotheses of diversification being more in KCVP area compared to NKCVP area was accepted. This fact revealed prevalence of less diversified crop pattern in NKCVP than KCVP area. In other words, crop pattern followed in NKCVP area was towards specialized farming and farmers have concentrated on few selected crops. The results of Ramesh (2020) also revealed similar findings of higher degree of diversification in KCVP area than NKCVP region.

4.1.7. Distribution of respondents across different levels of diversification

The values of Herfindahl indices were used to classify the sample farm households into five quartiles as relatively more diversified farms as one extreme category and the least diversified farms as another extreme category in both KCVP and NKCVP areas (Table 4.8). The comparison between the two situations is also presented in Figure 1. It could be observed from the results that, majority of the respondents in KC valley area (66%) fall in the category of higher degree of diversification (<0.50), followed by 22.50 per-cent in diversification index range of 0.5-0.6, and rest of the respondents belonged to other diversification category indices of 0.6-0.7 (2.50%), 0.7-0.8, 0.8-0.9 and more than 0.90 (8.75%). Hence, it can be inferred from the findings that majority of the respondents in KC valley have adopted relatively more diversified cropping pattern. This can be directly attributed to reasons such as higher proportion of area under irrigation (86.54%) on account of better recharge of borewells than NKCVP area. In addition, farmers in KCVP area realized better farm income and going for more diversified crop pattern involving higher capital requirements.

Table 4.8: Distribution of respondents according to Herfindahl diversification index

Sl. No.	Herfindahl Index	K-C valley area (0.42)		Non-KC valley area (0.69)	
		No. of respondents	Percentage	No. of respondents	Percentage
1	<0.50	53	66.25	9	11.25
2	0.5-0.6	18	22.50	29	36.25
3	0.6-0.7	2	2.50	8	10.00
4	0.7-0.8	1	1.25	5	6.25
5	0.8-0.9	1	1.25	1	1.25
6	>0.90	5	6.25	28	35.00
		80	100.00	80	100.00

In contrast, only 11.25 per cent of respondents in NKCVP area fall in the category of less than 0.5. This indicated higher degree of diversification adopted by relatively smaller proportion of the respondents in NKCVP area.

The largest proportion of farmers (36%) in the NKCVP area, fall in the category of diversification index of 0.5-0.6. However, one-fourth of the respondents adopted highly specialized cropping pattern. More than ten per cent and six per cent of the respondents showed the HI (Herfindahl Index) index range of 0.60-0.70 and 0.70-0.80, respectively. Thus from the relating to the Non-KC valley area, we can infer that majority of respondents followed specialized in cultivation of few crops, or in other words, respondents adopted less diversified cropping pattern compared to their counterparts in KC valley area.

4.1.6 Description of variables used in Fractional probit model

The variables having possible impact on the crop diversification have been identified and are presented in Table 4.9. The age of the farmer respondents ranged between 16 and 69 years, with an average age of 44 years. The average number of years of formal school education of respondents was about eight years and it ranged between 0

Table 4.9: Summary statistics of variables used in fractional probit model

Variable	Variable description	Mean	Standard deviation	Minimum value	Maximum value	Expected sign
CDI	Crop diversification index	0.44	0.257	0	1	
FARMAGE	Age of the respondents (Years)	43.00	14.56	16	69	+
EDUC	Education level (years of formal education)	8.44	3.53	0	15	+
FARMINCOM	Farm income (Rs.)	187920.22	108756.12	12950	823145	+
FARMSIZE	Size of farm (acres)	3.78	2.99	0.5	20	+
ACCESEXTEN	Access to extension services (1 = Yes, 0 otherwise)	0.56	0.49	0	1	+
ACCESIRRI	Access to irrigation (1=Yes, 0=otherwise)	0.49	0.50	0	1	+
DISTMARKT	Distance to market (Km's)	12.46	12.14	0	62	+
HUMLBR	Human labour used (MD)	39	27.29	8	96	+

Note: Km's-Kilometers, MD-man-days

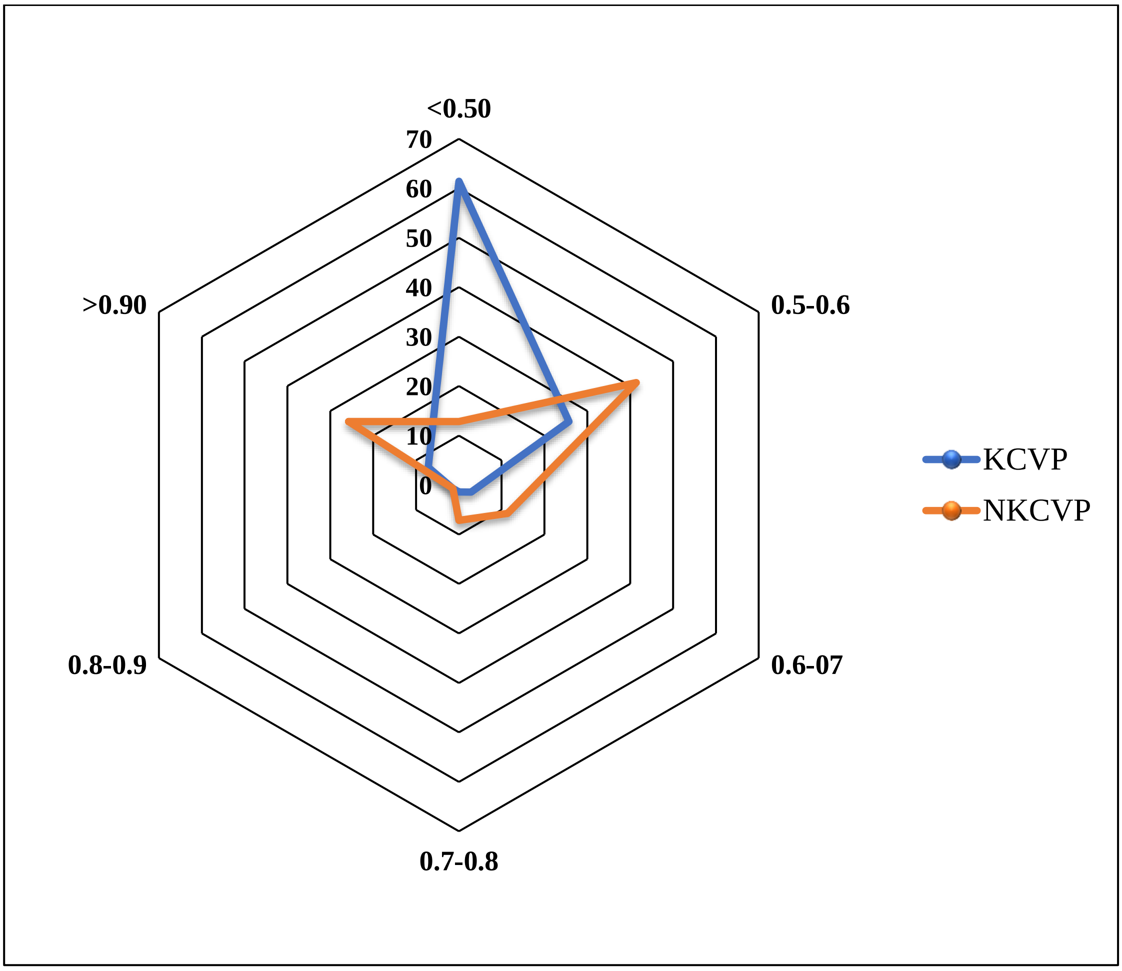

Fig. 4.3: Distribution of respondents according to diversification index

to 15 years, indicating presence of illiterate respondents in the sample. The size of landholding is another important factor influencing diversification. The respondents in the study area owned 0.5 acres to 20 acres of farm with average acreage of 3.78 acres. The human labour used on the sample farms was 39 man-days.

As regards distance of farm from market, the respondents' farms were located at an average distance of 12.46 kilometers to market with the farthest farm distance of 62 kilometers. Irrigation dummy and access to extension services were the other two variables considered to estimate their influence on crop diversification. The variables considered for the model are expected to have significant influence on the crop diversification and were selected based on the previous literature and consultation with the experts on the subject.

The results of the fractional probit calculated using the model presented in the methodology section are presented in Table 4.10. Majority of the selected predictor variables have shown positive and significant effect on crop diversification in the study area. The test statistics showed that the model chosen for estimating the crop diversification and its determinants was found to be a good fit, as the Wald's criteria of $\chi^2(8)$ of 296.44 was found to be highly significant. The results showed that crop diversification was triggered by heterogeneity of the different farming systems adopted and socio-economic characteristics of the respondents.

The estimated coefficients for age (0.027), farm income (4.022), irrigation dummy (0.287) and access to extension services (0.445) revealed positive and significant influence on the crop diversification (Table 4.10). While, size of land holdings and the distance to market (-0.006) showed negative impact on crop diversification as revealed by the negative coefficients for these variables. Although coefficient for education level (0.017) found to be positive but fail to exert any significant influence on the crop diversification, and hence hypothesis of factors affecting crop diversification was accepted.

Table 4.10: Estimates of fractional probit model on factors affecting crop diversification

SL. No.	Variables	Parameters	Coefficients	z value	P value	Marginal effect
1	FARMAGE	X_1	0.0271	6.80	0.0002***	0.227
2	EDUC	X2	0.0172	1.77	0.0760*	0.335
3	FARMINCOM	X_3	4.0223	2.56	0.0101***	0.244
4	FARMSIZE	X_4	-0.0341	-2.49	0.0192***	-0.031
5	ACCESEXTEN	D_1	0.2868	3.67	0.0001***	0.314
6	ACCESIRRI	D_2	0.4454	5.18	0.0023***	0.566
7	DISTMARKT	X_5	-0.0061	-0.36	0.7204	-
8	HUMLBR	X_6	0.0008	1.45	0.1483	-
9	Constant	A_0	0.4613	-	-	-
10	Log pseudo-likelihood value		-80.04		-	-

Note: *, *** indicates significance at ten and one percent probability level, respectively

4.1.7 Marginal efficiency of factors affecting crop diversification

The chosen independent variables were regressed against the SI (Simpson index) of crop diversification as dependent variable. It could be inferred based on the coefficient for age of the respondents that as people grow older, with acquired experience would change their objective from profit maximization to risk minimization by diversifying the crops. With one per cent increase in the age of respondent, the practicing crop diversification would increase by about 22 per cent as revealed by the marginal effect for the variable (Table 4.10). These results are consistent with the findings reported by Rehima *et al.*(2013) while studying factors affecting crop diversification in Ethiopia. As expected, education level of the respondents had positive and significant influence on the diversification and these results are in-line with study conducted by Inoni *et al.* (2021). As income of farmer increases he tend to re/invest more on the farm by taking up more number of crops suitable to the region, which provides him not only protection against possible risks but also assure some expected income from farming. Results on influence of previous years' farm income indicated that one per cent increase in farm income would increase the diversification by 24 per cent. This result again reconfirms the influence of increased income on diversification presented earlier. But the study made by Das and Kumar (2017) revealed that diversification, up to certain level helps improve farm income but excessive diversification might lead to misallocation of resources and hence a fall in income.

Further, result also revealed that increase in average land holdings, the extent of crop diversification would decrease, *i.e.*, with the increase in land holdings farmers tend to go for more specialized crops in the study area. Farmers can practice greater degree of farm mechanization and realize benefits of economies of scale, addition farmers could able to cut down the overhead cost in the usage of services of durable assets in production. The increase in average land holdings would decrease the diversification on farm marginally by 3.1 per cent as revealed by marginal effect. These results are contradictory to the results of Sichoongwe *et al.* (2014), who reported that an increase in the size of landholding would better enable a farmer to diversify. With the extra size of landholding, the farmer can decide how many crops to grow based on his or her production decisions.

Distance to the market had negative effect on crop diversification. This implies availability of market in the nearby places would favour the crop diversification, as marketing of produce would be easy. Similar results were reported by Monika *et al.* (2017). Access to extension service, measured in terms of frequency of contacts made with extension service providers like Department of Agriculture (RSK), Input dealers, discussion with neighbors and friends were also the important factors found to influence a household's decision to diversify. Every contact with extension service provider had resulted in about 31 per-cent increment in crop diversification above average. Similar impact of access to extension services on diversification was reported by Mandal and Bezbaruah (2013).

Irrigation being one of the major factors influencing crop production, better access to irrigation favoured by recharge of borewell in KCVP area showed positive and significant influence on the crop diversification. In addition with the assured irrigation, farmers can grow more number of crops per unit area (mainly vegetables) leading to increased cropping intensity. In addition, diversification help realize higher benefits through appropriate crop rotations and maintenance of soil health, avoid damage by the soil born insects, pests and diseases . Usually in Non-KC valley area farmers go for less water requiring crops due to groundwater scarcity. This may be attributable to the fact that unlike KCVP area, in NCKVP area, farmer are not getting benefit of groundwater recharge through filling of tanks as in the case of KCVP area. Every percent increased access to irrigation water in the study area could result in increased crop diversification by 56 per cent, as revealed by the marginal effect (Table 4.10).

4.1.8 Maximum likelihood estimates for translog stochastic frontier model

Maximum likelihood estimates of parameters of the stochastic frontier production function (SFPF) are presented in the Table 4.11. The model is analysed using software R-studio and the output elasticities were estimated assuming half-normal distribution and estimated.

The estimated value of σ^2 was positive (0.00002) and found to be statistically significant at one per cent. These positive values indicated existence of technical inefficiency. The differences between the actual (estimated) and frontier (potential) output are due to inefficiency and not chance alone. Gamma (γ), the variance ratio, which explains the total variation in output from the frontier level of output attributed to technical efficiency. The value of gamma ranges between 0 and 1, with values approaching zero indicate that farmers are technically efficient, and value nearer to 1, indicating farmers are technically inefficient. It could be seen from the table that the value of gamma is 0.23, which is closer to 0, implying that farmers are technically efficient. The estimated value of γ (the ratio of the variance of output due to technical efficiency) was 0.2370 for the preferred half normal model, indicating that about 23 percent of the difference between actual and potential frontier output are mainly due to the inefficiency factors which are under the control of farmers (Table 4.11).

Table 4.11: Maximum likelihood estimates for translog stochastic frontier model

Sl. No.	Particulars	Coefficient	Z-value	SE	P-value	Marginal effect
	Dependent variable: Composite Crop Productivity (tomato yield)					
	Constant	2.0671	2.4010	0.8610	0.0160*	-
1	Ln FERT	4.0552	31.5514	0.1285	2.2e-16***	0.85
2	Ln PEST	-1.8951	-0.1270	0.1492	0.8989	-
3	Ln FYM	1.1701	2.8902	4.0500	1.2e-5***	0.16
4	Ln HL	7.2967	8.8421	0.8229	0.3765	-
5	0.5 X Ln FERT $(X_1)^2$	5.1622	38.7722	0.1331	0.0001***	0.10
6	0.5 X Ln PEST $(X_2)^2$	-1.3096	-1.4397	0.9096	0.1499	-
7	0.5 X Ln FYM $(X_3)^2$	1.6515	3.9286	0.4203	8.545e-05***	0.09
8	0.5 X Ln HL $(X_4)^2$	0.0968	-0.3821	0.2533	0.7024	-
9	Ln FERT x Ln PEST	-3.9220	-17.3251	0.2263	0.0800	-
10	Ln FERT x Ln FYM	2.1562	1.9751	1.0919	0.0482 *	0.31
11	Ln FERT x Ln HL	3.3870	-32.8101	0.1032	0.0010**	0.21
12	Ln PEST x Ln FYM	2.6761	1.4363	0.8971	0.0648	-
13	Ln PEST x Ln HL	0.5864	1.8315	0.3201	0.0670	
14	Ln FYM x Ln HL	4.1395	21.5552	0.1920	0.0311*	0.16
15	D1(KCVP=1,NKCVP=0)	3.2776	7.3069	0.4485	2.2e-16***	0.05
16	D2(Extn services=1,otherwise=0)	2.1633	4.3268	0.4999	2.733e-13***	0.03
17	D3(crop diversification index)	9.9091	25.0426	0.3957	1.508e-16***	0.12
18	(σ)2	0.0001	9.5877	0.2294	2.2e-16***	-
19	**γ**	0.2370	1.5600	0.1520	0.1187	-
20	Log-Likelihood	-1070.8				-
21	Sample size	160				

Note: Extension service dummy with value 1 for farmers sourcing information from more than 3 and 0 otherwise
***, **, * indicate significance at one, five and ten percent respectively.

The square terms (particularly FERT and FYM) and several of the interaction terms (Between FERT-FYM, PEST-FYM and PEST-HL) are significantly different from zero indicating translog production function fits well to the data than the Cobb-Douglas model, where interaction effects cannot be measured. It therefore justifies the non–linear functional form and that there existed interaction among the independent variables.

The results of maximum likelihood estimates of translog frontier function revealed that fertilizer was significantly influencing the crop productivity with an co-efficient value of 4.055. Pesticide usage was excessive in the study area with co-efficient value of -1.895 implying that higher usage of pesticide would reduce the crop productivity. Similarly, FYM and HL were positive and significantly influencing the crop productivity with coefficient values of 1.17 and 7.29 respectively (Table 4.11).

The interactive effect between fertilizer and pesticides (-3.922) was negatively influencing the crop productivity, as generally pesticides usage was extensive on sample farms in the study area, this might resulted in development of resistance of pest to applied pesticides. Thus in-spite of higher usage of pesticide farmers were unable to realize higher yields. While, the interactive effect of FYM and FERT was found to be positive and significantly (2.156) influencing the crop productivity. However, many studies have concluded an increased correlation between the organic (FYM) and inorganic fertilizers (chemical fertilizers). Thus findings of the study showed that with fixed proportions of FYM and fertilizers, could increase the yields of crops in the study area.

The interactive effects of fertilizer and human labour (3.387) and combined effect of PEST and FYM (9.671) were positive and significantly influencing the productivity of crops, as the coefficients were significant at five per cent and ten per cent probability level, respectively. In other words, negative effect of pesticides has reduced by the FYM input. The combined effect of FYM and human labour was positive and significantly influencing the crop yields in the study area. Dummy for irrigated area was found positive and significantly influencing the composite crop productivity with marginal effect of 5.3 per cent. Thus, these results revealed greater potential of increasing the crop productivity on farmers’ filed having irrigation facility through KC valley project.

Access to extension services has a vital in assisting farmers in the production decision making process, as it is reliable and up to date source of information, technical advice, training programs and improves farm management. The result showed that farmers who have availed extension services (2.167) was positive and significantly influencing the productivity of crops. In addition, farmers with access to extension services adopted a relatively diversified farming system than those who had no access.

Crop diversification had a positive and highly significant effect on the productivity of crops with coefficient value of 9.09 and significant at one per-cent probability level, as different crop combinations can provide agronomic benefits in terms of pest management and soil quality, among other things. The estimation of the model involves estimating the parameters of the frontier function and estimating inefficiency. As the model is technically efficient, we are not estimating the efficiency or inefficiency of inputs.

The computed marginal effects of the input variables and their interactions are presented in Table 4.11, Combined effect of FERT-HL (0.21%) and FYM-HL (0.16%) have the largest impact as they are regarded as the most important factors influencing the crop productivity followed by Fertilizer-FYM (0.31%) and PEST-FYM (0.028%) interactions.

With respect to Fertilizer-FYM, the marginal effect turned out to be 0.31 per-cent, in other words a unit change in Fertilizer-FYM would affect the productivity by 0.31 per cent. In addition, interaction effect of FYM-HL revealed that a unit increase in the use of fertilizer and Human labour together would increase crop productivity by 0.164 per cent. Diversification index of sample farms influencing the crop productivity and the marginal effect was 0.12 per-cent, i.e., if a farmer cultivates more number of crops in unit area, the complementarity among the crop would increase crop productivity by 0.12 per cent. Access to extension services and Irrigation dummy were also found positive and significantly influencing the crop productivity with an marginal effects being significant at three and five percent, respectively. Thus the timely and easy access to up to date technical information would help to realize the better crop productivity in presence of irrigation facility.

4.2.1. Livestock rearing

Livestock rearing is a very popular in the study region because this activity would not only supplement farm income and help better utilization of farm resources. It is interesting to note that cent percentage of the respondents had dairy as a subsidiary occupation in both the KCVP and NKCVP area. The average number of cows per household was two, which valued at Rs.109800 and Rs.102370, respectively in both the KCVP and NKCVP area along with one young stock.

The annual income earned from sale of milk for two animals was Rs.220320 and Rs.216270; and imputed income from cow-dung manure per year from two animals animal was Rs.14109 and Rs.13960 in KCVP and NKCVP, respectively. In KCVP area, 31.86 per cent and 31.34 per cent of the total cost was on rice bran followed by concentrate with 23.31 per cent and 23.40 percent, 9.22 per cent and 9.50 per cent of total cost on labour, The proportion of animal insurance accounted for 9.10 per cent and 8.79 per cent of total cost, share of expenditure on dry fodder was 6.44 per cent and 6.51 per cent, while interest on working capital, which was taken at 8 per cent per annum (opportunity cost) with 6.71 per cent and 6.27 per cent, expenditure on green fodder with 5.10 per cent and 5.38 percent. About two per cent of total cost was spent on medicines per year in KCVP and NKCVP area, respectively. The findings of the present study are found similar to the findings of Vanitha (2016) who conducted study on tomato based farming system in Eastern Dry Zone of Karnataka. The total cost incurred in rearing of two animals was Rs.152558.46 and Rs.152122.30 in KCVP and NKCVP area, respectively. The net returns realized were Rs.40935.27 and Rs.39053.85 per year / animal and the returns per rupee of expenditure was 1.53 and 1.51 in KCVP and NKCVP area, respectively (Table 4.12).

4.2.2: Economics of mulberry cultivation

Kolar is known as district of milk and silk, hence attempt was also made to investigate in detail about the economics of mulberry cultivation, as farmers invariably undertake the cultivation of mulberry if not coccon production and earn income from selling of mulberry leaves for the large number of people in the area involved in silkworm rearing. Mulberry, an important subsidiary occupation in the study area, so many of the respondents practicing it along with other crop and livestock enterprises in both KCVP and NKCVP area. It could be observed from the results presented in Table 4.14 that the total cost of mulberry cultivation during a year included the amortized establishment cost which is included as part of fixed costs and variable costs. The total cost per crop of mulberry did not varied much between the two situations and it was Rs.61534.69 in KCVP area and Rs.62841.76 in NKCVP area

Total variable cot was around 42.12 and 44.99 per cent of total cost in respective areas. The major cost components in variable costs were, labour cost (20.07 % and 21.64 %), Fertilizers (6.66 % and 8.01 %), Plant protection chemical (2.68% and 2.16%), Weeding (2.57% and 2.91%), Inter-cultivation (2.29 and 2.48%), Irrigation charges(6.43% and 6.11%) and interest on working capital which was assumed at 7 percent per annum (1.42% and 1.52%) in both KCVP and NKCVP areas, respectively.

The total fixed cost accounted for 57.88 per cent and 55.01 per cent of total cost in KCVP and NKCVP area, respectively. Amortized establishment cost was the major component in fixed cost with 25.98 and 25.68 percent in total fixed cost followed by rental value of the land which accounted for little more than twenty per cent in KCVP area and in NKCVP it was 16.63 per cent. The other items of fixed cost included managerial cost (assumed at 10% of working cost) depreciation, land revenue. On an average four crops were taken up in a year by majority of farmers in study area. The total value of mulberry leaves was Rs.103544 and Rs.102988.45 respectively in KCVP and NKCVP area. With average selling price of around Rs.420 per bag which weighs approximately 60 Kg’s farmers realized gross returns of Rs.25886 and Rs.25747.11per crop in KCVP and NKCVP area, respectively. The cost of production was almost same in KCVP (Rs.1022/bag) than NKCVP (Rs.1029/bag), due to higher rental value of land and little lower mulberry leaves yield. With respect to returns per rupee of expenditure, there was no much difference existed between KCVP and NKCVP areas with ratio of 1.68 and 1.64 respectively (Table 4.14). These results were found similar to a study made by Dyavappa (2012) on an economic analysis of mulberry cultivation, production and marketing of silk cocoons in North Karnataka, who reported returns per rupee expenditure value of 1.22.

Table 4.12: Cost and returns of dairy in KCVP and NKCVP area

SL. No.	Particulars	KCVP (n=80)	% to TC	NKCVP (n=80)	% to TC	% diff.
1	Milch animal	2	-	2	-	-
2	Average value (Rs.)	109800	-	102370	-	6.77
3	Young stock (No.)	1	-	1	-	0.00
4	Average per day milk yield	16.36	-	16.02	-	2.08
5	Average value of young stock (Rs.)	10770	-	10260	-	4.74
I.	**Input cost**					
A	Rice bran (Rs./year)	48618.18	31.86	47678.02	31.34	1.93
B	Concentrate (Rs./year)	35572.72	23.31	35595.44	23.40	-0.06
C	Medicines (Rs./year)	3105.68	2.03	3447.64	2.27	-11.01
D	Expenditure on green fodder	7780.02	5.10	8190.00	5.38	-5.27
E	Expenditure on dry fodder(TL)	9870.00	6.47	9901.00	6.51	-0.31
F	Labour (Rs./year)	14068.18	9.22	14450.01	9.50	-2.71
G	Interest on working capital (8 % pa)	9521.18	6.24	9540.97	6.27	-0.21
II.	**Variable cost**	128535.10	84.25	128803.07	84.67	-0.21
A	Amortized cost of animal	3500.00	2.29	3580.00	2.35	-2.29
B	Maintenance cost (water, electricity etc.)	5484.09	3.59	5144.11	3.38	6.20
C	Depreciation on fixed capital (10 % pa)	1148.41	0.75	1216.11	0.80	-5.90
D	Insurance	13890.00	9.10	13379.00	8.79	3.68
III.	**Total cost (Rs./year)**	152558.46	100.00	152122.30	100.00	0.29
IV.	Returns					
V.	Milk value (Rs./year)	220320.00	-	216270.00	-	1.84
VI.	Manure (Rs./year)	14109.00	-	13960.00	-	1.06
VII.	Gross returns (Rs./year)	234429.00	-	230230.00	-	1.79
VIII.	Net returns (Rs./year)	81870.54	-	78107.70	-	4.60
IX.	Net returns per cow (Rs./year)	40935.27	-	39053.85	-	4.60
X.	**Return per Re. expenditure**	**1.53**	**-**	**1.51**	**-**	1.31

4.2 Economics of major crops grown in KCVP and NKCVP area

As mentioned above, after the implementation of KCVP in the Kolar district, cropping intensity has increased. Initially, the region being the drought prone area, cultivating mainly millets, ragi, plantation crops and some of the vegetable crops, wherever they sourced water from a very deeply dugged borewells. Now the situation is very much changed, due to higher rate of success of borewell and water from failed borewells has led to some what assured groundwater availability. Due to better recharge of dried wells along with functioning wells, farmers are getting water output from borewells throughout the year. This has favoured the cultivation of more number of vegetable crops instead of plantation crops in the region. The major crops grown in the KCVP area included vegetables like tomato, potato, beans, cabbage, cauliflower, carrot and other crops like ragi, fodder maize and mulberry.

In NKCVP area, majority of farmers are cultivating tomato and potato along with ragi and mulberry crops for their livelihood. The details of costs and returns of above mentioned crops are presented in the following subsections.

4.2.1 Cost and returns of ragi cultivation in KCVP and NKCVP area

The economics of ragi cultivation was studied by working out cost on various inputs, output realized and selling price using standard cost and returns concepts. The details on per acre cost of cultivation and returns realized by the respondents in both the situations are presented in Table 4.15. It could be observed from the table that the total variable cost was found to be comparatively higher in NKCVP (Rs.21743.02) than in KCVP area (Rs.20724.15). Among the total variable cost, labour cost was the major component with 27.46 percent (KCVP) and 29.45 per cent (NCVP) of the total cost. Farm yard manure constituted for 18.40 per cent and 20.21 per cent to total cost, followed by fertilizers (2.87% and 3.14%). Similar results were reported by Bellundagi *et al.* *(*2017) while studying cost- returns and marketable surplus of ragi in Central Dry Zone of Karnataka.

Table 4.13: Establishment cost of Mulberry in KCVP and NKCVP area (Per acre)

Sl. No.	Particulars	KCVP			% to TC	NKCVP			% to TC	% difference
		Qty.	Rate (Rs.)	Value (Rs.)		Qty.	Rate (Rs.)	Value (Rs.)		
I	**Establishment cost**									
1	Cuttings(No.)	3732	3.78	14106.96	22.06	3718	3.93	14611.74	22.63	-3.58
2	FYM (TL)	3.44	3100.00	10664.00	16.67	3.04	3100.00	9424	14.60	11.63
3	Chemical fertilizer			8086.31	12.64			9215.6	14.27	-13.97
A	Nitrogen(Kg)	103.60				113.9				
B	Phosphorus	43.10				32				
C	Potassium	30.50				28				
4	Human Labour	51.32	500.00	25660.00	40.13	53.27	500	26635	41.26	-3.80
5	Machine Labour(points)	6.40	846.70	5418.88	8.47	5.5	846.7	4656.85	7.21	14.06
	Total Establishment cost			63936.15				64543.19		-0.95

Table 4.14: Cost and returns of Mulberry cultivation in KCVP and NKCVP area (Per acre)

Sl. No.	Particulars	KCVP (n=43			% to TC	NKCVP (n=32)				% diff.
		Qty.	Rate (Rs.)	Value(Rs.)		Qty.	Rate (Rs.)	Value (Rs.)	% to TC	
I.	**Variable cost**									
1	Human Labour	24.70	500.00	12350.00	20.07	27.20	500.00	13600.00	21.64	-10.12
2	Fertilizers			4099.20	6.66			5132.00	8.17	-25.20
3	Plant protection chemical			1647.33	2.68			1358.00	2.16	17.56
4	Weeding	6.32	250.00	1580.00	2.57	7.32	250.00	1830.00	2.91	-15.82
5	Inter-cultivation	2.82	500.00	1410.00	2.29	3.11	500.00	1556.00	2.48	-10.35
6	Irrigation charges	15.82	250.00	3955.00	6.43	15.36	250.00	3840.00	6.11	2.91
6	Interest on working capital (7% p.a.)			876.45	1.42			956.06	1.52	-9.08
	Total variable cost			**25917.98**	42.12			**28272.06**	44.99	-9.08
II	**Fixed cost**									
1.	Amortized establishment cost			15984.03	25.98			16135.80	25.68	-0.95
2	Depreciation			1024.00	1.66			1445.00	2.30	-41.11
3	Rental value of land (prevailing rate)			12342.00	20.06			10450.00	16.63	15.33
4	Managerial cost(10% of working capital			2591.80	4.21			2827.21	4.50	-9.08
5	Amortized drip irrigation			437.00	0.71			569.00	0.91	-30.21
6	Interest on fixed capital(10% p.a.)			3237.88	5.26			3142.70	5.00	2.94
	Total Fixed cost per crop			**35616.71**	**57.88**			**34569.70**	**55.01**	**2.94**
III.	**Total cost of cultivation (per crop)**			**61534.69**	**100.00**			**62841.76**	**100.00**	**-2.12**
A	Main yield(bag)	60.2	430	25886.00		61.07	421.6	25747.11		0.54
B	No. of crops	4				4				
IV	**Total returns**			**103544.00**				**102988.45**		0.54
V.	Returns per crop			25886.00				25747.11		0.54
VI.	cost of production			1022.17				1029.01		-0.67
VII.	**Net returns**			**42009.31**				**40146.69**		4.43
VIII.	**Returns per rupee of expenditure**			**1.68**				**1.64**		2.61

Total fixed cost was relatively higher in KCVP area (Rs.16600.60) compared to NKCVP area (Rs.14786.11) due to higher rental value of land in KCVP (Rs.12342) than NKCVP area (Rs.10450). The cost of cultivation was comparatively higher in KCVP (Rs.37324.75) than NKCVP area (Rs.36529.14). Total returns were slightly more in KCVP (Rs.48534.80) than NKCVP (Rs.46905.98), but cost of production of ragi was found higher in NKCVP area(Rs.2002.46/q) and in KCVP (Rs.1883.06/q). However, due to higher yield in KCVP area (17.2 tonnes) than NKCVP area (16.96 tonnes), farmers realized returns per rupee of expenditure in KCVP(1.30) area than in NKCVP(1.28) area (Table 4.15).

4.2.2. Cost and returns of Tomato cultivation in KCVP and NKCVP area

The total variable cost in cultivation of an acre of tomato was Rs.148011in KCVP area and Rs.147531 in NKCVP area. Among the total variable cost, labour cost was the major component in both KCVP and NKCVP accounting for 14.55per cent and 13.92 per cent of the total cost of cultivation.

Tomato is being considered as a labour intensive crop, because various specific operations like staking, harvesting through pickings have to be carried out at regular intervals; threading is done atleast 3 times based on growth of the crop, which all demand higher amount of labour

It is also known fact that tomato is very delicate, succulent and susceptive crop to pest and diseases, hence there is need to take care of the plant regularly, Therefore, the cost on plant protection chemicals was one another major constituent of total variable cost in both KCVP and NKCVP area accounting for 11.24 per cent and 13.48 percent of total cost. To protect the crop and have good crop stand and yield, farmers go for regular spraying of pesticides and insecticides, twice or thrice a week irrespective of the incidence of pest or disease. This would lead to higher cost on PPC chemicals and adds to cost of cultivation. Mulching is another important practice farmers follow for tomato crop to maintain optimum moisture in the soil by preventing water evaporation. In process of marketing, even only buyer has to pay the commission, but commission is also collected from the farmers and hence, marketing cost was higher which accounted for Rs.20275 and Rs.21335 in KCVP and NKCVP area, respectively (Table 4.16). The results are found similar to the study made by Vanitha (2016), where in she reported about eight per cent of the cost of cultivation was incurred towards the commission charges.

It could be also observed from Table 4.16 that, the total fixed cost was Rs.31860 and Rs.29939 respectively in KCVP and NKCVP area, which accounted for about 17 per cent of the total cost of cultivation. Farmers in KCVP area realized higher (Rs.226636) returns compared to NKCVP (Rs.199766). This was due to higher yields in KCVP (138.70 q/ac) compared to NKCVP area (121.07 q/ac) and hence cost of production was lower in KCVP area(Rs.1297) than in NKCVP area (Rs.1606) . As a result, net returns and returns per rupee of expenditure were higher in KCVP (Rs.46765and 1.26) than in NKCVP area (Rs.22295 and 1.13).

4.2.3 Cost and returns of potato production in KCVP and NKCVP area (per acre)

The proportion of area allocated for potato cultivation was more in NKCVP than in KCVP. The cost of cultivation incurred for one acre was Rs.140109 in KCVP and Rs.116727 in NKCVP area. Among the different items of cost, the percentage share of seed cost to total cost was high and it was 16.08 per cent in KCVP and 19.52 per cent in NKCVP area (Table 4.17).

Potato like many of the vegetable crops demands higher labour and cost on human labour accounted for 15.16 per cent and 17.19 percent of the total cost in KCVP and NKCVP area, respectively. The expenditure on plant protection chemicals was the next important item of cost with 13.27 per cent and 16.20 per cent share in total cost of cultivation, due to high incidence of pest and diseases in the study area. The cost on plant nutrients through chemical fertilizer (10.03% and 12.26%) and Farm yard manure (5.64 % and 6.40%) together accounted for about twenty per cent of the total cost of cultivation in both KCVP and NKCVP areas. These results are found to be similar to the study made by Singh *et al.* (2019) on economic management and analysis of Potato cultivation. The total fixed cost was accounted 33.09 per cent and 20.24 per cent of the total cost in KCVP and NKCVP area, respectively.

Table 4.15: Cost of cultivation of Ragi in KCVP and NKCVP area (per acre)

Sl. No.	Particulars		KCVP (n=48			% to TC	NKCVP (N=37)			% to TC	% diff.
Sl. No.			Qty.	Rate (Rs.)	Value (Rs.)		Qty.	Rate (Rs.)	Value (Rs.)		
I	**Variable cost**										
1	Seeds(Kg.)		6.13	47.00	288.00	0.77	6.37	47.00	299.39	0.82	-3.95
2	FYM (TL)		2.41	2850.00	6868.50	18.40	2.59	2850.00	7381.50	20.21	-7.47
3	Chemical fertilizer				1149.25	3.08			1238.46	3.39	-7.76
A	Nitrogen(Kg)		39.07	-	-	-	43.5	-	-	-	-
B	Phosphorus		24.22	-	-	-	29.89	-	-	-	-
C	Potassium		23.12	-	-	-	18.2	-	-	-	-
4	Labour	Man-days	25	410.00	10250.00	27.46	26.24	410.00	10758.40	29.45	-4.96
		Machine hours	1.23	846.00	1040.58	2.79	1	850.00	850.00	2.33	18.31
5	Transportation of resources				427.00	1.14			480.00	1.31	-12.41
6	Interest on working capital for 6 months (7% p.a.)				700.81	1.88			735.27	2.01	-4.92
	Total variable cost				20724.15	55.52			21743.02	59.52	-4.92
II	**Fixed cost**					0.00				0.00	
1	Depreciation				1384.00	3.71			1445.00	3.96	-4.41
2	Rental value of land (prevailing rate)				12342.00	33.07			10450.00	28.61	15.33

Sl. No.	Particulars	KCVP (n=48			% to TC	NKCVP (N=37)			% to TC	% diff.
		Qty.	Rate (Rs.)	Value (Rs.)		Qty.	Rate (Rs.)	Value (Rs.)		
3	Managerial cost(10% of working capital			2072.41	5.55			2174.30	5.95	-4.92
4	Interest on fixed capital(10% p.a.)			802.19	2.15			716.81	1.96	10.64
	Total Fixed cost			16600.60	44.48			14786.11	40.48	10.93
III	**Total cost**			37324.75	100.00			36529.14	100.00	2.13
A	Main yield(q)	17.2	2355	40506.00		16.96	2339	39669.44		1.97
B	Straw (t)	2.6	3088	8028.80		2.43	2978	7236.54		9.87
IV.	Total returns(A+B)			48534.80				46905.98		3.15
V.	Marketing cost			2385.00	5.96			2580.00	6.54	-8.18
VI.	Equivalent main yield (q)	19.82				18.24				2.57
VII.	Net returns (Rs.)			11210.04				10376.84		8.31
VIII.	Returns per rupee of expenditure			1.30				1.28		1.79
IX.	Cost of Production (Rs./q)			1883.06				2002.46		-1.20

Table 4.16: Cost of cultivation of tomato in KCVP and NKCVP area (per acre)

Sl. No.	Particulars		KCVP(n=43)			% to TC	NKCVP(n=27)			% to TC	% diff.
			Qty.	Rate (Rs.)	Value (Rs.)		Qty.	Rate (Rs.)	Value (Rs.)		
	Variable cost										
1	Seedlings(No.)		7245	1.63	11809	6.57	8742	1.50	13113	7.39	-0.11
2	FYM (TL)		5.51	2927.00	16128	8.97	4.14	2965.00	12275	6.91	0.24
3	Chemical fertilizer				9739	5.41			11089	6.24	-0.14
A	Nitrogen(Kg)		111.6				109.52				
B	Phosphorus		63.76				69.78				
C	Potassium		59.09				66.32				
4	Other micro-nutrients(Kg)		28		9709	5.40	23.9		8176	4.60	0.16
5	Cost of sticks for staking		1589	3.89	6181	3.44	1930	3.72	7180	4.04	-0.16
6	Wire(Kg)		30	70.00	2100	1.17	32.15	70.00	2251	1.26	-0.07
7	Thread(Kg)		69	62.65	4322	2.40	73	59.20	4322	2.43	0.00
8	Plastic mulch(Kg)		89	198.99	17710	9.85	88	200.00	17600	9.91	0.01
9	Weedicide				3979	2.21			4099	2.31	-0.03
10	Plant protection chemical				20210	11.24			23937	13.48	-0.18
11	Labour	Man-days	52.34	500.00	26172	14.55	67.23	500.00	24717	13.92	0.06
		Machine hours	3.12	890.00	2776	1.54	1.5	850.00	1275	0.71	0.54
12	Transportation of resources				8590	4.78			8957	5.04	-0.04
13	Irrigation cost		14.32	250.00	3580	1.99	14.21	250.00	3553	2.00	0.01
14	Interest on working capital (7% p.a.)				5005	2.78			4989	2.81	0.00

I	**Total variable cost**			148011	82.29			147531	83.13	0.00
	Fixed cost				0.00					
1	Depreciation			1384	0.77			1445	0.81	-0.04
2	Rental value of land (prevailing rate)			12342	6.86			10450	5.88	0.15
3	Managerial cost(10% of working capital)			14801	8.23			14753	8.31	0.00
4	Amortized cost of drip irrigation			437	0.24			569	0.32	-0.30
5	Interest on fixed capital (10% p.a.)			2896	1.61			2722	1.53	0.06
II	**Total Fixed cost**			31860	17.71			29939	16.86	0.06
III	**Total cost**			179871	100.00			177470	100	0.01
IV	Marketing cost			20275				21335		-0.05
V	Main yield(Qtl.)	138.7	16.34	226636		121.07	16.50	199766		0.12
VI	Total returns			226636				199766		0.12
V	Cost of production			1297				1606		-0.24
VI	Net returns			46765				22295		0.52
VII	Returns per rupee of expenditure			1.26				1.13		0.11

Table 4.17: Cost of cultivation of potato in KCVP and NKCVP area(per acre)

Sl. No.	Particulars		KCVP			% to TC	NKCVP			% to TC	%difference
			Qty.	Rate (Rs.)	Value (Rs.)		Qty.	Rate (Rs.)	Value (Rs.)		
	Variable cost										
1	Seeds(qtl.)		10.21	2206	22528	16.08	10.28	2217	22791	19.52	-1.17
2	FYM (TL)		2.77	2850	7903	5.64	2.61	2863	7472	6.40	5.45
3	Chemical fertilizer				14054	10.03			14313	12.26	-1.84
A	Nitrogen(Kg)		51.00				56.00			0.00	
B	Phosphorus		20.00				21.00			0.00	
C	Potassium		17.00				32.00			0.00	
4	Other micro-nutrients		18.00		600	0.43	21.32		860	0.74	-43.33
5	Plant protection chemical				18590	13.27			18912	16.20	-1.73
6	Labour	Man-days	42.47	500	21239	15.16	40.14	500	20071	17.19	5.50
		Machine hours	1.34	890	1193	0.85	1.21	878	1062	0.91	10.92
7	Irrigation cost		17.90	250	4475	3.19	17.90	250	4475	3.83	0.00
8	Interest on working capital(7% p.a.)				3170	2.26			3148	2.70	0.69
I.	**Total variable cost**				93752	66.91			93105	79.76	0.69
	Fixed cost										
1	Depreciation				1024	0.73			1145	0.98	-11.82

2	Rental value of land (prevailing rate)			12342	8.81			10450	8.95	15.33
4	Managerial cost(10% of working capital			9375	6.69			9310	7.98	0.69
5	Amortized cost for drip irrigation			437	0.31			569	0.49	-30.21
6	Interest on fixed capital(10% p.a.)			23178	16.54			2147	1.84	90.74
II.	**Total Fixed cost**			**46356**	**33.09**			**23622**	**20.24**	**49.04**
III	**Total cost**			**140109**	**100.00**			**116727**	**100.00**	**16.69**
A	Yield(Qtl.)	98.00	1455.60	142649		100.43	1192.10	119723		16.07
IV	Total returns			142649				119723		16.07
	Total cost of cultivation			140109				116727		16.69
V	Cost of production			1430				1162		18.70
VI	Net returns			2540				2996		-17.94
VII	Returns per rupee of expenditure			1.02				1.03		-0.74

It could be also observed from Table 4.17 that farmers realized marginally higher net returns in NKCVP (Rs.2996) area than KCVP area (Rs.2540) and also the cost of production was also higher in KCVP area (Rs.1430) than NKCVP (Rs.1162) which rejects the hypotheses of lower cost of production in KCVP area than NKCVP. Return per rupee of expenditure was found higher in NKCVP area (1.03) than in KCVP area (1.02) (Table 4.18).

4.2.4 Cost and return analysis of Cabbage in KCVP area (per acre)

The cost and returns structure for cabbage crop in KCVP area is depicted in the Table 4.18. The total cost of cultivation was found to be Rs.105918 per acre of which variable cost (Rs.81743) accounted most with 77.18 percent of total cost and fixed cost (Rs.24175) was accounted for 22.82 per cent of total cost. Total returns per acre of cabbage cultivation were Rs.116410 with returns per rupee of expenditure of 1.10. This indicated for every one rupee of investment on cabbage production, farmers in the study area were getting returns of 1.10 rupees. The cost of production was found Rs.6842 per tonne of cabbage production and the selling price was Rs.7520 per tonne.

Among the different items of variable cost, cost on plant protection chemicals was the highest with 21.79 percent of total cost, as cabbage is more prone to pest attack. The expenditure on human labour (17.33%) was the next important item of cost as it demand more labour for spraying, weeding and harvesting. These results are found similar to the study made by Raghupathi and Kumar, (2018) who analysed economics of cabbage production in Kolar district of Karnataka, who also reported expenditure on PPC and labour were the major items of cost. Cost on chemical fertilizers (12.54%), Seedling (9.97 %) and FYM (8.36 %) were the other items of variable cost. Among the fixed costs, rental value of land was high (11.65%) because of improved irrigation facility throughout the year in KCVP, there is greater demand for demand and land rent is increasing in the study area. Farmers realised total yield 15.48 tonnes and net returns of Rs.10491 from an acre of cabbage cultivation (Table 4.18).

Table 4.18: Cost of cultivation of cabbage in KCVP area (per acre)

Sl. No.	Particulars		Cabbage			% to TC
			Qty.	Per unit cost(Rs.)	value(Rs.)	
1	Seedlings(No.)		21120.00	0.50	10560	9.97
2	FYM (TL)		3.00	2950.00	8850	8.36
3	Chemical fertilizer				13279	12.54
A	Nitrogen(Kg)		61.00	-	-	-
B	Phosphorus		48.00	-	-	-
C	Potassium		55.23	-	-	-
4	Other micro-nutrients		13.00	-	480	0.45
5	Plant protection chemical		-	-	23081	21.79
6	Labour	Man-days	36.00	500.00	18353	17.33
		Machine hours	1.00	1066.00	1066	1.01
7	Irrigation cost		13.24	250.00	3310	3.13
7	Interest on working capital per crop (7% p.a.)		-	-	2764	2.61
I	**Total variable cost**				**81743**	**77.18**
	Fixed cost					0.00
1	Depreciation		-	-	1024	0.97
2	Rental value of land (prevailing rate)		-	-	12342	11.65
3	Managerial cost(10% of working capital)		-	-	8174	7.72
4	Amortized cost for drip irrigation		-	-	437	0.41
5	Interest on fixed capital(10% p.a.)		-	-	2198	2.07
II.	**Total Fixed cost**				**24175**	**22.82**
III	**Total cost**				**105918**	**100.00**
	Yield(tonnes)		15.48	7520	116410	109.91
IV	**Total returns**				**116410**	**109.91**
V	Cost of Production				6842	
VI	Net returns				10491	
VII	Returns per rupee of expenditure				1.10	

4.2.5 Cost and returns analysis of Coriander in KCVP area (per acre)

The total cost of cultivation of coriander is presented in the table 4.19. The total cost of cultivation of coriander in KCVP area was Rs.46653 and gross returns from per acre of coriander cultivation is Rs.64887. Net returns were found Rs.18235per acre in KCVP area.

Among the total cost of cultivation of coriander, variable cost was high (60.77percent of total cost) compared to fixed cost (39.23 percent of total cost). As timely irrigation, weeding, intercultural operations are needed for the crop so the labour cost was the major component in variable cost of coriander with 33.57 percent of total cost(Rs.46653) followed by Seed cost was 9.28 percent(Rs.4330) of total cost, cost on fym with 4.52 percent of total cost(2109.7), as crop requires very less amount of fertilizers, cost on chemical fertilizers was less(3.90 percent of total cost) compared to other input variables. And even usage of plant protection chemicals was also very less (Rs.1180, which is 2.53 percent of total cost) compared to other vegetable crops in the region. And marketing cost, as coriander being highly perishable cost of marketing was higher (Rs.5893).

Table 4.19: Cost of cultivation of coriander in KCVP area(per acre)

Sl. No.	Particulars	Coriander			% to TC
		Qty.	Per unit cost (Rs.)	Value (Rs.)	
	Variable cost				
1	Seeds(Kg.)	17.32	250	4330	9.28
2	FYM (TL)	0.73	2890	2110	4.52
3	Chemical fertilizer			1820	3.90
A	Nitrogen(Kg)	23.00			
B	Phosphorus	18.00			
C	Potassium				
4	Other micro-nutrients	5.00		180	0.39
5	Plant protection chemical			1180	2.53
6	Labour(Man-days)	31.32	500	15660	33.57
7	Irrigation cost	8.45	250	2113	4.53
7	Interest on working capital (7% p.a.)			959	2.06
I.	**Total variable cost**			**28351**	60.77
	Fixed cost				0.00
1	Depreciation			1024	2.19
2	Rental value of land (prevailing rate)			12342	26.45
4	Managerial cost(10% of working capital			2835	6.08
5	Amortized cost for drip irrigation			437	0.94
6	Interest on fixed capital(10% p.a.)			1664	3.57
II.	**Total Fixed cost**			**18302**	39.23
III.	**Total cost**			**46653**	100.00
A	Yield(cuts)	10267.00	6.32	64887	
IV.	**Total returns**			**64887**	
V.	Marketing cost			5893	
V	**Cost of Production(Rs./cut)**			**5**	
VI.	**Net returns**			**18235**	
VII	**Returns per rupee of expenditure**			**1.39**	

Among the fixed cost, rental value of land was the major component with 26.45 percent (Rs.12342) of total cost of cultivation, followed by managerial cost (6.08%), depreciation (2.19%), interest on fixed capital calculated 10 percent per annum (3.57%) and Amortized cost for drip irrigation (0.94 % of total cost) (Table 4.20). These results were found similar to the study made by Meena *et al.* (2020) on economic analysis of coriander.

4.2.6 Cost and returns of carrot production in KCVP area (Per acre)

The details on quantity of inputs used with their values per acre in carrot cultivation by the respondents in study area are presented in Table 4.20. It could be observed from the table that the total cost of cultivation of carrot per acre was Rs.46746, in which the proportion variable cost was more(60.83%) compared to fixed cost (39.17%).The major item in the variable cost was labour (Rs.8945) with 19.14 percent of total cost followed by farmyard manure (Rs.6555 and14.02%). As carrot is more susceptible to root not nematodes, collar rot farmers in the study area applied more quantity of farm yard manure.

Further, due to this fact, farmers used higher dosage and increased number of sprays of pesticides and nematicides to control the pest and disease attack and incurred a cost of Rs.4318 which account for nine percent of the total cost of cultivation. Farmers spent about Rs.3600 towards marketing of their produce. Cost of chemical fertilizers (Rs.2355) was about five per cent and seed cost about two percent of total cost(Table 4.20) .

The major component of fixed cost in per acre cultivation of carrot was rental value of land (Rs.12342 and26.40 %) followed by managerial cost (Rs.2844and6.04%), depreciation (Rs.1032 and 2.19%), interest on fixed capital (@10%, Rs.1665and 3.56%) and amortized cost on drip irrigation infrastructure (Rs.437 and 0.93%). These results are contradictory to the results of Kumar(2019), who reported seed cost accounted for the highest proportion followed by marketing cost, cost on FYM, labour cost, cost on chemical fertilizers in total variable cost of carrot production in Kolar district of Karnataka. The cost of production per quintal of carrot was Rs.686 and returns per rupee of expenditure was 1.19 (Table 4.20).

Table 4.20: Cost and returns of carrot production in KCVP area (per acre)

Sl. No.	Particulars		Carrot			% to TC
			Qty.	Rate(Rs.)	Cost (Rs.)	
1	Seeds(Kg.)		1.02	1126.00	1149	2.46
2	FYM (TL)		2.30	2850.00	6555	14.02
3	Chemical Fertilizer				2355	5.04
A	Nitrogen(Kg)		32.00			0.00
B	Phosphorus		27.32			0.00
C	Potassium		14.78			0.00
4	Other micro-nutrients		23.17		625	1.34
5	Plant protection chemical				4318	9.24
6	Labour	Man-days	17.89	500.00	8945	19.14
		Machine hours	1.25	890.00	1113	2.38
7	Transportation of resources				632	1.35
8	Irrigation charges		7.13	250.00	1783	3.81
9	Interest on working capital (7% p.a.)				962	2.06
I	**Total variable cost**				28435	60.83
	Fixed cost					0
1	Depreciation				1024	2.19
2	Rental value of land (prevailing rate)				12342	26.40
3	Managerial cost(10% of working capital)				2844	6.08
4	Amortized cost for drip irrigation				437	0.93
5	Interest on fixed capital(10% p.a.)				1665	3.56
II.	**Total Fixed cost**				**18311**	**39.17**
III.	**Total cost**				**46746**	**100.00**
	Yield(Qtl.)		73.34	759.70	55716	
IV.	**Total returns**				**55716**	
V.	**Marketing cost**				**3590**	
VI.	**Cost of production(Rs./Qtl.)**				**686**	
VII.	**Net returns**				**8970**	
VIII.	**Returns per rupee of expenditure**				**1.19**	

4.2.7 Cost and returns of beans in KCVP area (Per acre)

The total area under beans cultivation in KCVP area was 17 acres. The average cost of cultivation per acre of beans was Rs.119312.14, of which total variable cost was Rs.94858.82 (79.50 percent of total cost) and fixed cost was found to be Rs.24453.33 (20.50 percent of total cost).Farmers incurred a total cost of Rs.122803 per acre of beans cultivation. In the total cost almost eighty per cent was variable cost (Rs.96955) and remaining was fixed cost (Rs.25848).

In the total variable cost, expenses on labour (Rs.30350 and 24.71%) was the major component as more laborers required to perform various operations like staking, weeding and harvesting operations,) followed by cost on chemical fertilizers (Rs.12712and 10.35%), PPC (Rs.11673 and 9.51%) to protect crop from high incidence of pest and disease in the region , cost on plastic mulch (Rs.8184 and 6.66%) for moisture conservation, FYM (Rs.7980 and 6.50%), staking materials (Rs.7192 and 5.86%), cost on thread (Rs.6230 and 5.07%), wire (Rs.3780 and 3.08%), interest on working capital (Rs.3279 and 2.67%) and lastly cost of seeds (Rs.1811) accounted for about 1.47 percent of total cost in the KCVP area (Table 4.21).

Like in the case of other crops, rental value of land was the major component in fixed cost ((Rs.12342 and 10.05%) followed by managerial cost (Rs.9485.88 and 7.90%), interest on fixed capital calculated at 10 per cent per annum and depreciation of farm assets. Farmers realized total returns Rs.176076 from an acre of beans cultivation by spending Rs.122803 in production of a tonne of beans. The returns per rupee of expenditure was found to be reasonably high (1.43) (Table 4.21) indicating profitableness of beans cultivation. Similar results were found by Vanitha (2016) while studying tomato based farming system in Kolar district of Karnataka.

4.2.8 Existing farming systems in the study area

The various components of different farming systems practiced by the sample farmers in the study area included vegetables, crops, Mulberry and dairy activities, whose economic analysis was presented in the previous section. These values are plugged into the economic analysis of different farming systems followed in the study area. Among the different farming systems, four major farming systems each in both KCVP and NKCVP area were identified.

Table 4.21: Cost and returns of beans cultivation in KCVP area (per acre)

Sl. No.	Particulars		Beans			% to TC
			Qty.	Per unit cost (Rs.)	Value (Rs.)	
	Variable cost					
1	Seeds(Kg.)		2.45	739.00	1811	1.47
2	FYM (TL)		2.80	2850.00	7980	6.50
3	Chemical fertilizer				12712	10.35
A	Nitrogen(Kg)		108.00			0.00
B	Phosphorus		92.00			0.00
C	Potassium		88.00			0.00
4	Other micro-nutrients(Kg)		25.00		890	0.72
5	Plant protection chemical				11673	9.51
6	Cost of sticks for staking (No.)		1789.00	4.02	7192	5.86
7	Wire(Kg)		42.00	90.00	3780	3.08
8	Thread(Kg)		89.00	70.00	6230	5.07
9	Plastic mulch(kg)		62.00	132.00	8184	6.66
10	Labour	Man-days	60.70	500.00	30350	24.71
		Machine hours	1.00	850.00	850	0.69
11	Irrigation cost		8.10	250.00	2025	1.65
12	Interest on working capital (7% p.a.)				3279	2.67
I.	**Total variable cost**				**96955**	**78.95**
	Fixed cost					0.00
1	Depreciation				1024	0.83
2	Rental value of land (prevailing rate)				12342	10.05
3	Managerial cost(10% of working capital)				9695	7.90
4	Amortized cost for drip irrigation				437	0.36
5	Interest on fixed capital (10% p.a.)				2350	1.91
II.	**Total Fixed cost**				**25848**	**21.05**
III	**Total cost**				**122803**	**100.00**
A	Yield(tons)		7.3	24.12	176076	
IV.	**Total returns**				**176076**	
V.	**Net returns**				**53273**	
VI.	**Returns per rupee of expenditure**				**1.43**	

It is interesting to note that dairy was one of the components in majority of the farming systems along with vegetable component in the study area. Mulberry is another component of farming systems as most of the farmers in both KCVP and NKCVP area were cultivating the same. In KCVP area, more than thirty per cent of the farmers were practicing farming system with vegetables-crops-mulberry-dairy components. The proportion of farmers practicing farming system with vegetables-mulberry-dairy components was 22.50 per cent. The next important third farming system noticed in the area included components of vegetables-crop-dairy components (28.75%) and lastly Vegetables-dairy was the fourth farming system practiced by 18.75 percent of farmers in study area.

Similarly, in NKCVP area major farming systems followed included; Vegetable-livestock component, which was practiced by majority of respondents (40%) followed by vegetable-crop-mulberry-dairy component (26.25%), vegetable-crop-dairy components (20.00%) and vegetables-mulberry-dairy component (13.75%) (Table 4.22). The major vegetables grown by the respondents included Tomato, Potato, beans, carrot, coriander in KCVP area, while tomato and potato were the major vegetables grown in NKCVP area.

Table 4.22: Distribution of respondents according to the Existing major farming systems followed in KCVP and NKCVP

Sl. No.	Farming system	KCVP		NKCVP	
		No. of respondents	% to total	No. of respondents	% to total
1	V+C+M+L	25	31.25	21	26.25
2	V+M+L	18	22.50	11	13.75
3	V+C+L	23	28.75	16	20.00
4	V+L	15	18.75	32	40.00
	Total	80	100.00	80	100.00

Note: V= Vegetables, C=Crops other than vegetables (Ragi, fodder maize, pulse crops), M= Mulberry and L=Livestock (Dairy)

4.2.9 Sources of farm income on sample farmers

The sources of income of the respondents in KCVP and NKCVP area on per farm and per acre basis are presented in Table 4.23. It could be observed from the table 4.23 that farmers in NKCVP (4.06 ac) owned about 10 per cent of higher farm size than their counterparts in KCVP area (3.64 ac). Hence analysis was carried out on both per farm and per acre basis. Farmers in NKCVP (Rs.515011) realized about 23 per cent higher income than farmers in KCVP area (Rs.397541) area. This was attributable to larger proportion of area under mango cultivation, which is more remunerative than other crop enterprises and had accounted for 35 per cent of the income in NKCVP area.

The component wise analysis revealed that among the different sources, the income from vegetables was major component in KCVP area Rs.164584 (41.40%), and income from mango cultivation was more in NKCVP area(Rs.180228 and 35%). Income from Livestock (Rs.117215 and 29.49%) was the second most important source followed by income other crops (Rs.60737 and 15.28%), Mulberry (Rs.36863 and 9.27%) and income from mango (Rs.18144 and 4.56%) in KCVP area.

While in the case of NKCVP area, after mango income from vegetables (Rs.121834 and 23.66%) was next highest source of income followed by livestock (Rs.115115 and 22.35%), income from other crops Rs.79656 (15.47%) and income received from mulberry was the least Rs.18177(3.53%).

Due to difference in the farm size, the comparison was made on per acre basis between the KCVP and NKCVP areas. AS mentioned earlier, due to better access to irrigation, the per acre income differences between KCVP and NKCVP area was 126 per cent for mulberry, 50.68 per cent for vegetables and about 14 per cent from dairying in favour of KCVP farmers. So that it is evident that growing vegetables in KCVP area is more profitable (50%) compared to NKCVP, hence the hypotheses of growing vegetables in KCVP area was accepted. While due to higher proportion of area under mango, owning these orchards from many years and cultivation other field crops, in which farmers in this regions are very well verse could able to realize higher returns to the extent of 88.77 per cent and 13.90 per cent, respectively than farmers of KCVP area.

4.2.10 Component wise per farm profitability of the farming systems in KCVP area

The findings on component wise per farm profitability for major farming systems practiced by the farmers in KCVP area are presented in Table 4.24.

Farming System-I

The average area under crops in farming system-I of KCVP area was 4.12 acres of which vegetables crops covered 1.65 acres and rearing two milch animals per farm . The per farm gross returns from the vegetables was the highest (Rs.306590) which accounted for 38.76 per cent of the total returns, followed by dairy (Rs.234429 and 29.64%), mulberry (Rs.58319 and 20.02%) and crop component (Rs.45798 and 5.79%), As against this farmers have spent total cost of Rs.246715, Rs.152558, Rs.94087 and, Rs.36173 towards vegetables dairy, mulberry and crops, respectively.

Thus farmers could realized the net returns over total cost of Rs.59875, Rs.81871 Rs.64232 and Rs.9626 respectively from vegetables, dairy, mulberry and crops with returns per rupee of expenditures 1.24, 1.54, 1.68 and 1.27.

Among the different components of the farming system-I, on the basis of returns per rupee of investment, mulberry cultivation (assuming four crops per year) found to be the most profitable enterprise (1.68) followed by rearing of two milch animals (1.54), cultivating on 0.94 acres of cereals (1.27) and surprisingly vegetable component (consisting of various crops) found to be the least profitable with returns of Rs.1.24 per rupee of expenses. Thus, farmers are under the assumption of vegetable cultivation was highly profitable, as they get voluminous sale receipts from vegetables being harvested almost at once by ignoring lakhs of expenses in their cultivation and simply compare them with returns from other cereal crops.

Farming system-II

The average area under the vegetable crops was 2.232acres and the number of dairy animals was 1.94, which is approximated to two animals and the area under mulberry cultivation was 1.35 acres. The total cost of cultivation of the vegetable crops was Rs.**306357** and the total cost of maintaining of two dairy animals was Rs.152558 and the total cost of cultivation of mulberry was Rs.83072. The gross returns were Rs.372183, Rs.234429 and Rs.139784 from vegetable crops, dairy and mulberry cultivation respectively (Table 4.24). The net returns from the vegetable crops were Rs.65826, from dairy it was Rs.81871 and from mulberry cultivation it was Rs.56713with returns per rupee of expenditure was found 1.21, 1.54 and 1.68 for vegetable crops, dairy and mulberry respectively (Table 4.24).

Among different components of Farming system-II, on the basis of returns per rupee of expenditure, mulberry was crop was found more profitable with RRE of 1.68 compared to rearing of two dairy animals (1.54) and cultivating vegetable crops (1.21) which require relatively more investment on the farm.

Farming system-III

The highest area in farming system-III of KCVP area was occupied by the vegetable crops (2.52 acres) followed by other crops which includes mango(1.445 acres) and number of the dairy animal in the farming system was 1.82 approximated to 2 animals(Table 4.24). The total cost of cultivation for major vegetable crops (Rs.330732) followed by dairy (Rs.152558) and other crops (Rs.88495) and whereas, the net returns were highest for vegetables (Rs.82049) followed by dairy (Rs.81871) and other crops realized the net returns of Rs.32330. The returns per rupee spent for vegetables was 1.25, from other crops (1.36) and for dairy (1.54). And it was concluded that, in farming system III, dairy was most profitable followed by crops and vegetable crops on the basis of returns per rupee of expenditure.

Farming system-IV

In KCVP area, farming system includes only vegetable crops and dairy as its components. The crops occupied maximum area of 2.76 acres and the number of milch animals was two. The total cost of cultivation of vegetable crops was Rs.348145 and per farm cost of two dairy animals was Rs.152558. The net returns were highest from vegetable crops (Rs.84160) and from dairy it was found Rs.102740. The returns per rupee spent was highest for dairy (1.54) followed by vegetable crops (1.23) (Table 4.24).

Table 4.23: Sources of farm income on sample farmers

Sl. No.	Income source	KCVP Income (Rs.)			NKCVP Income (Rs.)			% difference	
		Per farm	Per acre	%	Per farm	Per acre	%	Per farm	Per acre
1	Vegetable Crop	164584	45215.38	41.40	121834	30008.37	23.66	35.09	50.68
2	Livestock(dairy)	117215	32201.92	29.49	115115	28353.45	22.35	1.82	13.57
3	Mulberry	36862	10126.92	9.27	18177	4477.09	3.53	102.79	126.19
4	Other crops	60737	16685.99	15.28	79656	19619.70	15.47	-23.75	-14.95
5	Mango	18144	4984.62	4.56	180228	44391.13	34.99	-89.93	-88.77
6	Total per farm	397541	109214.56	100.00	515011	126850.00	100.00	-22.81	-13.90
7	Farm size (acres)	3.64			4.06			-10.34	

Table 4.24: Component wise per farm profitability of the farming systems in KCVP area

Sl. No.	Components	Area	Total cost	Total returns	Net returns	RRE
FS-I(V+C+M+L)(n=17)						
1	Vegetable crops					
A	Tomato	1.06	190663	240234	49571	1.26
B	Potato	0.06	8266	8416	150	1.02
C	Carrot	0.18	8403	9806	1403	1.17
D	Beans	0.12	14491	20777	6286	1.43
E	Cabbage	0.24	24891	27356	2465	1.10
	Sub-total	**1.65**	**246715 (46.59)**	**306590 (41.14)**	59875	1.24
2	Other crops					
A	Ragi	0.71	26538	34508	7970	1.30
B	Fodder maize	0.23	9635	11290	1655	1.17
	Sub-total	0.94	36173 (6.39)	45798 (5.79)	9626 (4.46)	
3	Mulberry	1.53	94087 (17.77)	158319 (21.25)	64232 (29.79)	1.68
4	Livestock(dairy 2)		152558 (28.80)	234429 (31.46)	81871 (37.97)	1.54
	Total	**4.12**	**529532**	**745136**	**215603**	1.41
FS-II(V+M+L)(n=15)						
1	Vegetable crops					
A	Tomato	0.83	149833	188788	38955	1.26
B	Carrot	0.30	14024	16715	2691	1.19
C	Cabbage	0.73	77638	85328	7690	1.10
D	Potato	0.20	28022	28530	508	1.02
E	Beans	0.17	36841	52823	15982	1.43
	Sub-total	**2.23**	**306357 (56.52)**	**372183 (49.86)**	65826 (32.20)	1.21
2	Mulberry	1.35	83072 (15.33)	139784 (18.73)	56713 (27.74)	1.68
3	Livestock(dairy)		152558 (28.15)	234429 (31.41)	81871 (40.05)	1.54

Sl. No.	Components	Area	Total cost	Total returns	Net returns	RRE
	Total	**3.58**	**541988**	**746397**	**204409**	**1.38**
			FS-III(V+C+L)(n=20)			
1	Vegetable crops					
A	Tomato	1.15	206852	260631	53779	1.26
B	Carrot	0.22	10284	12258	1973	1.19
C	Cabbage	0.3	31775	34923	3147	1.10
D	Coriander	0.32	14155	20764	6609	1.47
E	Potato	0.22	30824	31383	559	1.02
F	Beans	0.3	36841	52823	15982	1.43
	Sub-total	**2.52**	**330732 (57.84)**	**412781 (53.74)**	82049 (41.80)	1.25
2	Other crops					
A	Ragi	1.05	39191	50962	11771	1.30
B	Mango	0.4	49304	69863	20559	1.42
	Sub-total	**1.45**	**88495 (15.47)**	**120825 (15.73)**	**32330 (16.47)**	**1.36**
3	Livestock		152558.46 (26.68)	23442 9(30.52)	81871 (41.71)	1.54
	Total	**3.97**	**571784.72**	**768034.3**	**196250**	**1.34**
			FS-IV(V+L)(n=15)			
1	Vegetable					
A	Tomato	1.03	185807	234115	48308	1.26
B	Carrot	0.41	19320	23028	3707	1.19
C	Cabbage	0.25	26797	29452	2654	1.10
D	Coriander	0.27	11767	17260	5493	1.47
E	Potato	0.37	51280	52209	930	1.02
F	Beans	0.43	53174	76241	23067	1.43
	Sub-total	**2.76**	**348145 (69.53)**	**432304 (64.84)**	**84160 (50.68)**	**1.24**
2	Livestock		152558 (30.47)	234429 (35.16)	81871 (49.31)	1.54
	Total		**500703.06**	**666733**	**166030**	**1.33**

It is evident from the returns per rupee of expenditure of all selected four farming systems, farming system with more enterprises/components was more profitable i.e., V+C+M+L(1.41) followed by V+M+L(1.38), V+C+L(1.34) and V+L(1.33). Hence hypotheses of farming system with more enterprises being profitable was accepted.

4.2.11 Component wise per farm profitability of the farming systems in NKCVP area

The results on component wise per farm profitability for major farming systems practiced by the farmers in NKCVP area are presented in Table 4.25.

Farming System-I

The average area under crops in farming system-I of NKCVP area was 4.32 acres of which vegetables crops covered an area of 1.39 and rearing two dairy animals per farm. The per farm gross returns from the vegetables (Rs.259757) and from dairy animals were more (Rs.253282.) which accounted for 30.44 per cent and 29.64 percent of the total returns, followed by crop component (Rs.195657 and 22.93%) and mulberry (Rs.144596 and 16.95%). As against this farmers have spent total cost of Rs.244109, Rs.152558, Rs.81051 and, Rs.157788 towards vegetables, dairy, mulberry and crops, respectively.

Thus net returns realized by respondents over total cost of Rs.**9173**, Rs.81871, Rs.63545 and Rs.37869.13 respectively from vegetables, dairy, mulberry and crops with returns per rupee of expenditures 1.04, 1.71, 1.78 and 1.24.Hence, it is evident from the returns from rupee of expenditure was found higher for mulberry, as it yields four crops per year followed by rearing two dairy animals, income from other crops and income from vegetables very less compared to other components of farming system.

Farming system-II

The average area under farming system-II of NKCVP is 3.36 acres of which area under vegetables was 1.733 acres and area under mulberry with 1.636 acres and system consisted of two dairy animals on an average (Table 4.25). The total cost of cultivation of vegetables under this farming system was 268277 which is 52.11 percent of total cost of farming system followed by dairy (Rs.152122 and 29.55 %)and mulberry (Rs.94444 and 18.34%).And total returns realized from vegetable cultivation was Rs.280286(39.56%)followed by dairy (Rs.259757 and 36.66%) and mulberry (Rs.168489 and 23.78%). Net returns were found highest for dairy animals (Rs.107635and 55.57%) followed by mulberry (Rs.74045 and 38.23%) and vegetables (Rs.12010 and 6.20%) with returns per rupee of investment was high more for mulberry (1.78), dairy (1.71) and vegetables (1.04).Hence it was observed from returns per rupee of expenditure, mulberry was more profitable for farmers in the study area, as mulberry crop being perennial and gets returns year round with almost four crops compared to rearing of two dairy animals and growing vegetables .

Farming system-III

The average area under crops in farming system-III of NKCVP area was 5.26 acres of which vegetables crops covered an area of 1.16 and growing other crops like ragi, fodder maize and mango in an area of 4.10 acres along with rearing two dairy animals per farm. The per farm gross returns were more for other crops (751872 and 63.13%) followed by dairy animals (Rs.259757 and 21.82%) and vegetables (Rs.179185 which accounted for 15.04 percent of total returns to the farming system. As against this farmers have spent total cost of Rs.613321, Rs.152122 and Rs.161088 towards other crops, dairy and vegetables respectively.

Thus, net returns realized by respondents over total cost of Rs.138550, Rs.107635 and Rs.18096 respectively from other crops, dairy and vegetables with returns per rupee of expenditures 1.23, 1.71 and 1.11. Hence, returns from rupee of expenditure revealed that growing of other crops mainly mango was profitable for the farmers in this farming system as mango being perennial crop and most of the farmers in the region do export mango and have good availability of markets nearby. And rearing 2 milch animals was next best component of farming system and growing of vegetables was found least among three components as growing of vegetables is associated with many kinds of agricultural risk (credit, price and marketing risk).

Farming system-IV

Farming system IV of NKCVP consists of Vegetable and dairy component. The area under vegetables was 1.90 acres and farmers possessed two dairy animals. The total cost of cultivation of growing vegetables was found Rs.293778 which is 65.88% from cultivating vegetable crops and for rearing two dairy animals(Rs.152122 and 34.12%) and gross returns realized was Rs.311991(54.57%) and Rs.259757(45.43%). Net returns were found more for rearing dairy animals (Rs.107635) than cultivating vegetables (Rs.18213) which is shown in returns per rupee of expenditure and it was 1.71 for dairy animals and 1.06 for vegetable crops.

Among selected four farming systems in NKCVP, Farming system-II(V+M+L) was found more profitable compared to other three farming systems with returns per rupee of investment of 1.38 followed by Farming system-I(1.34), Farming system-III(1.29) and farming system-IV(1.28).Hence it is inferred from the results that farmers in NKCVP get more returns by vegetables, mulberry and rearing two dairy animals instead of growing other crops like mango, ragi and fodder maize.

Among the above mentioned farming systems in KCVP and NKCVP area, the results of the study revealed that majority of the sample farmers irrespective of region included dairy as one of the components of the system. This was due to the fact that dairy was a regular source of income to the farmers round the year. Urban markets in the vicinity and good transport facility coupled with the good irrigation facility in all the seasons lead to the inclusion of the vegetables as a major component of the system by the famers of study area when compared with the farmers of the NKCVP area. It was observed from the above tables that vegetables were grown intensively on KCVP area compared to NKCVP area due to supplemental irrigation throughout the year whereas in NKCVP maximum of three vegetable crops(tomato, potato and chilli) were grown in the region due to non-availability of water due to which farmers in this region have an major area under plantation crops like mango which requires lower cost and labour requirement.

Table 4.25: Component wise per farm profitability of farming system in NKCVP area

Sl. No	Components	Area	TC	TR	Net returns	RRE
FS-I(V+C+M+L)(n=21)						
1	Vegetable crops					
a	Tomato	1.11	215274	221140	5866	1.03
b	Potato	0.24	26307	29345	3038	1.12
C	Chilli	0.05	2528	2797	269	1.11
	Sub-total	**1.39**	**244109 (38.44)**	**253282 (29.68)**	**9173 (4.02)**	**1.04**
2	Other crops					
a	Ragi	0.64	25180	33172	7993	1.32
b	Fodder maize	0.03	1308	1594	285	1.22
C	Mango	0.86	131300	160891	29591	1.23
	Sub-total	**1.53**	**157788 (24.85)**	**195657 (22.93)**	**37869.13 (17.35)**	**1.24**
3	Mulberry	1.40	81051 (12.76)	144596 (16.95)	63545 (29.12)	1.78
4	Livestock(dairy no.2)		152122 (23.95)	259757 (30.44)	107635 (49.32)	1.71
	Total	**4.93**	**635071**	**853293**	**218222**	**1.34**
FS-II(V+M+L)(n=11)						
1	Vegetable crops					
a	Tomato	1.10	213524	219342	5818	1.03
b	Potato	0.36	40124	44757	4633	1.12
c	Chilli	0.27	14628	16186	1558	1.11
	Sub-total	**1.73**	**268277 (52.11)**	**280286 (39.56)**	**12010 (6.20)**	**1.04**
2	Mulberry	1.636	94444 (18.34)	168489(23.78)	74045(38.23)	1.78
3	Livestock(2)		152122	259757	107635	1.71

Sl. No	Components	Area	TC	TR	Net returns	RRE
			(29.55)	(36.66)	(55.57)	
	Total	**3.36**	**514842.65**	**708533**	**193690**	**1.38**
FS-III(V+C+L)(n=16)						
1	Vegetable crops					
a	Tomato	0.50	97233	99883	2650	1.03
b	Potato	0.32	34929	38962	4033	1.12
c	Beans	0.19	20536	31056	10520	1.51
d	Chilli	0.16	8390	9283	894	1.11
	Sub-total	**1.16**	**161088 (17.38)**	**179185 (15.04)**	**18096 (6.84)**	**1.11**
2.Other crops(Including mango)						
a	Mango	3.97	607933	744944	137011	1.23
b	Ragi	0.09	3670.38	4835	1165	1.32
c	Fodder maize	0.04	1717.38	2092	374	1.22
	Sub-total	**4.10**	**613321 (66.19)**	**751872 (63.13)**	**138550 (52.42)**	**1.23**
3	Livestock (dairy-2)		152122 (16.41)	259757 (21.82)	107635 (40.72)	1.71
	Total	**5.26**	**926531**	**1190814**	**264282**	**1.29**
FS-IV(V+L)(n=32)						
1	Vegetable					
a	Tomato	1.11	215663	221540	5877	1.03
b	Potato	0.55	60352	67321	6969	1.12
c	Beans	0.08	8566	12954	4388	1.51
d	Chilli	0.17	9196	10176	980	1.11
	Sub-total	**1.90**	**293778 (65.88)**	**311991 (54.57)**	**18213 (14.47)**	**1.06**
2	Livestock (dairy-2)		152122 (34.12)	259757 (45.43)	107635 (85.53)	1.71
	Total	**1.90**	**445900**	**571748**	**125848**	**1.28**

The major vegetable crops grown in the KCVP area include tomato, potato, carrot, beans, coriander and cabbage. And majority of the farmer in study area included mulberry as a component in the system mainly due to the year round income from the crop, with investment made once the farmer can get assured income throughout the year through multiple crops from single planting.

Majority farmers in both KCVP and NKCVP area tried to meet food grain needs for the family consumption and fodder requirement for the livestock from their own farm production, which was clearly reflected in the components included in the farming systems practiced by sample farmers in the study area.

From supply side, it may be more profitable to grow some commercial crops and purchase the entire grain and fodder requirement, assuming no production and marketing risks. But most of the farmers choose one or two enterprises as their principal or main enterprises around which they developed their farming system- an enterprise that has high and sustained marginal returns. Farmers in the study areas added other enterprises to vegetable crop enterprise to ensure proper use of unused farm resources. Their enterprise combination depended on various factors like type of land, location, topography, fertility, irrigation, rainfall condition family labour availability, hired labour availability, other resource availability within and outside the family ,capital and availability of market for the produce.

It was also found that there was a well-established network of dairy co-operatives which served as good out let for milk marketing, besides supplying animal feeds, concentrates and regular veterinary services to the farmers in KCVP and NKCVP area.

When we compare farming systems in both KCVP and NKCVP area, returns per rupee of expenditure from vegetable cultivation and other crops (ragi, fodder maize and mango) was more in KCVP area than NKCVP area(Table 4.24 & 4.25), indicating that it was more profitable to grow vegetables and other crops in KCVP area than NKCVP area due to many factors like availability of irrigation and nearby urban markets. Returns from mulberry cultivation and maintaining of dairy animals yielded almost same returns per rupee of expenditure in KCVP and NKCVP area (Table 4.25&4.26). Farming system I of KCVP area is more profitable(V+C+M+L) followed by farming system II(V+M+L),farming system III(V+C+L) and Farming system IV(V+L).And in NKCVP area, Farming system II(V+M+L) is more profitable followed by Farming system-I (V+C+M+L), Farming system-III(V+C+L) and Farming system-IV(V+L).

4.2.12 Resource use efficiency analysis of sample farms

4.2.12.1 Resource use efficiency analysis of sample farms in KCVP area

The details on estimated technical efficiency and pure technical efficiency at both the constant returns to scale and variable returns to scale, in KCVP area are presented in Table 4.26.

The results on technical efficiency revealed a mean efficiency scores of 0.745 and 0.90 for technical and pure technical efficiency in farming system I, whereas in farming system II, the scores were 0.70 and 0.80, respectively. While in the case of farming system III, the technical and pure technical efficiency scores found to be 0.65 and 0.80, respectively with corresponding scores of 0.68 and 0.83 for farming system IV.

The distribution of farmers according to technical efficiency scores revealed that in farming system I, 29.41 percent (5 farmers) of respondents were operating at below the efficiency score of 0.49, 11.76 percent each (2) of respondents were in the efficiency range of 0.5-0.69 and 0.7-0.89, 17.65 percent (3) of respondents were in the range of 0.9-0.99 and 29.41 per cent (5) of respondents operating at the most efficient level of technical efficiency with score of 1.00 under constant returns to scale. On the other hand, at variable returns to scale (Pure efficiency) almost, two-third (64.71%)of respondents were operating at efficiency score of 1, three (17.65%) of the farmers operating in the efficiency score range of 0-0.49 and 5.88 per cent each (exhibited efficiency range of 0.5-0.69,0.7-0.89 and 0.9-1.0 (Table 4.26).

In farming system II, relatively higher proportion (46.67%) of the respondents were technically the most efficient with the efficiency score of 1, followed by 26.67 per cent (4) operating in the range TE score range of less than 0.49, 20 per cent (3) in the TE score range of 0.5-0.69 and 6.67 (one) percent of respondents were in the range of 0.70-

0.89 (Table 4.26). While results on distribution of sample farmers on the basis of pure efficiency (at variable returns to scale), 66.67 per cent (10) were found to be the most efficient with efficiency score of one followed by 20 (3 farmers) percent in the efficiency score range of 0.5-0.69 and 13.33 percent efficiency score below 0.49.

Relatively higher (38.10%) proportion of respondents in farming system III were less efficient with efficiency score of below 0.49 (8 farmers) followed by 23.81 per cent (5) were technically efficient with efficiency score of one,19.05 per cent (4) operation at 0.5-0.69, 14.29 per cent (3) at 0.7-0.89 and 4.71 per cent (one) were operating at the efficiency range of 0.9-1.0. While, with respect to pure technical efficiency, more than fifty (57.14) percent registered efficiency score of one followed by 23.80 percent(5) were operating efficiency score of less than 0.49 and two (9.52%)farmers were in the range of 0.5-0.69 and 0.9-1.0 (Table 4.26).

In the case of farming system IV practicing farmers of KCVP area, about one-third(7) of respondents were exhibited the efficiency score of less than 0.49 and one-fourth (5) of respondents reached the most efficient level of technical efficiency score of one, 20 per cent (4) respondents were in the range of 0.7-0.89, 15 per cent (3) were operating in the efficiency range of 0.5-0.69 and one farmer was operating with 0.9-1 technical efficiency. As against this nearly two-third(13) of the respondents under variable returns to scale achieved efficiency score of one followed only 20 per cent operating at efficiency score of below 0.49, 10 per cent operating in the efficiency score range of 0.5-0.69 and 5 per cent (one) between 0.9-1.0 efficiency score (Table 4.26).

4.2.13 Resource use efficiency of sample farms in NKCVP area (n=80)

The estimated technical and pure efficiency at constant returns to scale and variable returns to scale for sample farms is presented in table 4.27. The mean technical efficiency scores were 0.860, 0.77, 0.695 and 0.830 and that of pure technical efficiency levels were 0.907, 0.780, 0.8 and 0.69, for the Farming System I, Farming System II, Farming System III and Farming System IV, respectively.

The distribution of farmers according to technical efficiency scores revealed that in farming system I, 52.38 percent(11) of respondents were in the efficiency score range of 0.70-0.89 followed by 23.81 percent(5) of respondents were technically efficient with efficiency score of 1.00, 19.05 percent(4) were in the range of 0.90-1.00 and one farmer(4.76%) was in the range of 0.5-0.69 efficiency score. Whereas, on the other hand at variable returns to scale, 47.61 percent (10) were purely efficient with efficiency score of one followed by 33.33 percent (7) were in the range of 0.90-1.00 and 19.04 percent(4) in the range below 0.49(Table 4.27).

Majority of respondents in farming system II are technically efficient with 36.36 percent (4) with efficiency score of one and in the range of 0.7-0.89 and 27.27 percent each (3) and even at constant returns to scale, four farmers technically efficient with score of one, three farmers were in the range of 0.7-0.89 and 0.9-0.99.

In farming system III, 37.50 percent(6) of respondents were in the range of 0.50-0.69 followed by 31.25 percent(5) were technically efficient with efficiency score of 1.00,18.75 percent(3) were below 0.49 efficiency score, 12.50 percent(2) were in the range of 0.7-0.89 efficiency score. And assuming variable returns to scale, 62.5 percent (10) of respondents were purely technical efficient at variable returns to scale with efficiency score of 1.00 followed by 18.8 percent(6) were in the range of 0.5-0.69, 12.5 percent (2) were below 0.49, one farmer (6.25%) was in the range of 0.7-0.89(Table 4.27).

Farmers who were practicing farming system-IV in NKCVP area, among them majority of farmers (53.10%) were in the efficiency score range of 0.7-0.89 followed by 28.1 percent(9) were technically efficient with efficiency score 1.00,9.38 percent(3) were in the range of 0.50-0.69, 6.25 percent(2%) were below 0.49 efficiency score range and one farmer was in the efficiency range of 0.9-1.00. Efficiency scores for variable returns to scale i.e., pure technical efficiency was one for 62.5 percent(20) of sample respondents followed by 18.75 percent(6) were in the range of 0.90-1.00, 15.63 percent(5) were in the range of 0.70-0.89 and one farmer(3.12%) was in the efficiency score range of 0.5-0.69(Table 4.27).

4.26: Resource use efficiency of Selected Farming systems in KCVP (n=80)

	FS-I				FS-II				FS-III				FS-IV			
	TE@CRS		PE@VRS		TE@ CRS		PE@VRS		TE@CRS		PE@VRS		TE@CRS		PE @VRS	
Range	No.	% to total	No.	% total	No.	% to total	No.	% to total	No.	% to total	No.	% to total	No.	% to total	No.	% to total
0-0.49	5	29.41	3	17.65	4	26.67	2	13.33	8	38.10	5	23.80	7	35	4	20
0.5-0.69	2	11.76	1	5.88	3	20.00	3	20.00	4	19.05	2	9.52	3	15	2	10
0.7-0.89	2	11.76	1	5.88	1	6.67	0	0.00	3	14.29	0	0	4	20	0	0
0.9-1	3	17.65	1	5.88	0	0.00	0	0.00	1	4.76	2	9.52	1	5	1	5
1	5	29.41	11	64.71	7	46.67	10	66.67	5	23.81	12	57.14	5	25	13	65
	17	100	17	100	15	100	15	100	21	100	21	100	20	100	20	100
Mean	**0.745**		**0.9**		**0.7**		**0.8**		**0.65**		**0.8**		**0.68**		**0.83**	

Note: FS-I= V+C+M+L. FS-II: V+M+L, FS-III: V+C+L and FS-IV: V+L, where FS-Farming System, V= Vegetables, C=Crops other than vegetables (Ragi, fodder maize, pulse crops), M= Mulberry and L=Livestock (Dairy), CRS- Constant returns to scale, VRS- Variable returns to scale, TE-Technical Efficiency, PE-Pure Efficiency

4.27: Resource use efficiency of Selected Farming systems in NKCVP (n=80)

	FS-I				FS-II				FS-III				FS-IV			
	TE@CRS		PE@VRS		TE@CRS		PE@VRS		TE@CRS		PE@VRS		TE@CRS		PE@VRS	
Range	**No.**	**% to total**	**No.**	**% total**	**No.**	**% to total**	**No.**	**% to total**	**No.**	**% to total**	**No.**	**% to total**	**No.**	**% to total**	**No.**	**% to total**
0-0.49	0	0.00	4	19.04	0	0.00	1	9.09	3	18.75	2	12.5	2	6.25	0	0
0.5-0.69	1	4.76	0	0.00	0	0.00	0	0.00	6	37.50	3	18.8	3	9.38	1	3.12
0.7-0.89	11	52.38	0	0.00	4	36.36	3	27.27	2	12.50	1	6.25	17	53.10	5	15.63
0.9-1	4	19.05	7	33.33	3	27.27	3	27.27	0	0.00	0	0	1	3.13	6	18.75
1	5	23.81	10	47.61	4	36.36	4	36.36	5	31.25	10	62.5	9	28.10	20	62.50
Total	21	100	21	100	11	100	11	100	16	100	16	100	32	100	32	100
Mean	**0.860**		**0.907**		**0.77**		**0.780**		**0.695**		**0.800**		**0.83**		**0.69**	

Note: FS-I= V+C+M+L. FS-II: V+M+L, FS-III: V+C+L and FS-IV: V+L, where FS-Farming System, V= Vegetables, C=Crops other than vegetables (Ragi, fodder maize, pulse crops), M= Mulberry and L=Livestock (Dairy), CRS- Constant returns to scale, VRS- Variable returns to scale, TE-Technical Efficiency, PE-Pure efficiency

Two conclude on resource use efficiency on farms practicing four major identified farming systems in the study area, we can observe that some of the farmers in both the situations of KCVP and NKCVP area were operating at efficiency score of one and also farmers operating at efficiency score of less than one indicating these farms need to improve their efficient level as they were found less efficient. In the order of technical efficiency at constant returns to scale, farmers following Farming system I were found to be relatively more efficient(technically) , followed by farming system II, farming system IV and farming system III. In other words, resources are more efficiently utilized in farming system I compared to other three systems. This can be attributable to more number of components present in Farming System-I with vegetables, crops, mulberry and milch animals at variable returns to scale while the ordering of farming systems in terms of pure efficiency is same with except farming IV showing the least efficiency score in KCVP area. But in NKCVP area, among the selected four farming systems, farming system I was found more technically efficient followed by farming system II, IV and III(Table 4.27). These results show that resources are most efficiently used in farming system I. And between KCVP and NKCVP area, with technical efficiency at variable returns to scale, resources were found more efficiently used in NKCVP area than KCVP area. Hence hypotheses of resources being more efficiently used in KCVP area was rejected.

4.2.14 Resource saving from different sources in Farming System-I in KCVP area

The information on actual use of resources and optimal use of resources, saving in resources in Farming system-I (FS-I) are presented in Table 4.28. Optimal use of inputs obtained from the technical efficiency multiplied with actual use of inputs. We can infer from these results that it is possible through better operational practices to reduce the input quantities without affecting the present output. The optimum level of various inputs used by different components of the FS-I were arrived at using Data Envelopment Analysis (DEA) tool and were actual use of inputs or actual costs. It could be seen from the table that the actual expenditure on planting material was Rs.34122.80 against the optimal usage of Rs.30250. Farmers applied FYM quantity of 16.84 TL but the economically its optimal use would be 14.85 TL, which was 1.99 TL less than actual usage and farmers can save 11.81 percent FYM in Farming system I. Similarly, the analysis revealed there could be 13.60 per cent saving in fertilizer (132.89 Kg's), 12.87 per cent saving plant protection chemicals, 13.83 per cent of human labour (283.24 man days as against 328.72 man-days). Similar results were found by Pahlavan (2011), while studying resource use efficiency in tomato production in Iran who reported saving of 25.15 per cent.

Table 4.28: Resource saving from different sources in Farming System-I in KCVP area

Sl. No.	Inputs	Actual use	Optimal use	Resource saving	
				Quantity	Percent
1	Planting material(Rs.)	34122.80	30250.00	3872.80	11.35
2	FYM(TL)	16.84	14.85	1.99	11.81
3	FERT(Kg)	977.20	844.31	132.89	13.60
4	PPC(litres)	6.91	6.02	0.89	12.87
5	Labour(No.)	328.72	283.24	45.48	13.83

FYM- Farm Yard Manure, FERT- Fertilizers, PPC-Plant Protection Chemicals

4.2.15 Resource saving from different sources in Farming System-II in KCVP area

The information on actual use and optimal usage of resources in farming system II in KCVP area are presented in Table 4.29. It is observed from the table that the actual cost of planting material was Rs.11583.77 as against the optimal cost obtained from optimum plant population was less than the actual cost by Rs.615.14 and resource saving percentage with adoption of optimal usage of planting material was 5.31 percent from actual usage. Farmers applied an farm yard manure of 9.54 TL but the optimal use is 8.188TL which is 1.35 TL less than actual usage, 592.79 kg of fertilizer was used by farmers on the farm but the optimal use suggested to reduce the actual use by 73 Kg's which is 12.33 percent less than the actual use. Spraying of plant protection chemicals(litres) was 2.62 but optimal use is also around 2.44 which is 6.87 percent less than actual use and actual labour man-days used on farm is 164.74 but optimal plan suggests to reduce the use of labour man-days by 141.41 which is 14.16 percent less than actual use(Table 4.29). Similar results were found by Sapkota and Bajracharya (2018) who made a study on resource use efficiency analysis for potato production in Nepal.

Table 4.29: Resource use saving from different sources in FS-II in KCVP area

Sl. No.	Inputs	Actual use	Optimal use	Resource saving	
				Quantity	Percent
1	Planting material(Rs.)	11583.77	10968.62	615.14	5.31
2	FYM(TL)	9.54	8.188	1.35	14.18
3	FERT(kg)	592.79	519.70	73.08	12.33
4	PPC(liters/kg)	2.62	2.44	0.18	6.87
5	LC(man-days)	164.74	141.41	23.33	14.16

FYM(TL)-Farm Yard Manure in tractor loads, FERT(kg)-Fertilizer in kilograms, PPC-Plant Protection Chemicals, LC-Labour cost

4.2.16 Resource saving from different sources in FS-III in KCVP area

The actual and optimal usage of resources in farming system III of KCVP area are presented in Table 4.30. The results indicate the farmer to reduce the actual usage of resources to arrive at the present level of output in the study area. The actual cost of planting material was Rs.31660.91 but with the optimal use of planting material, the incurred cost may reduce by Rs.4447.43 which is 14.05 percent less than the actual cost. Use of FYM (TL) was 21.09 but the optimal use is 17.25 which is 18.21 percent less than the actual use of farm yard manure. Actual fertilizer use was 941.43 kg as against optimal use is 751.93(Kg) which is 20.44 percent less than the actual use.

Actual spray of plant protection chemicals was 6.435 liters as against optimal use of plant protection chemicals 5.54 liters which is 16.72 percent less than the actual use in the study area. And the labour man-days used on the farm is 385.12 but optimal plan suggests to reduce the use of labour man-days by 303.98 which is 81.13 less labour man-days (21.07%) on the farm(Table 4.30). A study made by Vo Hong Tu (2015) on resource use efficiency and economic loses: implications for sustainable rice production in Vietnam.

Table 4.30 Resource saving from different sources in FS-III in KCVP area

Sl. No.	Inputs	Actual use	Optimal use	Resource saving	
				Quantity	Percent
1	Planting material (Rs.)	31660.91	27213.48	4447.43	14.05
2	FYM(TL)	21.09	17.25	3.84	18.21
3	FERT (kg)	945.13	751.93	193.20	20.44
4	PPC (litres/kg)	6.43	5.36	1.07	16.64
5	LC (man-days)	385.12	303.98	81.13	21.07

FYM(TL)-Farm Yard Manure in tractor loads, FERT (kg)-Fertilizer in Kilograms,PPC-Plant Protection Chemicals, LC-Labour cost

4.2.16 Resource saving from different sources in FS-IV in KCVP area

Cost on planting material was one of the major component in cost of production of any crop. The actual cost on planting material was Rs.32708.12 in KCVP area but the optimum use in the farming system was Rs.28445.70 which is less by 13.03 percent from the actual level. Farm yard manure used on the farm was 16.05 TL but optimum use was 13.85TL, if farmers in the study area follow the optimum use then it id possible to reduce the use of fym by 13.68 percent from actual level. Actual use of fertilizers on the farm was 951.59 Kg's whereas the optimum use is 790.71kgs which is less by 160.88kgs (16.91 percent) from actual use. If the optimum plant protection chemicals (56.71 liters) are used on the farm compared to actual use of 67.15 liters, it reduces the usage by 10.44 liters (15.55 percent from actual use). Labour use in man-days on farm was 311.16 man-days but the optimal plan advises to reduce the actual use by 51.14 labour man-days which is 16.44 percent (Table 4.31) from the actual level in the study area. These results were inline with study made by Lokapur *et al* .(2014) on resource use efficiency of major vegetables in Belgaum district in Karnataka.

Table 4.31 Resource saving from different sources in FS-IV in KCVP area

Sl. No.	Inputs	Actual use	Optimal use	Resource saving	
				Quantity	Percent
1	Planting material(Rs.)	32708.12	28445.70	4262.43	13.03
2	FYM(TL)	16.05	13.85	2.20	13.68
3	FERT(kg)	951.59	790.71	160.88	16.91
4	PPC(litres)	6.71	5.67	1.04	15.55
5	HL(man-days)	311.16	260.02	51.14	16.44

FYM(TL)-Farm Yard Manure in tractor loads, FERT(kg)-Fertilizer in kilograms, PPC-Plant Protection Chemicals, LC-Labour cost

From the above tables it could be observed that in all the selected four farming systems, the resources have been over used to some extent. The cost on planting material, FYM(TL), fertilizers, plant protection chemicals and labour are the major input variables considered.

Table 4.32: Resource saving from different sources in FS-I in NKCVP area

Sl. No.	Inputs	Actual use	Optimal use	Resource saving	
				Quantity	Percent
1	Planting material(Rs.)	14638.25	14553.35	84.90	0.58
2	FYM(TL)	8.09	7.03	1.06	13.10
3	FERT(kg)	502.97	489.32	13.65	2.71
4	PPC(litres)	2.17	2.15	0.01	0.55
5	LC(man-days)	139.15	122.09	17.06	12.26

FYM(TL)-Farm Yard Manure in tractor loads, FERT(Kg)-Fertilizer in Kg's, PPC-Plant Protection Chemicals, LC-Labour cost

It is observed from the Table 4.32, actual use of planting material was Rs.14638.25 but optimal use is Rs.14553.35 which is less than the actual use. if optimal use of resource is followed then the farmer could save the cost on planting material by 84.90 which is 0.58 percent from the actual use. FYM used on the farm is 8.09 TL but the optimal plan suggests to use 7.03 TL of fym on the farm which is less than the actual use by 13.10 percent from actual use. In case of fertilizers used on the farm, 502.97 kg's of fertilizers is being used on the farm but optimal plan suggests to reduce the fertilizer use by 13.65 kg's which is 2.71 percent less than the actual usage. Labour used on the farm was 139.5 as against optimal plan suggests to reduce the labour use by 17 labour man-days which is 12.26 percent from the actual use of labour in farming system I of NKCVP (Table 4.33). Similar results were found by Paled and Guledagudda (2018) on resource use efficiency in hybrid seed production in Northern Karnataka.

In FS-II of NKCVP area, Actual use of inputs used on the farm were Planting material, FYM(TL), FERT (kg), PPC (litres) and labour(man-days) were presented in Table 4.33. The actual use of Planting material was Rs.16608.25 but the optimal use of planting material would cost Rs.13535.35 which could save the cost by 18.50 percent from the actual use. FYM(TL) used on the farm was 7.12 TL but the optimal use(7.03) is less than the actual use by 1.26 percent from the actual use. Actual use of fertilizers on the farm was 567 Kg's which is more than the optimal use(413 Kg's), optimal plan suggests to reduce the actual use of fertilizers by 27.07 percent of actual use. Plant protection chemicals used on the farm in litres was 2.70 but optimal is less than the actual use by 2.53 litres, which is 6.29 percent less than the actual use. And the labour used on the farm was 169 labour man-days but the optimal usage was 138.09 labour man-days which is less than 18.53 percent (Table 4.33) of actual usage of labour on farm in NKCVP area.

Actual use of inputs used on the farm were Planting material, FYM(TL), FERT(Kg), PPC(litres) and labour(man-days) were presented in Table 4.34. The actual use of Planting material was Rs.34390.19 but the optimal use of planting material would cost Rs.29245.60 which could save the cost by 14.96 percent from the actual use. FYM(TL) used on the farm was 5.06 TL but the optimal use(4.27) is less than the actual use by 15.58 percent from the actual use. Actual use of fertilizers on the farm was 296 Kg's which is more than the optimal use(216 Kg's), optimal plan suggests to reduce the actual use of fertilizers by 27.03 percent of actual use. Plant protection chemicals used on the farm in litres was 2.99 but optimal is less than the actual use by 0.46 litres, which is 15.38 percent less than the actual use. And the labour used on the farm was 108 labour man-days but the optimal usage was 94 labour man-days which is less than 12.96 percent (Table 4.34) of actual usage of labour on farm in NKCVP area. Similar kind of results were found by Naik *et al.*(2018) on Resource Use Efficiency of Soybean in Belagavi District of Karnataka, India.

Table 4.33: Resource saving from different sources in Farming System-II in NKCVP area

Sl. No.	Inputs	Actual use	Optimal use	Resource saving	
				Quantity	Percent
1	Planting material(Rs.)	16608.25	13535.35	3072.9	18.50
2	FYM(TL)	7.12	7.03	0.09	1.26
3	FERT(kg)	567.07	413.52	153.55	27.07
4	PPC(litres)	2.70	2.53	0.17	6.29
5	LC(man-days)	169.50	138.09	31.41	18.53

Actual use of inputs used on the farm were Planting material, FYM(TL), FERT(kg), PPC(litres) and labour(man-days) were presented in Table 4.33. The actual use of Planting material was Rs.16608.25 but the optimal use of planting material would cost Rs.13535.35 which could save the cost by 18.50 percent from the actual use. FYM(TL) used on the farm was 7.12 TL but the optimal use(7.03) is less than the actual use by 1.26 percent from the actual use. Actual use of fertilizers on the farm was 567 Kg’s which is more than the optimal use(413 Kg’s), optimal plan suggests to reduce the actual use of fertilizers by 27.07 percent of actual use. Plant protection chemicals used on the farm in litres was 2.70 but optimal is less than the actual use by 2.53 litres, which is 6.29 percent less than the actual use. And the labour used on the farm was 169 labour man-days but the optimal usage was 138.09 labour man-days which is less than 18.53 percent (Table 4.33) of actual usage of labour on farm in NKCVP area.

Table 4.34 Resource saving from different sources in Farming System -III in NKCVP area

Sl. No.	Inputs	Actual use	Optimal use	Resource Saving	
				Quantity	Percent
1	Planting material(Rs.)	34390.19	29245.60	5144.59	14.96
2	FYM(TL)	5.06	4.27	0.79	15.61
3	FERT(kg)	296.00	216.00	80.00	27.03
4	PPC(litres)	2.99	2.53	0.46	15.38
5	LC(man-days)	108.00	94.00	14.00	12.96

FYM(TL)-Farm Yard Manure in tractor loads, FERT(Kg)-Fertilizer in kilograms, PPC-Plant Protection Chemicals, LC-Labour cost

Table 4.35: Resource saving from different sources in Farming system-IV in NKCVP area

Inputs	Actual use	Optimum use	Resource Saving	Resource saving
Planting material(Rs.)	19599.48	16680.44	2919.04	14.89
FYM(TL)	3.55	3.05	0.5	14.08
FERT(kg)	283	221	62	21.91
PPC(litres/kg)	2.01	1.72	0.29	14.43
LC(man-days)	318.01	272.44	45.57	14.33

FYM (TL)-Farm Yard Manure in tractor loads, FERT (Kg)-Fertilizer(Kg's),PPC-Plant Protection Chemicals, LC-Labour cost

The information on actual use of planting material on the farm was Rs.19599.48 but the optimum use(Rs.16680.44) suggests to reduce by Rs.2919 which is 1.89 percent from the actual use. FYM used on the farm was 3.55TL but the optimal use is less by 0.5TL which is less by 14.08 percent of actual use. Actual fertilizer used on the farm was 283 Kg's which is higher than the optimal use by 62 Kg's. Plant protection chemicals used on the farm was 2.01 litres but the optimal use is 1.72 litres, if the farmers reduces the usage of PPC the resource saved is 14.43 percent of actual use. Labour man-days used on the farm was 318.01 which is higher than the optimum use(272.44 man-days), if farmers follows the optimal use then it would be possible to save the resources by 14.33 percent(Table 4.35) in study area.

In NKCVP area, resources were efficiently used in farming system II(Table 4.27) with efficiency score of one, followed by Farming system-I, III and IV respectively which is not only economical to farmer but also sustainable.

4.3 Estimation of risk and suggesting risk efficient farming system

There is no business which is free from risk, agriculture is more prone to it, as it faced number of risks like in production, marketing, financing, getting inputs, etc. However, if we adopt proper measures one can minimize the possible downfalls in returns to some extent and manage it successfully with proper planning. However, the question here is how to quantify the risk, so that then we can think of measures to mitigate the risk. Hence, in the present study, an attempt was made to investigate and quantify the risk associated with each of the identified farming systems in both KCVP and NKCVP area through various measures as summarized in Table 4.36 below.

4.3.1 Risk estimation and risk efficient farming system in KCVP area

The findings of analysis of risk associated with selected farming systems in terms of net returns in KCVP area are presented in Table-4.36. In KCVP area, the net returns were found to be the highest (Rs.60364.7) in farming system I followed by FS-II, FS-III and FS-IV with net returns of Rs.54915, Rs.54004.7 and Rs.34933.3, respectively. The standard deviation was found to be the highest in FS-III (Rs.27626.1) followed by FS-II (Rs.20989.5), FS-I (Rs.19325.5) and the least in FS-IV (Rs.12884.2). With respect to co-

Table 4.36: Descriptive statistics of net returns in KCVP and NKCVP area

Particulars	FS-I		FS-II		FS-III		FS-IV	
	KCVP	**NKCVP**	**KCVP**	**NKCVP**	**KCVP**	**NKCVP**	**KCVP**	**NKCVP**
Mean	60364.7	36353.2	54915	23303.9	54004.7	28369.8	34933.3	19641.8
S.D	19325.5	17983.9	20989.5	22359.6	27626.1	26372.5	12884.2	20002.4
C.V	32.21	49.46	38.22	95.94	51.15	92.95	36.88	101.83
Skewness	-0.66	0.58	-0.66	0.22	-0.003	-1.12	-0.58	0.1
Minimum	24099	13860.3	11064	-4701.4	12338	-19763	11575	-8945
Maximum	87125	69767.2	88751	53941.6	99195	54089.4	53309	50773.6
Range	63026	55906.9	77687	58643	86857	73852.8	41734	59718.5
T-test	3.64***(0.0074)							

efficient of variation in net returns, FS-I showed the lowest value (32.21%) followed by FS-IV (36.88%), FS-II (38.22 %) and FS-III (51.15 %). The measure of skewness was found negative in all the selected farming systems indicating downward risk in all the selected four farming systems. And it was found to be -0.67(FS-II), -0.66 (FS-I), -0.58 (FS-IV) and -0.003 (FS-III) (Table 4.36).

In NKVCP area, the mean or average net returns were found highest in FS-I (Rs.36353.2) followed by FS-III (Rs.28369.8), FS-II (23303.9) and FS-IV (Rs.19641.8) respectively. The standard deviation was found higher in FS-III (Rs.26372.5) followed by FS-II(Rs.22359.6), FS-IV(Rs.20002.4) and FS-I(Rs.17983.9) respectively. Co-efficient of variation was comparatively higher in FS-IV (101.83%) followed by FS-II (95.95%), FS-III (92.95%) and FS-I (49.46%) respectively. The co-efficient for skewness were positive for FS-I(0.587), FS-II(0.228) and FS-IV(0.106) indicating upward risk and higher returns and FS-III was found negative indicating downward risk(Table 4.36). T-test was conducted between the two regions to know whether there exist significant difference among the farm income of the respondents within the two areas under study (KCVP and NKCVP). The result was found significant at one percent (t-statistics =3.6, p-value =0.0074) indicating a highly significant difference between the two situations.

When we compare co-efficient of variation of income (CV) in KCVP and NKCVP area, variability in income was found less in KCVP area compared to NKCVP area, hence hypotheses of higher income variability in KCVP area was rejected.

4.3.2 Vegetable based farming system (VBFS) and Cumulative distribution function (CDF) in KCVP area

It is needless to say that any production activity or business activity is associated with one or the other type of risk, is more so when it comes to agriculture, as it largely deals with living things, influenced by many uncontrollable factors like rainfall, humidity, temperature, pest and diseases, market, technological changes and institutional factors. Hence, an attempt has been made examine the risk associated with different farming systems chosen for the study so as to evolve a risk efficient farming system among farming system considered for study. For this purpose Cumulative Distribution

Function (CDF) analysis as detailed in the methodology chapter was used to know the range and probabilities of net returns for different farming systems.

It could be observed from the CDF graph depicting the information on distribution of farmers on the basis of net returns against different probabilities associated with net returns practicing four alternative farming systems, viz., FS-I to FS-IV. It is clear from the graph that the net returns across these farming systems showed greater variation i.e., from Rs.11064 to Rs.99195.

FS-II has minimal outcome and FS-III has maximum net returns in KCVP area (Table 4.36). The CDF shows that all the farming systems showed the probability of positive net returns in the range of Rs.40,000 to Rs.80,000, the probability associated with it is 30-90 percent and there is an 100 percent probability that one farmer in FS-III would reach a net returns of almost Rs.1,00,000. Since CDF lines cross in the graph, we could not rank the alternative farming system's using first degree stochastic dominance, and hence the Stochastic Efficiency with Respect to a Function (SERF) was used to have a better ranking analysis. The analysis indicated that farming system III and farming system I were having more income earning alternatives, as its distribution line (dots) located on the right and preferred to those on the left line of Farming System IV and Farming System II

4.3.3 SERF Analysis and Certainly Equivalent in KCVP area

The Stochastic Efficiency with respect to Function (SERF) analysis was carried out to arrive at the risk aversion coefficient to evaluate the risk associated with different farming systems chosen for the study in both the category of farms. The SERF method calls for calculating Certainly Equivalent (CE) values over a range of Absolute Risk Aversion Coefficients (ARACs). The ARAC represents a decision maker's degree of risk aversion. The CE of a risky prospect is the sure sum with the same utility as the expected utility of the prospect. In other words, for a given utility function, it is the point mass at which the decision maker is indifferent between the value and the risky outcome. For a rational decision maker who is risk averse (the normal case), the estimated CE is typically less than the Expected Money Value (EMV) and greater than or equal to the

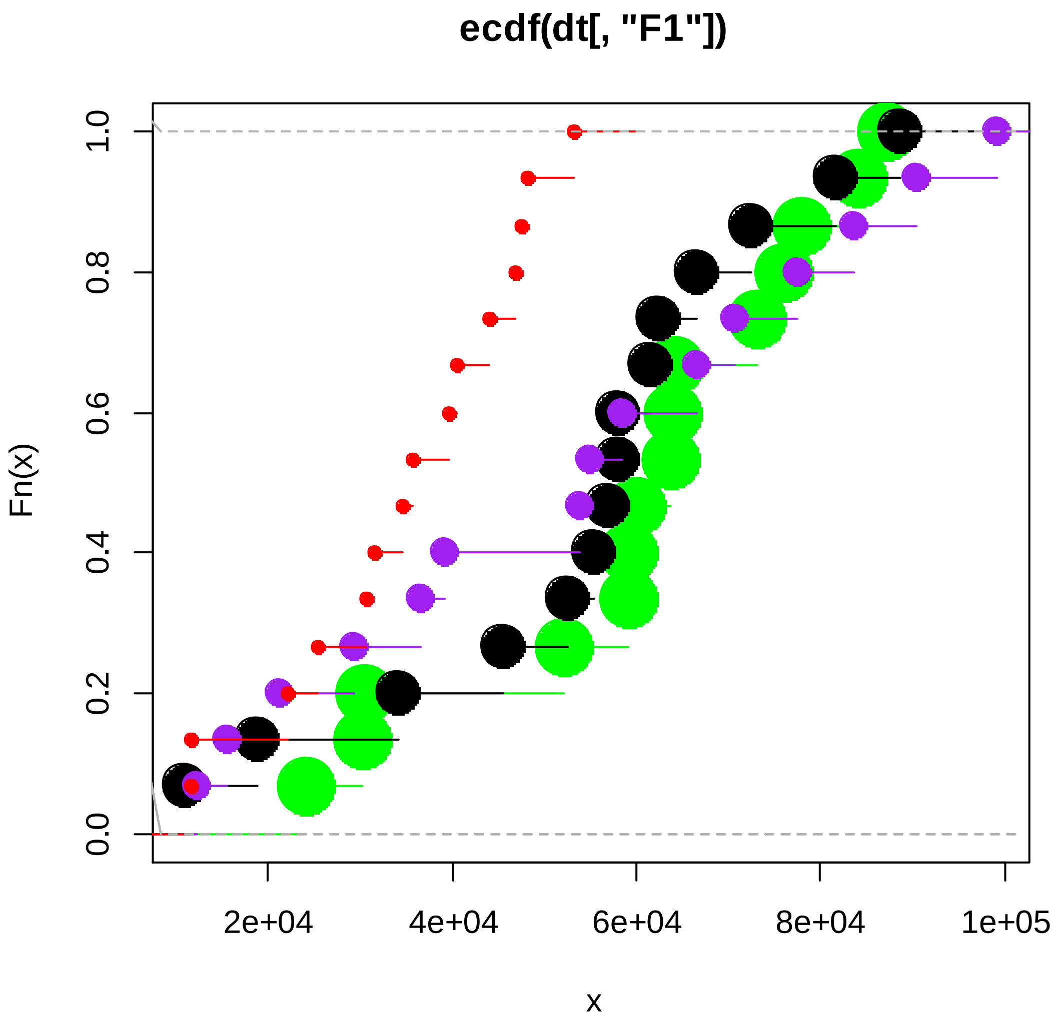

Fig. 4.4: VBFS and CDF Analysis in KCVP

(X-Net returns, FS-I- Green, FSII- Black, FS-III-Purple and FS-IV-Red, ARAC-Absolute Risk Aversion co-efficient)

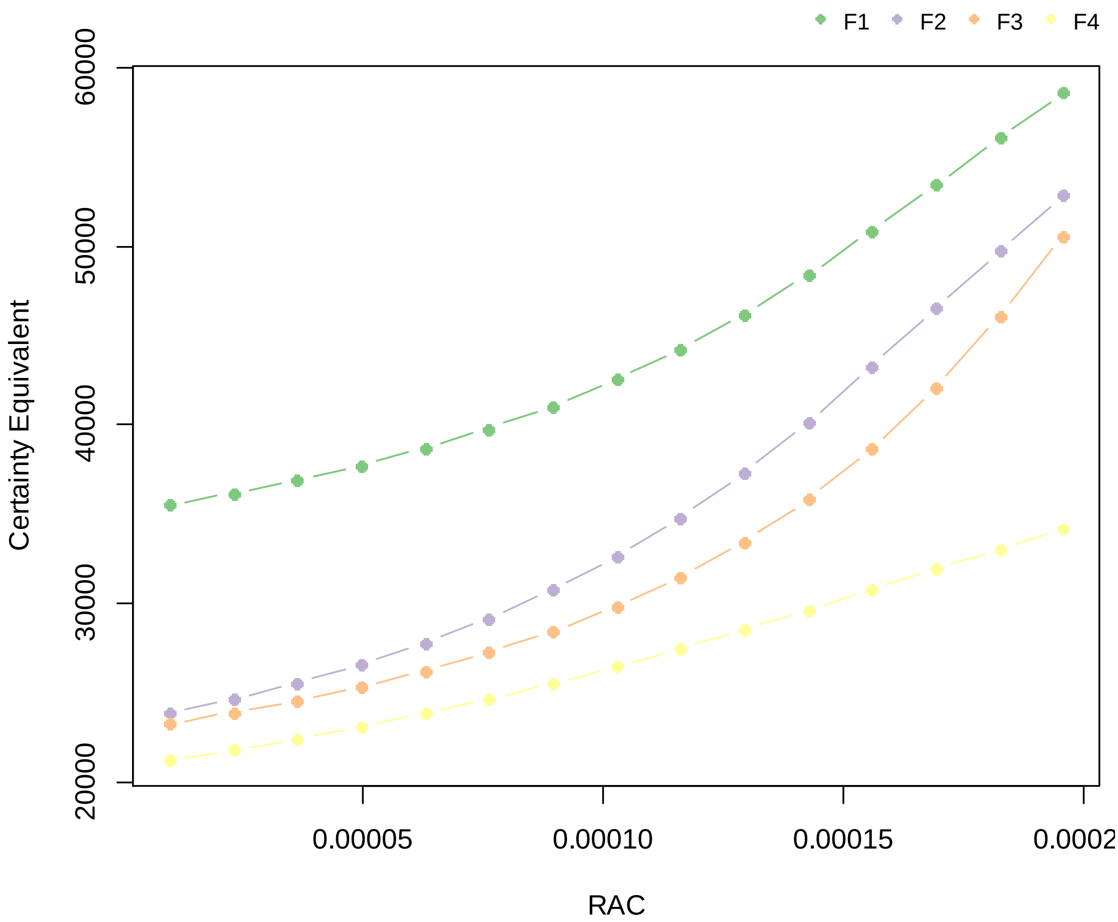

Fig. 4.5: Certainty equivalent and RACs of different farming systems in KCVP area

Table 4.37: Certainty Equivalent and Risk premium of different farming systems in KCVP area.

Sl. No.	Certainty Equivalent				Risk Premium(F-I as base)		
	FS-I	FS-II	FS-III	FS-IV	FS-II	FS-III	FS-IV
1	58599.29	52822.63	50538.54	34159.20	5776.60	8060.69	24440.04
2	56052.56	49754.36	46064.37	33065.99	6298.20	9988.19	22986.57
3	53424.47	46513.71	42070.29	31938.40	6910.75	11354.18	21486.07
4	50835.98	43255.84	38655.83	30795.88	7580.13	12180.15	20040.09
5	48397.49	40146.68	35804.21	29659.45	8250.80	12593.28	18738.04
6	46183.16	37309.48	33441.25	28549.29	8873.67	12741.91	17633.86
7	44224.70	34802.71	31479.30	27482.65	9421.99	12745.40	16742.05
8	42520.49	32630.40	29838.41	26472.53	9890.09	12682.08	16047.96
9	41049.29	30764.60	28452.81	25527.26	10284.70	12596.48	15522.03
10	39781.64	29164.60	27270.74	24650.89	10617.05	12510.91	15130.75
11	38686.99	27788.41	26252.15	23843.97	10898.58	12434.83	14843.02
12	37737.23	26598.15	25366.18	23104.49	11139.08	12371.05	14632.74
13	36908.10	25561.70	24588.90	22428.83	11346.41	12319.20	14479.28
14	36179.30	24652.65	23901.63	21812.41	11526.65	12277.67	14366.89
15	35534.14	23849.67	23289.63	21250.27	11684.48	12244.52	14283.88
Average	44407.66	35041.04	32467.62	26982.77	9366.614	11940.04	17424.88

minimum value (Hardaker *et al.,* 2016) The absolute risk aversion coefficients (ra(w)) in the analysis were ranged between zero to 0.0002, where zero being risk neutral and 0.0002 representing highly risk averse, with respect to the negative exponential utility function as given in Figure 4.5. It is evident from e Fig. 4.5 that Farming system I was found to be the more risk efficient than other three farming systems. It could be observed from the Table 4.35 that FS-I has an certainty equivalent of Rs.44407.66 with original level of utility derived by the respondents followed by FS-II (Rs.35041.04), FS-III (Rs.32467.62) and FS-IV(Rs.26982.77). FS-I dominants, at all levels of risk aversion coefficients of all other three farming systems. As the curve for FS-I lies above the curves for other farming systems. The certainty equivalent goes on increasing with increase in risk aversion coefficients indicating all the farmers in the FS-I (V+C+M+L) were found more risk efficient compared to farmers practicing other three selected farming systems. Thus as the number of components in the farming system increases, farmers become risk efficient as even though one crop fails they would stabilized their farm income from other components of the farming system. Similar kind of results were reported by Ishag, (2016) while studying on economic performance of goat breeds farming sustainability and policy analysis in Oman

4.3.4 Risk premium for farming systems from dominant farming system as Base

Risk premium which is regarded as the minimum amount need to be paid to a farmer to justify and maximizes his expected utility by switching from present farming system to another risk efficient farming system (Ishag, 2016). Risk premiums are arrived by subtracting certainty equivalent of less preferred farming system from the certainty equivalent of dominant farming system or risk efficient farming system, which yields utility-weighted Risk Premium (RP) at a given risk aversion level.

In Fig. 4.6, risk premium was calculated by vertical distance between certainty equivalents lines of most preferred (i.e., risk efficient) farming system and less preferred farming system. In the present study, FS-I was found to be the dominant or risk efficient farming system, so if we want to suggest the farmers to move from less preferred FS to

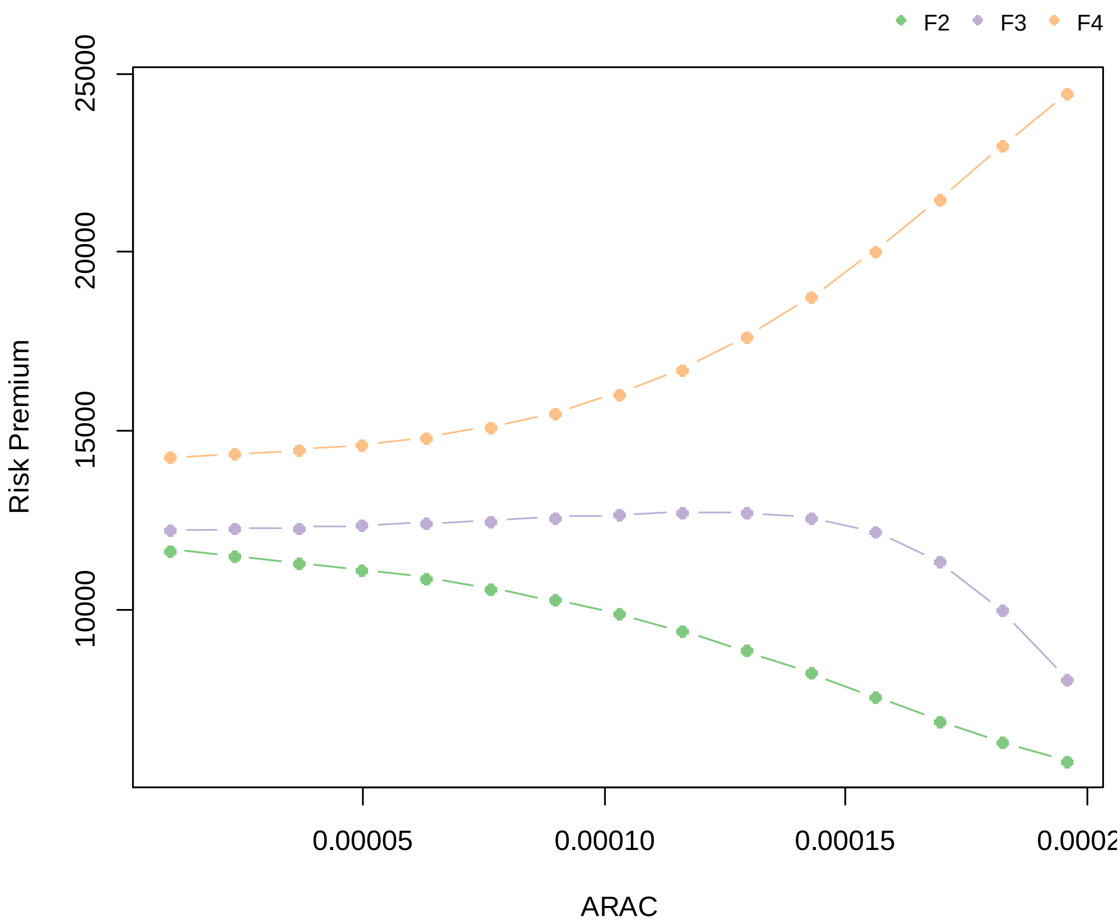

Fig. 4.6: Risk premium of different farming systems in KCVP area as against ARAC

(FS-I-Green, FSII- Black, FS-III-Purple and FS-IV-Red, ARAC-Absolute Risk Aversion co-efficient) the most preferred or efficient farming system, Say for example, from FS-II to FS-I, the amount of risk premium need to be paid to farmers was Rs.9366.614 and from FS-III to FS-I was Rs.11940.04 and from a least profitable farming system (FS-IV) to the most preferred or optima; system (FS-I) farmers need to be paid a premium of Rs.17424.88 at respective absolute risk aversion coefficients. Similar kind of results was also found by Ishag, 2016 while studying on Economic Performance of Goat Breeds Farming Sustainability and Policy Analysis.

4.3.5 Vegetable based farming systems (VBFS) and cumulative distribution function(CDF) in NKCVP area

To know the risk efficient farming system in NKCVP area, cumulative distribution function (CDF) analysis have been made to know the range and probabilities of net return value for different farming systems. The CDF graph(Figure 4.6) shows the net returns from four risky alternatives of FS-I to FS-IV, the net returns from all the farming systems vary from negative net returns to Rs.69767.18. Alternative FS-III had widest range i.e., FS-III had minimal income (Rs.-19763.4) and FS-I has maximum net returns (Rs.69767.18) in NKCVP area(Table 4.35). CDF in NKCVP area, showed that FS-II, FS-III and FS-IV had a 10 to 25 percent probability of getting negative net returns of about Rs.20,000 whilst only farmers practicing farming system I had 100 percent probability of getting positive net returns ranging from Rs. 19,000 to Rs.70,000. Farmers practicing FS-I, FS-II and FS-IV had 40 to 6o percent probability of getting an net returns of around Rs.20,000. The results revealed that majority of the farmers under FS-III had 40-100 percent probability of getting net returns of about Rs.40,000. Since the CDF lines cross in the graph we could not rank the farming systems and It was ranked based on stochastic efficiency with respect to function. The analysis indicated that farming system I was more income earning among selected four farming systems in NKCVP area, as its distribution is located towards right and preferred to those on the left line of farming system II, III and farming system IV(Fig. 4.6).

4.3.6 SERF Analysis and Certainly Equivalent in NKCVP area

The Stochastic Efficiency with respect to Function(SERF) analysis for the selected farming systems in the NKCVP area revealed absolute risk aversion coefficients ranging between ($r_a(w)$) zero being risk neutral to 0.00014 representing highly risk averse, with respect to the negative exponential utility function. As depicted from the Fig. 4.7, farming system I was found more risk efficient or dominating farming system than the other three selected farming systems. FS-I had an certainty equivalent of Rs.24059.97 followed by FS-II (Rs.5299.12), FS-IV(Rs.2639.672) and FS-III (Rs.-7548.32) as shown in Table 4.37 in NKCVP area, FS-I dominates all the other three farming systems at different risk aversion coefficients with certainty equivalent increasing with increased in risk aversion coefficients indicating all the farmers in the FS-I(V+C+M+L) were more risk averse compared to the other three selected farming systems. It is evident from the above figure that as the number of components in the farming system increases, farmers become risk efficient as even though one crop fails they would get income from other components of farming system. Similar kind of results were found by Ishag , 2016 while studying on goat based farming systems in Oman.

4.3.7 Risk premium and Absolute risk aversion co-efficient(ARAC)

In NKCVP area, it was evident from Figure 4.8 that FS-I(V+C+M+L) was found dominant or risk efficient farming system, so if we suggest the farmers to move from less preferred FS to most preferred i.e., from FS-II to FS-I, the amount of risk premium need to be paid to farmers was estimated at Rs.19186.79 and from FS-IV to FS-I was Rs.22781.36 (Table 4.37) and from a least preferred farming system(FS-III) to most preferred(FS-I) farmers need to be paid a larger premium of Rs.33973.12 at the respective absolute risk aversion coefficients. Similar kind of results was also found by Ishag, 2016.

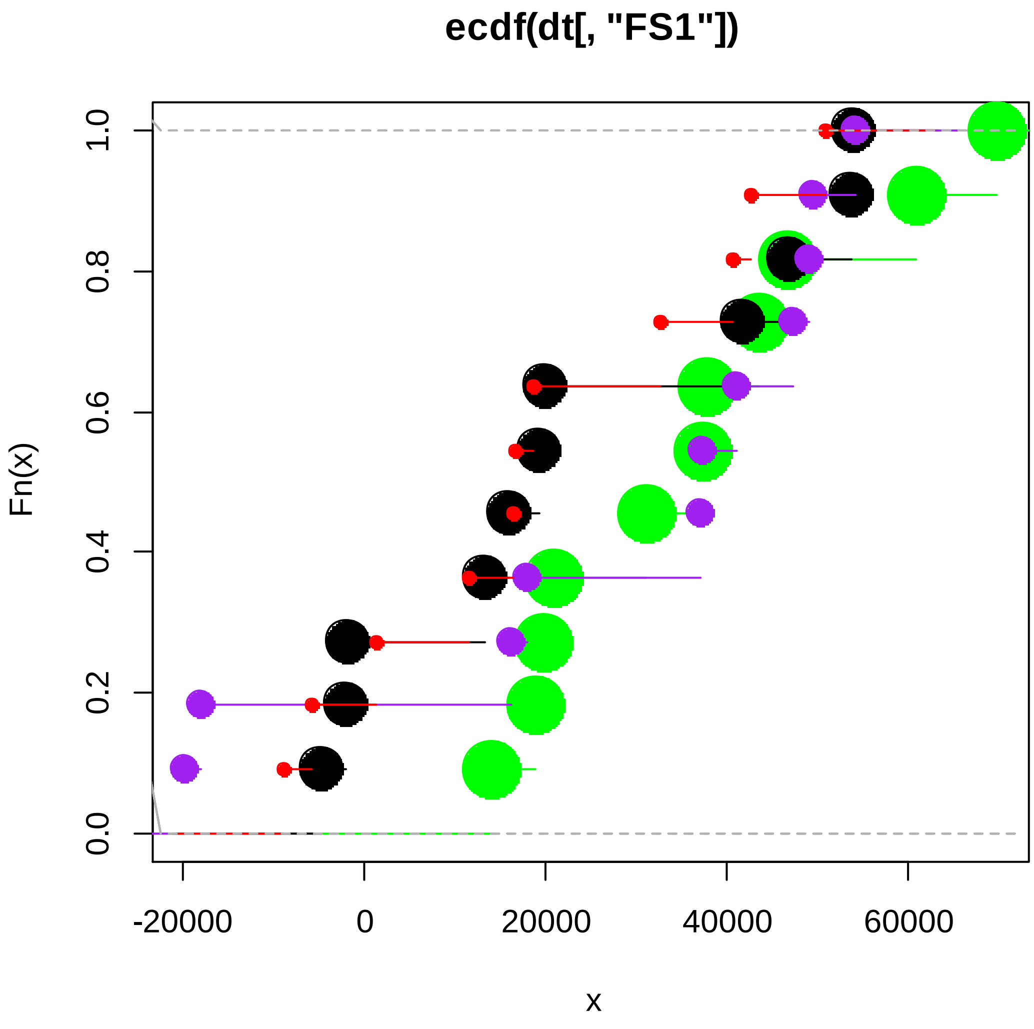

Fig. 4.7: VBFS and CDF Analysis in NKCVP area

(X- Net returns, FS-I-Green, FSII- Black, FS-III-Purple and FS-IV-Red, ARAC-Absolute Risk Aversion co-efficient)

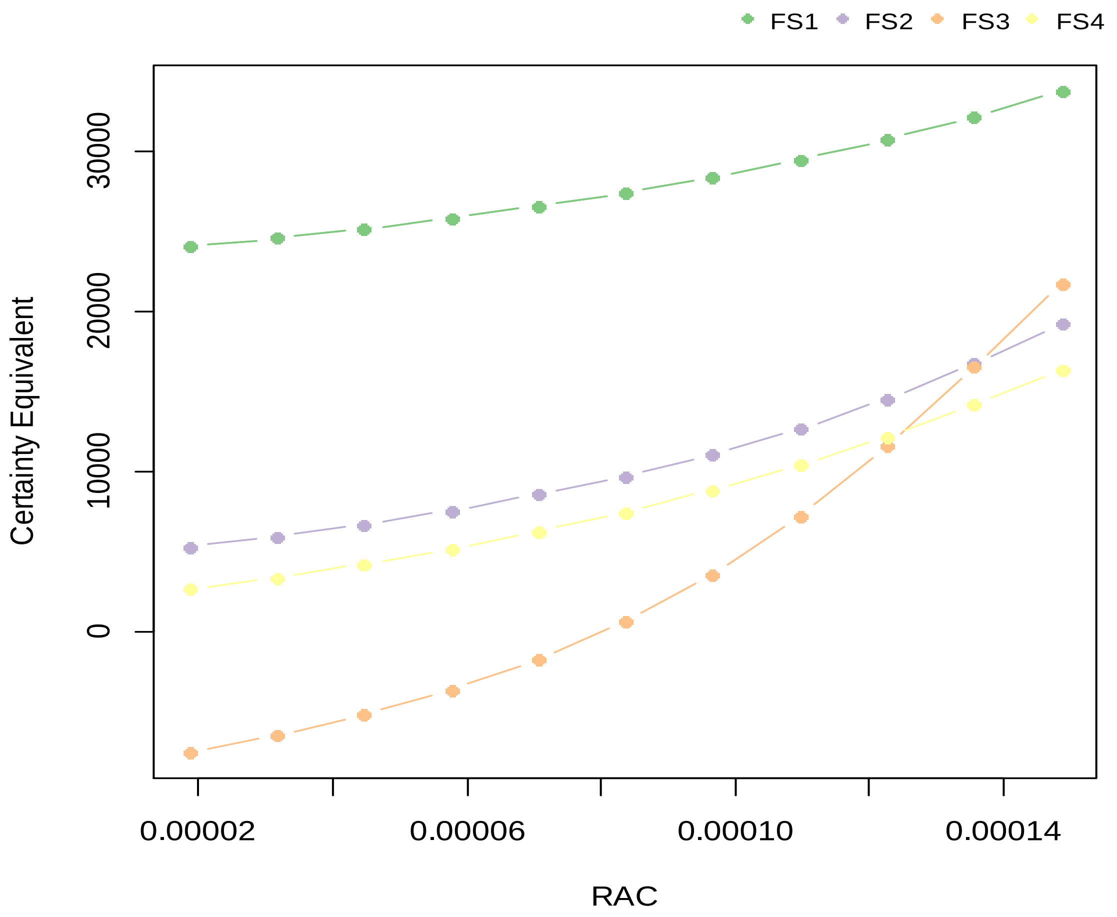

Fig 4.7: Certainty equivalent and RACs in NKCVP

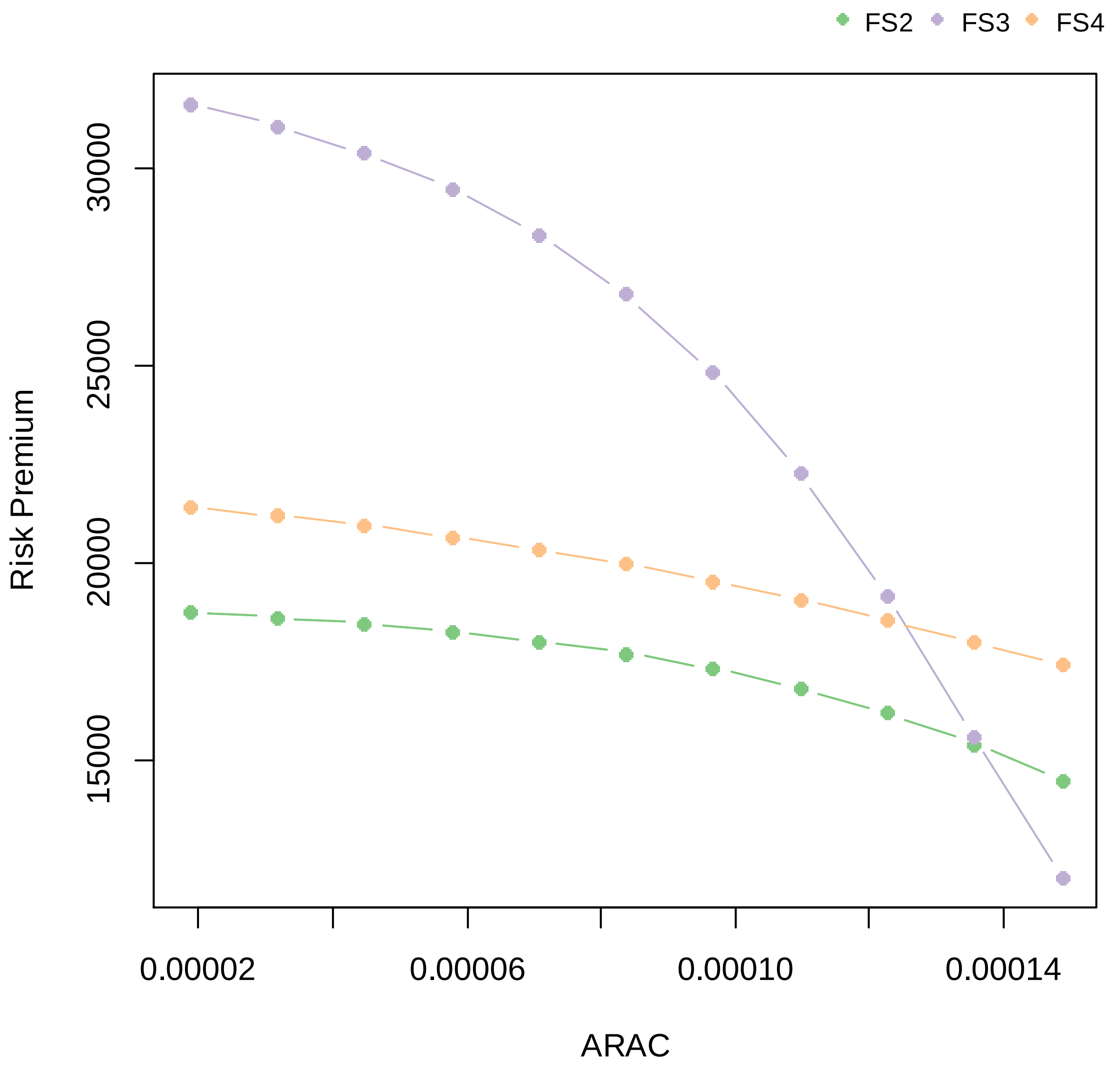

Fig. 4.8: Risk premium and ARAC in NKCVP area

Table 4.38: Certainty equivalent and Risk premium of farmers in NKCVP area

Sl. No.	CE				Risk premium(F1 as base)		
	F-I	FS-II	FS-III	FS-IV	FS-II	FS-III	FS-IV
1	33783.21	19261.76	21725.06	16339.20	14521.45	12058.14	17444.00
2	32192.80	16750.61	16561.81	14184.32	16681.82	21476.76	18944.28
3	30777.79	14558.68	11590.27	12211.68	17874.16	27514.64	20150.00
4	29528.37	12681.59	7216.897	10439.23	18502.64	30481.47	20998.07
5	28428.89	11085.46	3583.33	8865.313	18850.03	31985.55	21581.86
6	27461.70	9728.09	644.27	7476.50	19046.56	32812.42	21986.65
7	26609.46	8568.77	-1717.98	6253.87	19153.85	33298.68	22270.34
8	25856.28	7572.32	-3626.20	5177.21	19205.00	33597.46	22470.60
9	25188.10	6709.89	-5183.78	4227.20	19219.79	33784.83	22612.24
10	24592.78	5958.32	-6471.01	3386.42	19210.90	33902.02	22711.96
11	24059.97	5299.12	-7548.32	2639.67	19186.79	33973.12	22781.36
Average	**28043.58**	**10743.15**	**3343.12**	**8290.96**	**18313.91**	**29535.01**	**21268.31**

4.4 Externalities associated with KCVP implementation and Willingness to pay for KCVP area

4.4.1 Positive and Negative Externalities associated with use of treated sewage water in KCVP area

Implementation of KCVP in one of the drought prone district of Karnataka i.e., Kolar has accompanied with supplying treated sewage water to village tanks, which helped agriculture in the study area through borewell recharge has both positive and negative externalities. Opinion of farmers regarding the positive and negative externality due to the use of treated sewage water is presented in the following section.

Table 4.39: Positive externalities associated with implementation of KCVP

Sl. No.	Particulars	YES	
		Number	% total
1	Bore well recharged	80	100.00
2	Water table increased	41	51.25
3	Cropping pattern changed	54	67.50
4	Cropping intensity increased	44	55.00
5	Yield increased	8	10.00
6	Irrigated area increased(how much)	48	60.00
7	On farm employment increased	51	63.75
8	Reduced irrigation water scarcity	42	52.50
9	Increased land value	48	60.00

4.4.1 Positive externality with implementation of K-C Valley Project

In an attempt to know the impact of implementing the KCVP on the farming in the study area, most relevant statements were chosen in consultation with experts in the field of impact assessment like researchers, scientist and even beneficiaries during the pre-testing of data collection instrument and administered to respondents to collect the opinions and results are presented in Table 4.39. Cent percentage of famers in the region opined that borewells on their farms and in the region have recharged and giving better water output and even some of the failed bore wells started yielding water. Accordingly, more than fifty percent of respondents, opined that groundwater table in the region has been increased. During the survey they expressed that depth of water availability was around 1500 feet but now farmers in the region are getting water at about 600-850 feet depth of digging. More than three-fourth (67.5%) of the respondents expressed that cropping pattern in the region has changed due to water availability and now-a-days more emphasis is towards the vegetable and commercial crops than foodgrains. But remaining (32.50%) farmers opined no change of cropping pattern as they continue to grow same crops. Sixty percent of the respondents expressed that additional land area was brought under cultivation and with availability of irrigation, additional area was brought under irrigation and cropping intensity was increased.

Table 4.40: Negative externalities associated with KCVP

Sl. No.	Particulars	YES	
		No.	%
1	Soil quality decreased	17	21.25
2	Water contamination with effluents	39	48.75
3	Increased cost of production	13	16.25
4	Human health problems(skin diseases, cold and cough and other microbial infections)	27	33.75
5	Animal health problems	9	11.25
6	Usage of fertilizers increased	37	46.25
7	Usage of higher pesticides compared to earlier	66	82.5

Majority of the farmers (90%) of the respondents in the study area felt that the project implementation did not have any influence on the crop yield levels as they remained same. However, due to increased area under cultivation, on farm employment increased as expressed by 63.75 percent of sample farmers. More than fifty per cent (52.5%) of the farmers opined that project implementation has reduced irrigation water scarcity in the project area. These results were found similar to the findings of Ramesh, 2019 and Chandrakanth and Arun (1997), who reported the changed cropping pattern, increasing cropping intensity and generation of additional employment opportunities to the beneficiary farmers.

4.4.1.2 Negative externality with implementation of K-C Valley Project

Negative externalities associated with project implementation are documented in the above Table 4.40. As project being implemented five year ago, not much evidences of adverse effects were noticed (negative externalities). However, when farmers use water directly from the tanks filled with treated sewage water have noticed the effects like soil acidity and leaching, decreased yields mainly with tuber crops. In addition farm, fields which are situated beside the tanks are being water stagnated like in Narasapura and Uddapanahalli villages.

The opinions of respondents expressing about the negative externalities showed that farmers reported the less of negative effects than the positive effects of the KCVP project. Basically study area is known for growing of vegetables, hence with this increased access to irrigation water through recharged groundwater has led to further intensive vegetable cultivation. As these vegetables are more of fertilizer and pesticide demanding crops due to their susceptive nature on one hand, continuous cultivation of these crops on the same land year after year. This has led to higher usage of PPC (82.50%) and fertilizers (46.25%) and thus soil quality has decreased (21.25%) in the study area. The more serious issue reported by the respondents was of that treated water may pollute ground water (48.75%) and decrease the water quality. As during survey people in the region complained that the supplied water is not being correctly treated but it has been subjected to only primary and secondary filtration. Thus, people in the region are requesting for tertiary treatment. Sixteen percent of the farmers expressed that crop yields levels have decreased as these tanks became good habitat for many flies and insects, so they are attacking on the surrounding farms of tanks. One-third respondents expressed that due to bad smell and breeding of flies in the tanks, filled with this treated water causing allergies, skin rashes and some other health issues with people and even animals (11%) when animals drink water from these filled tanks. Similar kind of results were found by Ramesh who made a study in 2019 in the same area.

4.4.2.1 Willingness to pay for use of treated sewage water from KCVP area

Due to the absence of river canals and assured rainfall, the region has became an drought prone due to which, no water markets prevailed in the study area, and hence hypothetical market was created using double bounded contingent valuation method to assess the farmers' willingness to pay for assured irrigation through borewell recharge by filling the irrigation tanks in the study area; and equity in filling up of village tanks in study area. Determining the value of water serves as an option for improving water allocation and management of the irrigation systems (Karthikeyan *et al*., 2009). Hence, willingness to pay for assured irrigation through borewell recharge and equity in filling up of village tanks by treated sewage water, indicates the efficient use of water and increased ground water table in the drought region.

The farmers in the study area are presented with double bounded dichotomous CVM format. It was noticed that, majority of farmers in KCVP area expressed their willingness to pay for assured irrigation through borewell recharge and equity in distribution of treated sewage water to village tanks. Little more than one-third of the farmers expressed their willingness to pay for both initial and second bid followed by 30 percent (24 farmers) were not willing to pay for first bid but expressed their willingness to pay for second bid. Fourteen farmers (17.5%) belonged to No No category and 16.25 percent(13 farmers) expressed their willingness to pay for initial bid and expressed their unwillingness to pay for second bid (Table 4.41). The average willingness to pay for use of treated sewage water which would lead to borewell recharge was Rs.713.58 per acre per year.

Farmers were cultivating cereal crops and plantation and few vegetable crops due to scarcity of water and depletion of ground water in the study area. After implementation of KCVP, ground water table in the region has been increased and helped improve irrigation through borewell recharge and led to adoption of diversified cropping pattern and get assured income. This is the main reason for expressing their willingness to pay by majority of farmers in the study area. Some farmers in region expressed their unwillingness to pay because of their smaller land holdings and they were of the opinion that, it is the responsibility of government to fill the village tanks and help the farming in the region.

4.4.2.2. Factors determining WTP by farmers in KCVP area through borewell recharge

As farmers in the region benefitted from the KCVP through ground water recharge and increased ground water table, an attempt was made to know the factors affecting the willingness to pay for use of treated sewage water as they are receiving benefits since the project implementation from 2016. Multinomial logistic regression was used to find out the factors affecting the WTP by farmers in KCVP area. Pseudo R^2 (0.44) indicated that only 44 per cent of the variation in the dependent variable was explained by the independent variables included in the model.

YY category was taken as the base reference category. Results revealed that irrigated area, gross-farm income and crop diversification index was found positive and significantly influencing willingness to pay in case of YN category. In case of No Yes, awareness in the use of treated sewage water and grass farm income, while in the case of No No category awareness in the use of treated sewage water, gross farm income and crop diversification were found to be significantly influencing factors of respondents willingness to pay (Table 4.42). It could be observed from the results presented in the table that, as the irrigated area increase by one acre, the log of odds ratio, probability of YN category to probability to YY category raises by 1.21 indicating that if irrigated area increases by one acre the probability of moving to YY category is 0.23 (1-0.77=0.56). With increase in gross farm income by one percent, the log of odds ratio, probability of YN category and NY category to probability of YY category raises by 0.000234 indicating that if one percent increase in farm income, the probability of moving to YY category is 0.5 (1-0.50).

It could be also observed from table 4.42 that with respect to crop diversification, as the number of crops grown on the farm increases by one unit, the log of odds ratio, probability of YN category to YY category raises by 5.55 indicating one unit increase in diversification the probability that farmers moving from YN category to YY category is 0.11 (1-0.89). As regards education status of respondents, with increased education (number of years of schooling) increases, the log of odds ratio, probability of NN category to probability of YY category raises by 0.000803 indicating if number of years of schooling increases by one, probability that the farmers in the study area may move from NN category to YY category is 0.50 (1-0.50), indicating favourable impact of education towards WTP.

Table 4.41: Distribution of respondents according to category of bids and willingness to pay

Sl. No.	Particulars	No. of farmers	Per cent
1	Yes Yes(YY)	29	36.25
2	Yes No(YN)	13	16.25
3	No Yes(NY)	24	30.00
4	No No(NN)	14	17.50
	Total	80	100.00
	Mean WTP (Rs. per acre per year)	**713.58**	

Table 4.42: Factors affecting willingness to pay for assured irrigation and equity in distribution of KC valley water in the study area

Sl. No.	Explanatory variables	Yes No (YN)		No Yes (NY)		No No (NN)	
		Co-efficient	p value	Co-efficient	p value	Co-efficient	p value
1	Age (years)	0.107 (0.526)	0.41	0.0366 (0.509)	0.404	-0.0098 (0.497)	0.835
2	Education attainment (years of schooling)	0.069 (0.517)	0.635	-0.031 (0.492)	0.790	0.000803 (0.50)	0.034**
3	Irrigated Area (acres)	1.21 (0.770)	0.020**	0.720 (0.672)	0.036	0.5065 (0.623)	0.146
4	Gross farm income (` per annum)	-2.34E-04 (0.500)	0.053*	-2.88E-05 (0.500)	0.0712*	3.84E-04 (0.5000)	0.129
5	Crop diversification index	-5.555 (0.896)	0.037**	2.43 (0.919)	0.250	4.82 (0.99)	0.054*
6	Awareness	0.452 (0.611)	0.789	0.598 (0.645)	0.520	0.5680 (0.638)	0.441

Note: LRChi-square=-57.96 Pseudo R^2=0.441; Base category: Yes Yes (YY); Figures in parentheses indicate probability value;
** and * indicates significant at five per cent and ten per cent probability level, respectively

Table 4.43: Functional analysis to find the extent of farmers WTP in KCVP (Tobit analysis)

Sl. No.	Explanatory variables	Co-efficient	p value
1	Age (years)	-0.0157	0.191
2	Education attainment (years of schooling)	0.284	0.078*
3	Gross farm income	0.00232	0.885
4	Irrigated area	118.72	0.092*
4	Scarcity of water	1.833	0.0012***
5	Crop diversification index	0.323	0.001***
	Constant	-152.10	

Note: ***, and * indicates significant at one per cent, and ten per cent probability level, respectively

Log likelihood value = -60.31, pseudo R^2=0.4998, Prob > chi^2 =0.0000

4.4.2.3. Functional analysis to find out farmers willingness to pay for KCVP

Farmers actual willingness to pay for assured irrigation through borewell recharge and equity in filling up of village tanks with treated sewage water was estimated using the tobit model [Table 4.43]as used by many researchers like Ravi,(2018); Rohith and Chandrakanth, (2011); Divya *et al.* (2015). Actual amount the farmers willing to pay for KCVP project was taken as dependent variable for the selected tobiit model. Actual willingness to pay was zero for NN category which makes it suitable to use the tobit model. Zero willingness to pay indicates that the farmers may think that the water is a free gift of nature and he/she cannot afford to pay for use of water (Divya *et al.*, 2015).

The tobit equation obtained was presented below:

WTP(Rs.)=-152.10-0.0157(X1)+0.284(X2)+0.00232(X3)+118.72(D1)+1.833(X5)+0.323(X6)

Education, irrigated area, scarcity of water and crop diversification index found to have significant impact on willingness to pay for use of treated sewage water through borewell recharge and equity in filling up of village tanks through treated sewage water hence hypotheses of factors affecting willingness to pay was accepted. And Similar kind of results was found by Divya *et al.* (2015)

WTP(Rs.) = -152.10-0.0157(47.16)+0.284(9.13)+0.00232(248442.125)+118.72(3.146)+1.833(1)+0.323(0.577)

WTP= Rs.801.651 per acre per year

Thus, it is evident from the analysis that, the mean willingness to pay is Rs.801.651 per acre and per year, for the use of treated sewage water through borewell recharge and equity in distribution of treated sewage water to village tanks in study area.

V SUMMARY AND CONCLUSIONS

Vegetables are important constituents of Indian agriculture. Vegetables play a very crucial role in achieving various objectives of the nation like nutritional security doubling farmers income, employment generation, due to their shorter duration, high yield, nutritional richness, economic viability and ability to generate on-farm and off-farm employment. Vegetable production has now become a remunerative farm enterprise sustaining the livelihoods of most of the small and marginal farmers in rural areas. About five-six years back, farmers in Kolar district were cultivating millets, ragi, plantation crops along with few vegetable crops. But, after the implementation of Koramangala Chellaghatta Valley Project (KCVP) in the region, increased groundwater table, rejuvenation of the dried up wells, which started yielding water, resulted in changed cropping pattern and increased cropping intensity with dominant component of vegetable crops. Livestock being invariably assured source of regular income for the farmers of the region.

Against this background, an attempt was made in this study to evaluate different vegetable based farming systems in study area. Farming system is focused on a few selected inter-dependent, interrelated and inter-linking production systems, based on crops, animals and related subsidiary enterprises (Sachin, 2016). Farming systems help to provide year round employment, improved fertility status of soil, reduced risk and assumed to be sustainable. Vegetable based farming system represented the system in which farmers who grew vegetables as the base crop and a number of other crops (Ragi, fodder maize and Mango) and subsidiary occupations such as growing mulberry crop and livestock enterprises with substantial income. There are a few studies on vegetable based farming system and in the light current national objectives, farming system approach in analyzing the problems of agriculture is gaining lot of importance. Present study throws light on the crop diversification, factors affecting crop diversification, risk associated with different vegetable based farming system, externalities associated with KCVP including willingness to pay for treated sewage water in the study area. Keeping all these aspects in view, this study made an in depth econometric analysis of vegetable based farming systems in KCVP area with the following specific objectives.

1. To estimate the extent of crop diversification and to identify the factors affecting crop diversification in the study area.
2. To identify and estimate the economics and resource use efficiency of different vegetable based farming systems.
3. To assess the risk in vegetable based farming system and to suggest risk efficient farming system
4. To estimate the externalities associated with KCVP and to know the willingness to pay for the KCVP in study area.

5.1 Study area and sampling design

The study was carried out in the Kolar district of Karnataka. Purposive random sampling design was employed for the selection of respondents. The primary data were collected from 160 farm households, consisting of 80 farm households in KCVP area and 80 from Non-KCVP area, i.e., area outside the KCVP. The distinction between two categories of respondents was on the basis of implementation of KCVP(village tanks filled) in the district. The data were collected from the respondents through personal interview method using pre-tested, well-structured schedule to achieve the objective of the study. The villages were selected randomly based on the area in which tanks were filled under the project in the district. Among various farming systems prevalent in the study area, four major farming systems from both the categories of area were chosen for the detailed economic analysis. Detailed information on age, education level, land holdings, cropping pattern, inputs used, output obtained of all the components taken up by the respondents were elicited with the help of pretested schedule through personal interview method. The data pertained to the agricultural year 2020-21.

5.2 Analytical tools employed

The data thus collected were subjected to various statistical and econometric analyses. The results obtained are presented in tabular form to facilitate easy comparison. Degree of crop diversification was measured using Herfindahl and Simpson index of crop diversification in KCVP and NKCVP area. Economics of all the farm enterprises in chosen vegetable based farming system were analyzed using cost and return analysis, the resource use efficiency of different vegetable farming systems (VBFS) was studied by using Data Envelopment Analysis (DEA). The co-efficient of variation was used for measuring variability (risk) associated with different vegetable based farming systems. Multinomial logistic regression was used to calculate the actual willingness to pay for use of treated sewage water by filling village tanks through KCVP which help recharge of borewells in the area and Tobit analysis was used to identify the factors affecting willingness to pay for being beneficiary of the KCVP .

Major findings of the study:

- Around fifty per cent and 36 percent of the respondents in KCVP and NKCVP area belonged to 36 to 50 years of age group, that being the most active category for working and earning the livelihood.
- The family size was 5 adult members consisting more of male members than the female in both KCVP and NKCVP area.
- Only one and a very few (14.51%) of the total sample respondents, were illiterates in KCVP and NKCVP category. Relatively higher proportion of (42.50% and 45.16 %) respondents had secondary education and only 5 percent and 13 per cent of the sample farmers were graduates in KCVP and NKCVP area, respectively.
- In the total landholding of 4.06 acres in NKCVP area and 3.63 acres in KCVP area, higher part of it was irrigated with corresponding area of 3.15 acres (86.58%) and 2.94 acres (72.41%).
- Relatively higher (55% and 43.75%) per cent of farmers in KCVP and NKCVP area were medium sized (2.5 to 5 acres) followed by Small farmers (<2.5 acres of agricultural land) who accounted for 32.50 per cent and 40 per cent of respondents followed by 12.50 per cent and 16.25 per cent of large farm size (> 5 acres of agricultural land).
- The proportion of respondents owning tractor in KCVP area was higher (35%) than in NKCVP area (21.25%). The corresponding figures for having cattle-shed was 57.50

percent and 40 percent.

- The value of farm assets (machineries, equipments and farm buildings) on KCVP farms was more (Rs.705308) than on NKCVP (Rs.547044) farms.

- Irrespective of farm situations, al l the respondents possessed two livestock animals.

- The area under vegetables was 120.72 acres in KCVP area and it was 88.5 acres in NKCVP area. The major vegetable crops grown in kharif season included Tomato (28.5 ac.), potato (11 ac.), cabbage (7.5 ac.), beans (17 ac.), carrot (9.20 ac.), coriander (8 ac.), chilli (6.5 ac.) and other vegetables on 6.5 acres in KCVP area, while, tomato (9 ac.), potato (5 ac.), cabbage (3.5 ac.) and other vegetables (9.52 acres) were grown during rabi season.

- In NKCVP area, tomato (26 ac.), potato (24 ac.), beans (8.5 ac.), carrot (4.5 ac.), chilli (4.5 ac.) and other vegetables (5.5 ac) grown in kharif and rabi season crops included tomato, potato and other vegetables. Ragi was grown on 34.5 acres and 11 acres during kharif and rabi seasons in KCVP area the corresponding figures for NKCVP were 41 acres and 15.50 acres.

- Herfindahl index for diversification was 0.42 in KCVP area and 0.68 for NKCVP area indicating more diversification in KCVP region. Similarly, Simpson Index of 0.58 In KCVP and 0.32in NKCVP area also indicated higher diversification KCVP area.

- KCVP area showed higher cropping intensity (177.74 %) than NKCVP area (137.25%).

- Results of fractional probit model revealed that education (0.017), age (0.027), farm income (4.022), farm size (-0.034), access to extension services (0.2868) and region dummy (0.4454) were the significant factors affecting crop diversification in the study area.

- Farmers spent Rs.152558.46 and Rs.152122.30 and realized net returns of Rs.40935.27 and Rs.39053.85 per year / animal with returns per rupee of expenditure of 1.53 and 1.51 in KCVP and NKCVP area, respectively.

- The total cost did not vary much between the two situations for each crop of mulberry (Rs.61535 and Rs.62842) and gave gross returns of Rs.103544 and Rs.102989 in KCVP and NKCVP area, respectively. The corresponding return per rupee of expenditure was 1.68 and 1.64.

- The cost of cultivation was marginally higher in KCVP (Rs.37324.75) than NKCVP area (Rs.36529.14) so also the total returns (Rs.48535 and Rs.46906) and returns per rupee of expenditure (1.30 and 1.28).

- Farmers in KCVP area realized higher returns (Rs.226636) compared to NKCVP area (Rs.199766) by spending Rs.179871 and Rs.177470 with net returns and returns (Rs.46765 & 1.26 and Rs.22295 & 1.13).

- The cost of cultivation incurred for one acre of potato was Rs.140109 in KCVP and Rs.116727 in NKCVP area and gross returns realized were of Rs.142649 (KCVP) and Rs.119723 (NKCVP). The respective figures for cabbage were Rs.105918 (total cost), Rs.116410 (total returns) and 1.10 (RRE) in KCVP .

- The total cost of cultivation of coriander in KCVP area was Rs.46653 and gross returns from per acre of coriander cultivation were Rs.64887. Net returns were found to be Rs.18235per acre in KCVP area. The corresponding values for carrot were Rs.46746 Rs.55716 and 1.19.

- The beans farmers spent Rs.119312.14 and obtained returns of 176076 with returns per rupee of expenditure of 1.43

- In KCVP area, more than thirty per cent of the farmers were practicing farming system-I involving vegetables-crops-mulberry-dairy components. The proportion of farmers practicing farming system-II with vegetables-mulberry-dairy components was 22.50 per cent. The next important farming system –III in the area included components of vegetables-crop-dairy components (28.75%) and lastly 18.75 percent of farmers followed farming system-IV which consisted of vegetables-dairy.

- Similarly, in NKCVP area, the proportion of farmers practicing aforesaid system was 40 per cent (FS-IV), 26.25 per cent (FS-I), 20 per cent (FS-III) and 13.75 per cent (FS-

II).

- Among different sources of income, income from vegetables was Rs.164584 (41.40%) followed by income from Livestock (Rs.117215 and 29.48%), other crops (Rs.60737 and 15.28%), Mulberry (Rs.36863 and 9.27%) and income from mango (Rs.18144 and 4.56%) in KCVP area.

- In NKCVP area, Income from mango cultivation was found to be very high (Rs.180228 and 35%) followed by income from vegetables (Rs.121834 and 23.66%), livestock (Rs.115115 and 22.35%), income from crops (Rs.79656 and 15.47%) and the least income was from mulberry (Rs.18177 and 3.53%).

- The farmers in Farming system-I realized net returns of Rs.59875, Rs.81871, Rs.64232 and Rs.9626 respectively from vegetables, dairy, mulberry and crops with corresponding returns per rupee of expenditures of 1.24, 1.54, 1.68 and 1.27.

- Among different components of Farming system-II, on the basis of returns per rupee of expenditure (RRE), mulberry was crop was found more profitable (1.68) compared to dairying (1.54) and vegetable crops (1.21) in KCVP area.

- In Farming system-III of KCVP area, dairy (1.54) was the most profitable enterprise followed by crops (1.36) and vegetables(1.25) on the basis of returns per rupee of expenditure.

- The returns per rupee spent were the highest for dairy (1.54) followed by vegetable crops (1.23) in Farming system-IV of KCVP area.

- Net returns realized from vegetables, dairy, mulberry and crops by the respondents over total cost were Rs.9173, Rs.81871, Rs.63545 and Rs.37869.13, respectively with returns per rupee of expenditures of 1.04, 1.71, 1.78 and 1.24 from farming system-I in NKCVP area.

- Similarly, in farming system-II of NKCVP area, net returns were found to be the highest for dairy animals (Rs.107635and 55.57%) followed by mulberry (Rs.74045 and 38.23%) and vegetables (Rs.12010 and 6.20%) with higher returns per rupee of investment of mulberry (1.78), dairy (1.71) and vegetables (1.04).

- The returns realized from other crops, dairy and vegetables per rupee of expenditures was 1.23, 1.71 and 1.11 from Farming system-III in NKCVP area, while in farming system –IV

- The dairy animals with vegetables cultivation gave returns per rupee of expenditure of 1.71 and 1.06 in NKCVP area.

- The comparison of different farming systems in KCVP area, revealed that Farming system I (V+C+M+L) was more profitable followed by farming system II (V+M+L),farming system III (V+C+L) and Farming system IV(V+L), while in NKCVP area, Farming system II (V+M+L) was more profitable followed by Farming system-I (V+C+M+L), Farming system-III (V+C+L) and Farming system-IV(V+L).

- The results on technical efficiency revealed a mean efficiency scores of 0.745 and 0.90 for technical and pure technical efficiency in farming system I, whereas in farming system II, the scores were 0.70 and 0.80, respectively. While in the case of farming system III, the technical and pure technical efficiency scores found to be 0.65 and 0.80, respectively with corresponding scores of 0.68 and 0.83 for farming system IV in KCVP area.

- The mean technical efficiency scores were 0.860, 0.77, 0.695 and 0.830 and that of pure technical efficiency levels were 0.907, 0.780, 0.8 and 0.69, for the Farming System I, Farming System II, Farming System III and Farming System IV, respectively in NKCVP area.

- The actual expenditure on planting material was Rs.34122.80 against the optimal usage of Rs.30250. Similarly, farmers can save 11.81 percent of FYM 13.60 per cent of fertilizers, 12.87 per cent of plant protection chemicals and 13.83 per cent of human labour in FS-I of KCVP area.

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labour in FS-I of KCVP area.

- There is possibility of resource saving by following the optimal usage in Farming system-II of KCVP area ranging from 6.87 percent (PPC) to 15.31 per cent (planting material)

- The optimal production could be reached in farming system-III of KCVP area by reducing the usage of most of the resources. The quantum of saving would be the highest for human labour (21.07%), followed by fertilizer (20.44%), FYM (18.21%), PPC (16.64%) and cost on planting material (14.05%).

- In Farming system-IV of KCVP, among different resources, the quantity of fertilizer saved would be the highest (16.91%) followed by human labour (16.44%), PPC (15.55%), FYM (13.68%) and cost on planting material (13.03%) as per the results on resource use efficiency analysis.

- Similar analysis for NKCVP area revealed that , by adopting the optimal resource use, farmers could save expenses on all the inputs, which was relatively higher in the use of FYM (13.10%), followed by human labour (12.26%) and fertilizer (2.76%), while farmers usage level of planting material (0.58%) and PPC (0.55%) was almost optimal.

- Since most of the farmers in FS-II were operating at technically most efficient level with efficiency score of almost one and hence resources were optimally used, while in the case of FS-III the resource use analysis revealed possibility of resource saving with the highest proportion of savings in fertilizer (27.03%) use followed by FYM (15.61%), PPC (15.38%), cost on planting material (14.96%) and Human labour (12.96%).

- In FS-IV of NKCVP area, almost twenty two percent of fertilizers could be saved with optimal usage followed by cost on planting material (14.89%), PPC(14.43%), human labour(14.33%) and FYM(14.08%).

- The variability in income anlysed using the Co-efficient of variation showed the highest variability in FS-III (51.15%) followed by FS-II (38.22%), FS-IV (36.88%)

and FS-I (32.21%) found to be associated with relatively lesser degree of variability in KCVP area. Thus, all the farming systems followed by the respondents indicated their nature of lower risk .

- On the other hand, the prevailing farming systems in NKCVP area showed still higher instability in farm income as revealed by the higher coefficient of variation for all the systems compared to KCVP area. The CV in income was found to be the highest for FS-IV (101.83%) followed by FS-II (95.94%), FS-III (92.95%) and FS-I (49.46) indicating FS-I has higher risk compared to other three Farming systems.
- The results of Cumulative Distribution Function (CDF) showed that all the farming systems had the probability of positive net returns (Range Rs.40,000 to Rs.80,000) in the probability range of 30-90 percent. There is one farmer in FS-III who would reach net returns of Rs.1,00,000 with 100 percent probability.
- The absolute risk aversion coefficients (ra(w)) using negative exponential utility function of Stochastic Efficiency with respect to Function (SERF) ranged from zero to 0.0002, with zero being risk neutral and 0.0002 representing highly risk averse.
- FS-I was found to be more risk efficient than other three farming systems. FS-I has a certainty equivalent of Rs.44408 with original level of utility derived by the respondents followed by FS-II (Rs.35041), FS-III (Rs.32468) and FS-IV (Rs.26983). FS-I dominated all levels of risk aversion coefficients of other farming systems. The certainty equivalent increased with increase in risk aversion coefficients indicating farmers adopting FS-I (V+C+M+L) were more risk efficient compared to farmers practicing other farming systems in KCVP area.
- It was also attempted to quantify the risk premium to be paid to farmers to move from their existing FS to the most efficient farming system. Analysis revealed that to move from FS-II to FS-I, the amount of risk premium need to be paid to farmers would be Rs.9367 and from FS-III to FS-I it would be Rs.11940 and from FS-IV to FS-I, the risk premium would be Rs.17425 at respective absolute risk aversion coefficients.
- The CDF analysis for farming system in NKCVP area showed that FS-II, FS-III and

FS-IV had a 10 to 25 percent probability of getting negative net returns of about Rs.20,000 whilst only farmers practicing FS I had 100 percent probability of getting net returns ranging from Rs.19,000 to Rs.70,000. Farmers practicing FS-I, FS-II and FS-IV had 40 per cent to 6o percent probability of getting net returns of around Rs.20,000.

- The Stochastic Efficiency with respect to Function (SERF) analysis for the selected farming systems in the NKCVP area revealed absolute risk aversion coefficients ($r_a(w)$) ranging between zero (neutral) and 0.00014 (highly risk averse), with respect to the negative exponential utility function of SERF.

- Farming system I in NKCVP area was found to be the most risk efficient than the other three farming systems. FS-I showed certainty equivalent of Rs.24060 followed by FS-II (Rs.5299) and FS-IV (Rs.2640) while FS-III exhibited negative (Rs.-7548.32) certainty equivalent.

- In NKCVP area, farmers to move to FS-I (V+C+M+L),the most risk efficient farming system, the amount of risk premium need to be paid to farmers was Rs.19187 for FS-II, Rs.22781 for FS-IV and Rs.33973 for FS-III at the respective absolute risk aversion coefficients.

- The analysis of opinions by respondents about positive externalities of project on the statements administered to respondents revealed that all the farmers (100%) in the region accepted recharge of borewells and received water from even some of the failed borewells. Further, more than fifty percent of respondents revealed increased groundwater table in the region. More than three-fourth (67.5%) of the respondents expressed that cropping pattern in the region has changed due to availability of water and remaining (32.50%) farmers opined that they continued to grow same crops. Sixty percent of the respondents expressed that additional land area was brought under cultivation. The on farm employment increase was expressed by 63.75 percent of sample farmers. More than fifty per cent (52.5%) of the farmers opined that project implementation helped to reduce irrigation water scarcity in the study area.

- With five years of project implementation, not much evidences of adverse effects were noticed (negative externalities). However, when farmers used water directly from the tanks filled with treated sewage water, they noticed the effects like soil acidity and leaching, decreased yields mainly with tuber crops. In addition, farm fields which are situated beside the tanks are being water stagnated like in Narasapura and Uddapanahalli villages.

- Negative externalities reported were increased usage of PPC (82.50%) and fertilsers (46.25%) and thus deterioration of soil quality (21.25%) in the study area. The more serious issue reported by the respondents was that treated water may pollute groundwater (48.75%) and adversely affect the water quality. Sixteen percent of the farmers expressed that crop yield levels decreased as these tanks became good habitat for many flies and insects, so they attacked the surrounding farms of tanks. One-third of the respondents expressed that due to bad smell and breeding of flies in the tanks, filled with the treated water was causing allergies, skin rashes and some other health issues with people and even animals (11%) when animals drink water from these tanks.

- The respondents, when presented with double bounded dichotomous CVM format to assess their willingness to pay for use of tank water, revealed that majority of farmers in KCVP area expressed their willingness to pay for assured irrigation through borewell recharge and equity in distribution of treated sewage water to village tanks. Little more than one-third of the farmers expressed their willingness to pay for both initial and second bid. However, 30 percent (24 farmers) were not willing to pay for first bid but expressed their willingness to pay for second bid. Fourteen farmers (17.5%) belonged to No-No category and 16.25 per cent (13 farmers) expressed their willingness to pay for initial bid and expressed their unwillingness to pay for second bid. The average willingness to pay for use of treated sewage water was Rs.713.58 per acre per year, as availability of treated sewage water would lead to borewell recharge and practice farming on assured irrigation.

- Tobit model was used to know the factors affecting WTP by farmers in KCVP area and it was found that education, farm income, scarcity of water and crop diversification index were the major factors influencing respondents to pay for KCVP.

Policy recommendations

- Diversification of enterprises by inclusion of vegetables, mulberry, livestock and other activities in the farming system helped to increase farm income and employment. Risk efficient plans considered profitability and the degree of risk involved in different crop and animal activities. The adoption of risk efficient plan would help farmers to generate sustained income from different farming systems. Hence, the extension agencies of State Department of Agriculture, Agricultural Universities and research institutes need to educate farmers about risk efficient plans through demonstrations.

- In different vegetable based farming systems, lack of sufficient labour during peak crop season was the major constraint. Hence, measures towards selective mechanization with strengthening or starting of custom hiring centres (CHCs) in the study area would be better proposition, as it would benefit majority of the small and marginal farmers to solve this problem..

- Farming systems involving animal component would reduce burden on external inputs such as chemical fertilizers. Hence, farmers may be encouraged to include animal component with subsidies and loans, which better utilize latent resources and exploit the complementary relationship.

- During survey, people in the region complained that the supplied water is not being properly treated and has been subjected to only primary and secondary filtration. Thus, request of people in the region for tertiary treatment needs worthy attention from the concerned authorities and missionary.

- Water users associations: For ‘regular and quality tertiary treatment of water, to prevent direct use of filled water in the tanks and creating awareness about the better utlisation of benefits from this novel idea of using the treated water for irrigation, there is a need to organise the water user association in the study area.

- Further, the existing mechanism of replication of similar projects in other parts of the state and country can be thought of by the policy makers, as in the initial years of its implementation (within five years) farmers have got economic benefits from the changes in the crop patern and better utilising the resource through diversification for stable farm income as the risk associated with farming in KCVP area found to be was relatively less due to assured irrigation for farming.

- Need for studies: The KCVP authorities are requested to fund the in-depth research studies on ‘testing of suitability of the water released through KCVP and its socio-economic impact’ and give due attention for timely publication of the findings for the benefit of stakeholders, so that it build the confidence among them for its usage.

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APPENDIX-I

Compound Annual growth rate of Area production and productivity of Vegetables in India

Year	Area (In ' 000 Hectare)	Production (In ' 000 MT)	Productivity (In MT/Hectare)
1987-1988	4120	48927	12
1991-1992	5593	58532	11
1992-1993	5045	63806	13
1993-1994	4876	65787	14
1994-1995	5013	67286	13
1995-1996	5335	71594	13
1996-1997	5515	75074	14
1997-1998	5607	72683	13
1998-1999	5873	87536	15
1999-2000	5991	90823	15
2000-2001	6250	93849	15
2001-2002	6156	88622	14
2002-2003	6092	84815	14
2003-2004	6309	93165	15
2004-2005	6756	101433	15
2005-2006	7047	110270	16
2006-2007	7584	115011	15
2007-2008	7848	125886	16
2008-2009	7982	129078	16
2009-2010	7985	133738	17
2010-2011	8495	146555	17
2011-2012	8990	156326	17
2012-2013	9205	162187	18
2013-2014	9396	162897	17
2014-2015	9542	169478	18
2015-2016	10106	169064	17
2016-2017	10238	178172	17
2017-2018	10259	184394	18
2018-2019	10073	183170	18
2019-2020	10316	189464	18
CAGR	3.198763596	4.58	1.30

APPENDIX-II

Compound annual growth rate of vegetables in Kolar district

Year	**Area(Ha.)**	**Production (MT)**	**Productivity (Kg./ha.)**
2010	33274	852692	25.63
2011	36084	969327	26.86
2012	36084	969327	26.86
2013	36084	969327	26.86
2014	36084	973843.5	26.99
2015	30559.9	759581.7	24.86
2016	33364	887938.1	26.61
2017	33615	903725.4	27.41
2018	41261	1337372	32.41
2019	34616	1322309	38.2
2020	38450.28	1413402	37.38
CAGR(overall)	1.00	1.04	1.03
CAGR(2016 after)	1.03	1.14	1.10

Per acre Cost and Returns of Mango cultivation in NKCVP area (n=80)

Sl. No.	Particulars	Value
1	Land preparation + digging pits	5665.60
2	Manure	9250.00
3	Fertilizers	10857.80
4	Planting materials	1650.00
5	Fencing	12040.00
6	Irrigation	2775.00
7	Labour	5756.00
	Total establishment cost	**47994.40**
8	Amortized cost	5452.40
9	Irrigation	2175.00
10	Growth regulators	6160.00
11	fertilizers	10050.00
12	PPC	11625.00
13	Labour	3240.00
14	Interest on working capital	3096.192
	Total variable cost	**41798.59**
	Fixed costs	
15	Rental value of land	10450.00
16	Interest on fixed capital	1222.18
17	Depreciation	1771.80
	Total Fixed cost	**13443.98**
I	**Total cost**	**55242.57**
	Returns	
II	Average yield (tons/farm)	3.80
III	Average price (Rs./ton)	16980.00
IV	Gross returns	64524.00
V	Net returns	9281.43
VI	Return per rupee expenditure	1.17

Appendix V: Schedule used for data collection

DEPARTMENT OF AGRICULTURAL ECONOMICS UAS, COLLEGE OF AGRICULTURE, GKVK BANGALORE-65

Schedule for data collection to be used for Ph.D. research

Research title: "Vegetable based farming system in Koramangala-Challaghatta(KC) Valley project area: An econometric analysis"

1. General Information

1.Name of the respondent : Phone number:
2.Village :
3.Occupation : Main :________________ Subsidiary :______________
4.Education : Illiterate /Primary /Secondary /College

5.Member of any institution : Panchayat / Cooperative society/Others

2.Family Composition

Category	Number	Available for	
		Agriculture	Other Profession
Adult Male			
Adult Female			
Children			

3.Land holding

Type	Dry land	Irrigated	Leased in /leased out	Garden/perennial	others	Total
Area (acres)						
Value (Rs.)						

4.Cropping pattern

Sl. No.	Crops	Season	Variety	Area (ac)	Source of irrigation	Production (Q)	Quantity marketed (Q)	Price (Rs./Q)	Market sold	To whom

5.Farm Assets

Sl. No	Name	Year of Purchase	Purchase price	Present Value	Expected life (Yrs)	Maintenance cost
1	Tractor					
2	Power tiller					
3	Bullock cart					
4	Wooden plough					
5	Iron plough					
6	Harrows					
7	Harvester					
8	Power tiller					
9	I.P Set					
10	Hand sprays					
11	Spades					
12	Processing equipment/machinery					
13	Others (specify)					

1. Farm buildings/Structures

Sl. No.	Items	Year of construction	Cost of construction (Rs.)	Present value (Rs.)
1	Farm house			
2	Cattle shed			
3	Poultry shed			
4	Pump shed			
5	Storage shed			
6	Threshing yard			
7	Others (specify)			

1. Details on Ground Water Irrigation

A. Bore well

Particulars	Well 1 Working/ failed	Well 2 Working/ failed	Well 3 Working/ failed
1. Year of drilling			
2. Cost of drilling (in Rs.)			
3. Drilling depth (ft)			
4. Diameter of well (inches)			
5. Casing length (cost in Rs.)			
6. Length of pipes (suction & delivery)			
7. Pump capacity (in HP)			
8. Pump (Cost in Rs.)			

9. Pump placement depth (ft.)			
10. Pump house			
11. Electrical Installation Cost.			
12. Water storage structure (Liters)			
13. Yield of the well (Inches)			
14. Other Costs (Specify)			

B. Drip irrigation

Sl. No.	Particulars	Details
1	Year of installation of irrigation structure/ Equipement	
2	Cost of main drip system (Rs.)	
3	Installation costs (Shifting of equipment and labour costs) (Rs.)	-
4	No. of emitters.	
5	Discharge per emitter in liters per time (Ltrs./hr).	
6	No. of hours of drip for each irrigation.	
7	Frequency of drip irrigation (Per week)	

C. Sprinkler irrigation

Sl. No.	Particulars	Details
1	Cost of equipment and other (*Viz.*, pipes)	
2	Installation Costs (Shifting of equipment and Labour Costs)(Rs.)	
3	No. of sprinklers in the area.	
4	Discharge per sprinkler per hour (Lts/hr)	
5	Frequency of sprinkler irrigation (Per week)	

Energy costs:

a. Method of irrigation:

b. Pump (HP):

c. Hours of electricity supply:

d. No. of units consumed:

e. Rate/Price (Per unit):

6. Possible benefits of K-C Valley project

Particulars	Before	After
Depth of borewell		
Yield of borewell (inches) a) Summer b) Rabi c) Kharif		
Irrigated area a) Summer b) Rabi c) Kharif		
Number of irrigations a) Summer b) Rabi c) Kharif		
Crops grown		

7. A Cost of cultivation of crops

Crop:…………, Variety:………………….., Area:…………….., Year of Planting,
Rental Value of Land:…….. Wage Rate: HL: M…W:…, Machine /Hour:……
Bullock Pair/hour ….………

Particulars	**Season_____ Crop____ Var:__ Area______**		**Season_____ Crop______ Area______**		**Season_____ Crop______ Area______**	
	Quantity	**Value**	**Quantity**	**Value**	**Quantity**	**Value**
1. Man days of labor						
2. Woman days of labour						
3. Bullock labour days						
4. Machine hours						
a) Tractor						
b) Others						
5.Seeds / planting material						
6.FYM (Tractor loads)						
7.Fertilizer type (Kg)						
a)						
b)						
c)						
8.PPCs: a)Liquid						
b) Dust						
9. Transport costs						
10.Packing costs						
11.Marketing costs						
12. Main product (Qtl)						
13. By product (Qtl)						

B. Marketing of the produce

Sl.No	Items	Quantity(kg)	Wastage(kg)	Cost incurred(Rs.)
	Crop 1:			
1	Grading/sorting			
2	Packaging			
3	Transportation			
4	Loading/unloading			
5	Processing			
6	Selling			
	Crop 2:			
1	Grading/sorting			
2	Packaging			
3	Transportation			
4	Loading/unloading			
5	Processing			
6	Selling			
	Crop 3:			
1	Grading/sorting			
2	Packaging			
3	Transportation			
4	Loading/unloading			
5	Processing			
6	Selling			

8. Crop wise Costs and returns (Perennials) in the study area

Crop: Variety: Season: Area: Spacing: Year of Planting:

Gestation Period:

A. Establishment Cost:

a. Labor utilization

Sl. No.	Particulars	Freq	Family		Hired		Bullock Pair		Machine Hours	
			M	W	M	W	owned	hired	owned	hired
1.	Land Levelling									
2.	Ploughing									
3.	Cleaning									
4.	Pit opening									
5.	Pit Filling									
6.	Nursery preparation (If Practiced)									
7.	Irrigation									
8.	Watch and Ward									

b. Material Costs

Sl. No.	Particulars	Quantity	Price/unit (Rs.)	Total cost
	Materials			
1.	Planting material			
2.	FYM			
3.	Vermicomposting.			
4.	Tank silt / External soil			
5.	Bio-fertilizers			
	a)			
	b)			
6.	Weedicides			
	a)			
	b)			
6.	Fertilizer			
	a)			
	b)			
7	Growth regulators			
	a)			
8	Plant protection chemicals			
	a)			
	b)			
10	Bio pesticides			
	a)			

B. Maintenance cost

Particulars	Crop______	Variety _______
	Quantity	Cost
1. Man days of labor		
2. Woman days of labour		
3.Bullock labour days		
4.Machine hours		
a)Tractor		
b)Others		
5.Seeds / planting material		
6.Manure (Tractor loads)		
7.Fertilizer type (Kg)		
a)		
b)		
c)		
8.PPCs: Liquid		
9. PPCs Dust		
10.Weedicides		
11. Growth Regulators		
12. Transport costs		
Packing costs		
Marketing costs		
13. Main product (Qtl)		
14. Price of main product		
15. By product (Qtl)		
16. Price of By product		

Mulberry

Leaf yield (kg/year): Cost of leaf (Rs./kg):

Total no. of crops per Year :

Qty of leaf sold:

9. Cost and returns of livestock sector

Sl. No.	Animals	No.	Purchased price(Rs.)	Present value (Rs.)	Production/Sale						Mainte nance cost	Total income
					Milk		Manure		Meat			
					Qty	V	Qty	V	Qty	V		
1	**Milch animals**											
	Cows											
	Buffaloes											
2	**Young Stock**											
	Cows											
	Buffaloes											
3	**Drought animals**											
	Bullocks											
	Cows											
	Buffaloes											
4	Poultry											
5	Sheep											
6	Goat											
7	Pigs											

C. Inputs for livestock

Sl. No.	Items	Quantity/month		Price (Rs.)
		Farm produced	Purchased	
	Dairy			
1	Groundnut cake			
2	Rice bran			
3	Concentrate			
4	Dry fodder			
5	Green fodder			
6	Medicines			
7	Labour (man days)			
	Sheep/Goat			
1	Mineral mixtures			
2	Green fodder			
3	Medicines			
4	Labour (man days)			
	Poultry			
1	Starter feed			
2	Finisher feed			
3	Medicines			
4	Labour (man days)			

10. Effects of use of treated sewage water

Positive effects/externality	**Yes/No**	**Negative effects/externality**	**Yes/No**
Bore well recharged		Soil quality decreased	
Water table increased		Water contamination with effluents	
Cropping pattern changed		Increased cost of production	
Cropping intensity increased		Human health problems(skin diseases, cold and cough and other microbial infections)	
Yield increased		Animal health problems	
Irrigated area increased(how much)		Usage of fertilizers increased	
On farm employment increased		Usage of higher pesticides compared to earlier	

11. Willingness to pay for the farmers for the equitable distribution of water

With the implementation of KC valley irrigation project, some of the tanks in the region have been filled with treated sewage water, which resulted in the recharge of near by borewells. In such cases, If government fixes some amount per acre and per year for every farmers in the region, will you be able to pay. If initial bid of water per year is Rs.1000/acre. This initial bid is based on the pilot survey.

- Are you willing to pay Rs. 1000 per acre? Yes / No
- If yes, are you willing to pay Rs.1500 per acre? Yes / No
- If no, are you willing to pay Rs.500 per acre?? Yes / No
- How much you are actually willing to pay per acre?

General information on Filling of tanks with treated sewage water

a. How frequently the tanks have been filled?

b. Tank size/capacity?

c. Protected provided for direct use of treated water?

d. How frequently Drying of tanks and desilting of tanks is being carried out?

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Drivers of Crop Diversification : An Empirical Evidence from Eternally Drought Prone Area of Karnataka

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Abstract

The paper has examined the crop diversification and factors affecting it in the Koramangala-Challaghatta (KC) valley project (KCVP) area and non-KC valley project (NKCVP) area of Kolar district, Karnataka using primary data collected from 140 randomly selected farm-households comprising of 70 each in KCVP and NKCVP area. The data were analysed using crop diversification index and fractional probit to assess the extent of crop diversification and factors affecting crop diversification. The empirical results revealed that herfindahl index of crop diversification was comparatively higher in KCVP irrigated area (0.423) than non-KC valley area (0.686) indicating higher degree of diversification in KCVP area. However, even under non-KC valley area too about 40 per cent of the respondents showed diversification index of 0.50. The results of fractional probit indicated that age, education, farm income, dummy for irrigation and access to extension services were found to be the major factors contributing to crop diversification in the study area. Thus, more emphasis on creating irrigation infrastructure and strengthening extension services would help diversification and minimize risk and stabilize farm income.

Keywords : Crop diversification, Herfindahl index, Farm income, Irrigation, KCVP, NKCVP

The risk is very inherent in any production process and it is more visible in farm sector especially in dry Agro-climatic zones. Farmers are advised to follow various measures to counteract the expected loss against the losses caused on account of various production, marketing and other risks. Hence, the adoption of diversified cropping pattern in one of the widely advocated strategy to the farmers. The crop diversification refers to a mix of farming systems rather than the shift from one given enterprise to another (Inoni *et al.,* 2021). It is also known by growing series of multiple crops mainly in one growing season on the same piece of land. As diversification being one of the possible strategy for farm households in stabilizing farm income and reducing various risks, like weather and market shocks by spreading both production and income risk over wide range of crops. Many a times climatic conditions like rainfall variability and risk aversion behavior of farm households makes farmer to go for diversification. Hence, crop diversification could be viewed as a hedge against risk due to shocks from extreme weather conditions, crop diseases & pests and unexpected fall of market prices, etc. The inherent characteristics of crop diversification that are widely accepted in the literature implies that it reduces potential risk against uncertainty by reducing high dependency on monoculture, reduces economic losses due to diseases, weed & infestation, and increases soil fertility through crop rotation (Krupinsky *et al.*, 2002). Crop diversification has become one of the viable option for resource sustainability, ecological balance, output growth, employment generation and above all the risk coverage.

Crop diversification is intended to give a wider choice in the production of a variety of crops in a given area so as to expand production related activities on various crops and also to lessen risk (Satish and Umesh, 2017). Crop diversification in India is generally viewed as a shift from traditionally grown, less remunerative cops to more remunerative crops. It is a strategy of shifting from less profitable to more profitable cropping pattern (Rathod *et al.,* 2011). The crop shift may include incorporation of high value crops through either vertical or horizontal diversification approach, more water consuming with less water consuming crops, replacing low yielding and low value crops with high yielding and high value crops like vegetables or pulses. Generally, diversification is an interactive effect of many factors like, resource related factors like fertility status of soil, rainfall; technology adoption related to seeds, fertilizer, storage, marketing and processing; investment capacity; economic factors like input and output prices, trade related policies, Government intervention; Institutional and infrastructure factors like research, extension and marketing. Although these factors are inter-related, the factors influencing area allocation to different crops depends mainlyon resource constraints along with economic considerations of relative crop prices rather than by other non-economic considerations. Similarly, economic factors play a relatively stronger role than non-economic factors in influencing the crop pattern in areas with a better irrigation and infrastructure potential.

Given the drawback of intensification and specialization of agricultural production has caused traditional crops upon which farm households' livelihoods have depended over the years and the consequent vulnerability and hunger in rural farming communities have made farmers to adopt crop diversification farming system (Inoni *et al.,* 2021). Apart from being a strategy against risk, crop diversification also reduces the vulnerability of agricultural production to climate variability and improves the household income. Therefore, this study was conceived to address various research questions like what is the extent of crop diversification? And what factors made farmers to diversify their farm fields? In eternally drought prone district *viz.,* Kolar district of Karnataka.

Kolar is a semi-arid drought prone district with an annual rainfall of less than 700 mm. In dryland areas, farmers are initially cultivating millets, groundnut, pulses, vegetables and mango due to scarce groundwater availability. Considering the significance of waste water on production and productivity of agriculture, Government of Karnataka had taken an initiative to implement Koramangala-Challaghatta Valley Project (KCVP), considered to be an unique project in the country. The scheme envisages filling of several tanks in Kolar and Chikkaballapur districts with treated sewage situation water from Bengaluru. The KCVP was initiated during November 2016 to supply treated sewage water to a total of 126 irrigation tanks situated in different clusters of Kolar and Chikkaballapur districts in a phased manner. Bengaluru Metropolitan and Karnataka State Government authorities have been grappling with the ever growing sewage problems. The KCVP thus has been designed to attain double benefits of help address the ever growing problem of Bangalore city's drain and sewerage water problems on one hand and on the other to rejuvenate the steadily declining groundwater table in the surroundings of the irrigation tanks in rural areas.

After implementation of KC valley project in the district, there is an improvement in diversification of crops, in addition and a study by Ramesh (2020) reported decreased depth of borewell drilling in the region as the project has led to replenishment of groundwater. In this backdrop present study is an attempt to know the extent of crop diversification and drivers of crop diversification in the study area.

Study Area and Selection of Farmers

The study was carried out in the Kolar district of Karnataka. Purposive random sampling design was employed for the selection of respondents. The primary data were collected from 140 farm households, consisting of 70 farm households in Koramangala Chellaghatta Valley Project (KCVP) area and 70 from Non-Koramangala-ChellaghattaValley Project (NKCVP) area, *i.e.,* area outside the KCVP area. The distinction between two categories of respondents was on the basis of implementation of KC Valley Project (KCVP) implementation (village tanks filled) in the district. The data were collected from the respondents through personal interview method using pre-tested, well-structured schedule to achieve the objective of the study. The villages were selected randomly based on the area in which tanks were filled under the project in the district. The required information regarding age, education level, average land holdings, cropping pattern, marketing practices pertained to the agricultural year 2020-21and farm income pertaining to previous year were collected. The sample villages included Chowdadenahalli, Doddavallabbi, Singenahalli, Dinnehosalli, Uddapanahalli, Lakshmisagara and Narasapura in KCVP area, while Imarakunte, Dasarathimmanahalli, Baipanahalli, Nukkanahalli, Hoodali, Bangarpete, Mulbagal and Mallasandra were the villages selected in NKCVP area.

Analytical Tools Used

The extent of diversification on the sample farmers was estimated using the standard methodologies as detailed below.

Herfindahl Index (HI): It is the sum of square of the proportion of area under each crop to the total cropped area and was estimated using the following equation:

$$HI = \sum_{i=1}^{N} P_i^2 \text{ .... (1)}$$

Where,

$P_i = \frac{Ai}{\sum Ai}$ is the proportion of area under i^{th} crop in the net sown area.

Then based on the index value, inference can be made as region is specialized if the value is closer to one and region is said to be adopting diversified copping pattern if index value approaches zero.

Simpson Index (SI): This measure of index is another widely used method for measuring diversification of crops of the region using the following equation:

$$SI = 1-\sum_{i=1}^{N} P_i^2 \text{ .... (2)}$$

Where,

$P_i = \frac{Ai}{\sum Ai}$ is the proportion of the i^{th} activity in acreage

The interpretation of results obtained from the Simpson Indices would be quite opposite to the interpretation of results obtained using HI, where, the value of index nearer to zero indicates area is marching towards specialization in growing of few crops and if index is closer to unity, that indicates zone is adopting diversified cropping pattern.

Fractional Probit Model : The fractional probit has been introduced by Papke and Wooldridge (1996) and has been extended to panel data by Papke and Wooldridge (2008).

Fractional probit model was used to identify the factors influencing crop diversification in the present study. The values of crop diversification indices obtained using Simpson Index of Crop Diversification (SICD), which ranges from 0 to 1 were used as dependent variable. This was regressed against various relevant regressors identified in consultation with the experts and previous literature related to the domain of the present study.

Fractional probit regression written as: $E(y/x)=\phi(x\beta)$

The model specification for the fractional probit regression model is given as:

$$Y=\beta_0+\beta_1X_1+\beta_2X_2+\beta_3X_3+\beta_4X_4+\beta_5X_5+\beta_6X_6+\beta_7D_1+\beta_8D_2+\mu \text{....(3)}$$

Where,

Y = SICD score

X_1 = Age (years)

X_2 = Education (No. of formal years of education)

X_3 = Farm income (Rs.)

X_4 = Average size of land holdings (acres)

X_5 = Distance to market (Kms)

X_6 = Human labour (Man-days)

D_1 = Region dummy (1 = irrigated area, otherwise '0')

D_2 = Access to extension services (1=Yes, otherwise '0')

Output-elasticities : Marginal effects of the explanatory variables at the mean could be obtained by:

$$\text{Marginal effect of } X_i = \frac{dy}{dXi} * \frac{\overline{Xi}}{\overline{Y}} \text{ (or) } b_i * \frac{\overline{Xi}}{\overline{Y}} \text{ ....(4)}$$

Where,

B = Parameter estimate (partial elasticity associated with each independent variable)

x = Mean of independent variable

y = Mean of dependent variable

Results and Discussion

Extent of Crop Diversification

The results on analysis of extent of diversification using the Herfindahl Index and Simpson Index are presented in Table 1. The value of Herfindahl index was 0.423 in KCVP area and 0.686 for NKCVP area, while, the

TABLE 1

Crop diversification in Kolar district of Karnataka

Index	KC valley irrigated area	Non-KC valley area
Herfindahl Index (HI)	0.423	0.686
Simpson Index (SI)	0.576	0.325

value of Simpson index was 0.576 for KCVP area thereby indicating that the region showed more diversification compared to in NKCVP area (0.325) revealing prevalence of less diversified crop pattern. In other words, crop pattern followed in NKCVP area was towards specialized farming and farmers have concentratedon few selected crops. The results of Ramesh (2020) also revealed similar findings of higher degree of diversification in KCVP area than NKCVP region.

Distribution of Respondents Across different Levels of Diversification

The values of Herfindahl indices were used in the present study to classify the sample farm households into five quartiles as relatively more diversified farms as one extreme category and the least diversified farms as another extreme category in both KCVP and NKCVP areas (Table 2). The comparison between the two situations is also presented in Fig.1. It could be observed from the table that, majority of the respondents in KC valley area (61 %) fall in the category of higher degree of diversification index of less than 0.50, followed by 25 per cent showed a diversification index in the range of 0.5-0.6 and rest of the 25 per cent of the respondents belonged to diversification categories of 0.6-0.7 (1.42 %), 0.7-0.8, 0.8-0.9 and more than 0.90 (7.14 %). Hence, it can be inferred from the findings that majority of the respondents in KC valley have adopted relatively more diversified crops due to various reasons such as assured irrigation availability and better farm incomerealisation.

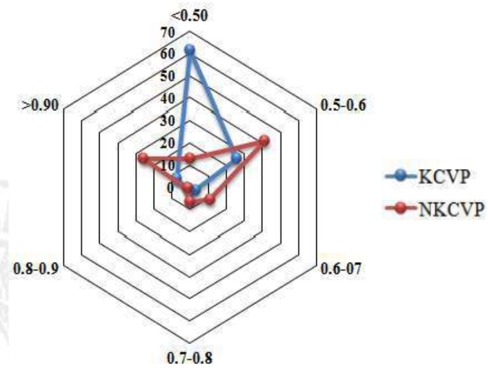

Fig. 1: Distribution of respondents according to diversification index

In contrast to KCVP area, 12 per cent of respondents in NKCVP area fall in the category of less than 0.5, indicating adoption of diversification by relatively smaller proportion of the respondents. The largest proportion of farmers (41 %) of the NKCVP area fall in the diversification index range of 0.5-0.6. However, one-fourth of the respondents fall in the category of adopting highly specialized cropping pattern. More than ten per cent and seven per cent of the respondents showed the HI index range of 0.60-0.70 and 0.70-

TABLE 2

Distribution of respondents according to Herfindahl diversification index

Herfindahl Index	KC valley area		Non-KC valley area	
	No. of respondents	Percentage	No. of respondents	Percentage
<0.50	43	61.42	9	12.85
0.5 - 0.6	18	25.71	29	41.42
0.6 - 07	2	2.85	8	11.42
0.7 - 0.8	1	1.42	5	7.14
0.8 - 0.9	1	1.42	1	1.42
>0.90	5	7.14	18	25.71
Total	70	100.00	70	100.00

0.80, respectively. Overall distribution of respondents in non-KC valley area infers that majority of respondents are towards the specialization or respondents adopted less diversified cropping pattern compared to KC valley area.

Determinants of Crop Diversification

The description of the variables having possible impact on the crop diversification have been identified and are presented in Table 3. The age of the farmer respondents ranged between 16 and 69 years, with an average age of 44 years. The number of years of schooling education of respondents was about eight years; however, formal year of education was ranged between zero to 15 years, indicating presence of illiterate respondents. The size of landholding is another important factor influencing diversification. The respondents in the study area own a farm size ranging between 0.5 acres to 20 acres with average acreage of 3.78. The number of man days of human labour used on the sample farmswas 39 man-days.

While considering the distance to market from the respondents' farms, they were located at an average distance of 12.46 kilometers to market with the farthest farm distance of 62 kilometers. Irrigation dummy and access to extension services were the other two variables considered to estimate their influence on crop diversification. The variables considered for the model are expected to have significant influence on the crop diversification and were selected based on the previous literature and consultation with the expert on the subject.

The results of the fractional probit model calculated using the model presented in the methodology section (Equation 3) are presented in Table 4. Majority of the selected predictor variables have shown positive and significant effect on crop diversification in the study area. The test statistics showed that the model chosen for estimating the crop diversification and its determinants found to be well fitted the data, with Wald's criteria, $\chi^2(8)$ found to be 296.44 and was highly significant. The estimated results have shown that crop diversification of the desired attributes was triggered by heterogeneity of the different farming systems adopted and socio-economic characteristics of the respondents.

The estimated coefficients for age (0.027), farm income (4.022), Irrigation dummy (0.287) and access to extension services (0.445) revealed positive and significant influence on the crop diversification (Table 4). While, size of land holdings and the distance to market had negative impact on crop diversification in the study area as revealed by the negative

TABLE 3

Summary statistics of variables used in fractional probit model

Variable	Variable description	Mean	Standard deviation	Minimum value	Maximum value	Expected sign
CDI	Intensity of crop diversification	0.44	0.257	0	1	
FARMAGE	Age of the respondents (Years)	43.00	14.56	16	69	+
EDUC	Education level (years of formal education)	8.44	3.53	0	15	+
FARMINCOM	Farm income (Rs.)	187920.22	108756.12	12950	823145	+
FARMSIZE	Size of farm (acres)	3.78	2.99	0.5	20	+
ACCESEXTEN	Access to extension services (1 = Yes, 0 otherwise)	0.56	0.49	0	1	+
ACCESIRRI	Access to irrigation (1=Yes, 0=otherwise)	0.49	0.50	0	1	+
DISTMARKT	Distance to market (Kms)	12.46	12.14	0	62	+
HUMLBR	Human labours used (Md)	39	27.29	8	96	+

TABLE 4

Estimates of fractional probit model on factors affecting crop diversification

Variables	Parameters	Coefficients	z value	P value
FARMAGE	X_1	0.027	6.80	0.0002*
EDUC	X_2	0.017	1.77	0.0760***
FARMINCOM	X_3	4.022	2.56	0.0101*
FARMSIZE	X_4	-0.034	-2.49	0.0192*
ACCESEXTEN	D_1	0.287	3.67	0.0001*
ACCESIRRI	D_2	0.445	5.18	0.0023*
DISTMARKT	X_5	-0.006	-0.36	0.7204
HUMLBR	X_6	0.0008	1.45	0.1483
Constant	β_0	0.461		
Log pseudo-likelihood value	-80.04			

Note: *, *** indicates significance atone and ten per cent probability level, respectively

coefficients for these variables. Although coefficient for education level found to be positive but fail to exert any significant influence on the crop diversification.

The chosen independent variables were regressed against the SI of crop diversification as dependent variable. It could be inferred based on the coefficient for age of the respondents that as people grow older, with acquired experience would change their objective from profit maximization to risk minimization by diversifying the crops. As one per cent increase in age of respondent would increase the practicing crop diversification by about 22 per cent as revealed by the marginal effect for the variable (Table 5). These results are consistent with the findings reported by Rehima *et al.* (2013). As expected, education level of the respondents had positive and significant influence on the diversification and these results are in-line with study conducted by Inoni *et al.* (2021). As income of farmer increases he tend to invest more on the farm by taking up many crops suitable to the region, which provides him assured income. Results on influence of previous years' farm income indicated that one per cent increase in farm income would increase the diversification by 24 per cent. But the study made by Das and Kumar (2017) revealed that diversification upto some level helps improve farm income but excessive diversification might lead to misallocation of resources and hence a fall in income. Increase in average land holdings would result in decreased crop diversification, *i.e.*, with the increase in land holdings farmers tend to go for more specialized crops in the study area, as they could go for practicing greater degree farm mechanization and benefits of economies of scale and cut down the overhead cost in the usage of services of durable assets in production. The increase in average land holdings would decrease the diversification on farm marginally by 3.1 per cent as revealed by marginal effect. These results are contradictory to the results of Sichoongwe *et al.* (2014), who reported that an increase in the size of landholding would better enable a farmer to diversify. With the extra size of landholding, the farmer can decide how many crops to grow based on his or her production decisions.

TABLE 5

Marginal efficiency of factors affecting crop diversification

Variables	Elasticity	Marginal effect
FARMAGE	0.027	0.227
EDUC	0.017	0.335
FARMINCOM	4.022	0.244
FARMSIZE	-0.034	-0.031
ACCESEXTEN	0.278	0.314
ACCESIRRI	0.445	0.566

Distance to the market had negative effect on crop diversification. This implies availability of market in the nearby places would favour the crop diversification, as marketing of produce would beeasy. This findingis in consistent with Monika *et al.*(2017). Access to extension service, measured in frequency of contacts made with extension service providers like Department of Agriculture (RSK), Input dealers, discussion with neighbours and friends were also the important factors found to influence a household's decision to diversify, *i.e.,* every contact with extension service provider had resulted inabout 31 per cent increment in crop diversification above average. Similar impact of access to extension services on diversification was reported by Mandal and Bezbaruah (2013).

Irrigation being one of the major factors influencing crop production, farmers using irrigated water from borewell recharge of KCVP area showed positive and significant influence on the crop diversification. It implies that with the availability of irrigation water farmers can grow more number of crops per unit area (mainly vegetables) with increased cropping intensity. In addition, it induces him to go invariably realize benefits from crop rotations beside maintenance of soil health. In addition, it can avoid damage by the soil born insects, pests and diseases due to practice of diversified crops. Usually in non-KC valley area farmers go for less water requiring crops due to inadequate groundwater. This may be attributable to the fact that they are not being benefitted by groundwater recharge through filling of tanks as in the case of KCVP area. Every per cent increased access to irrigation water in the study area could result in increased crop diversification by 56 per cent, as revealed by the marginal effect (Table. 5).

Agriculture being seasonal in nature and highly sensitive to various shocks like weather, market and poor access to irrigation. Crop diversification has been considered as one of the important strategy to stabilize farm income and reduce the extent of risk involved. Hence, the present study which was aimed examining the crop diversification and its determinants, found out that the crop diversification was found to be higher in KCVP area compared to NKCVP. Thus irrigation proved to be one of the major determinants of diversification. The results from the fractional probit model depicted a positive and significant association of age, education, farm income, access to extension services and irrigation dummy with crop diversification, while farm size and distance to market were negatively associated with diversification. The study concludes that irrigation and education are major determinants of crop diversification in the study area.

Extending the irrigation tanks filling opportunity to other areas and replication of similar kind of projects of treating sewage water use for irrigation would help to go for diversified cropping pattern, enhanced income and livelihood security of the farmers.

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