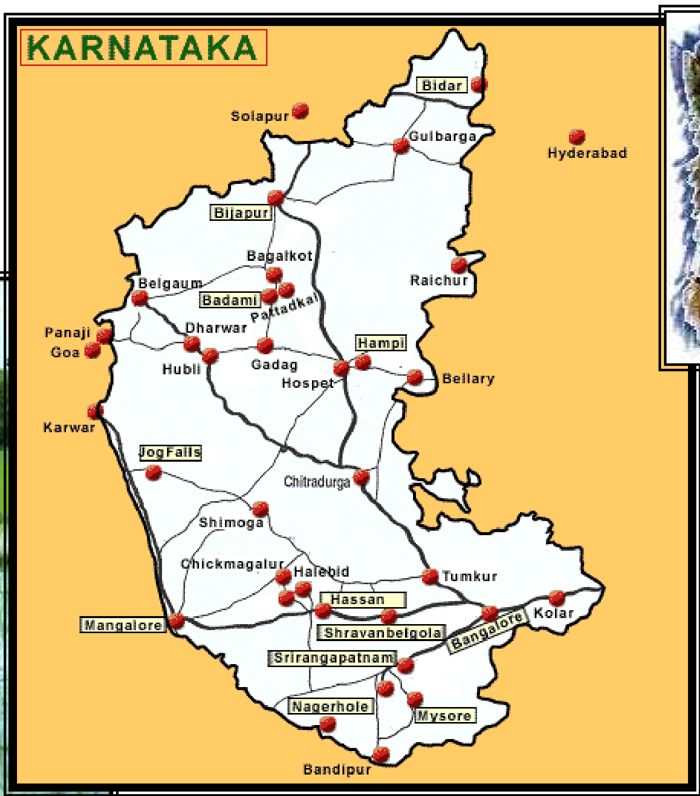
Agro-Ecological Impact Assessment of the Karnataka State Policy of Organic Farming (KSPoOF) in Five Districts of Karnataka State, India



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MSc Thesis Plant Production Systems
Wageningen University, November 2010

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Abstract

The agricultural sector in India employs 60% of the nation's working force but stagnating yields and prevalent farmers' suicide rates are threatening the development of the sector. Policies that promote intensive farming have led farmers into high debts through the continuous purchasing of external inputs that have become crucial for their farming systems to function. Karnataka state holds one of the highest rates of farmer suicides amongst all the states in India. The Karnataka state Policy of Organic Farming (KSPoOF) encourages organic farming in order to reduce external input which can reduce the cost burden for farmers, enhance soil fertility which can increase the production and ultimately increase the sustainability of the agricultural sector.

The aim of this research is to quantitatively analyze the ecological impacts of conversion to organic farming, using agro-ecological indicators, within five taluks[1] in Karnataka state, India. Through literature reviews three agro-ecological indicators were chosen and operationalized through a set of explanatory variables as to represent the state of soil quality, water quality and agrobiodiveristy: (i) soil organic carbon, (ii) water electrical conductivity, and (iii) planned biota per ha. These indicators were compared in three situations to measure and analyze the impact of implementing KSPoOF production schemes. The three situations are: (i) farms before the policy in 2006; (ii) farms in policy villages in 2009 (2009_P); (iii) farms neighboring to the ones with 2009_P, where the policy was not launched yet (2009_N). In addition, the differences in farming practices among the three above-mentioned situations are also analyzed. Finally, analysis led towards linking the differences of farming practices to agro-ecological indicators.

The results showed that the conversion of five sampled taluks (in different agro-ecological zones in the state) took place in varied pace and with a varied extent. Other agricultural schemes and mindsets of market orientation are considered to be more dominant than KSPoOF, therefore the adoption of organic farming principles as promoted by KSPoOF has reduced. Bijapur_Bijapur (B_B) and Mysore_HD Kote (M_HK) had 100% organic fertilizer usage in 2009_P which meets one of the standards of organic farming, but in Kolar_Gowribdibnur (K_G) hardly any conversion had taken place. The policy was found to positively influence the soil organic carbon content in M_HK. The increment of SOC content was observed in three taluks and the phenomenon was mainly caused by the abundantly available micronutrients in organic fertilizers in B_B and M_HK. However, in K_G, higher percentage of maize cultivation is assumed to provide good sources as green manure. For the analysis of agrobiodiversity, the analysis is influenced greatly by the land holding size of farmers', therefore the influence of the policy can not be concluded. It would help to have more data about types and numbers of species in the agricultural landscapes. Water quality seems not significantly being influenced by the policy in general. However, the opposite effect of policy was observed as significantly higher water electrical conductivity appeared in Udupi_Udupi in 2009_P compared to 2009_N. The result indicated that organic farming should be tailored designed according to local situation to really receive the benefit as expected.

This report presented the state of conversion to organic farming in 5 taluks in Karnataka state and the agro-ecological impacts due to the conversion. Besides, my experiences of being an intern in NGO, Ashoka Trust for Research in Ecology and the Environment (ATREE) conducting this research are described in my internship report which is attached as Appendix VI within this report.

[1] A taluk equals to a sub-district comprising several villages or village clusters.

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1. <u>Introduction</u>

1.1 Background of the Research

1.1.1 Agricultural Crisis in India

Agriculture has long been a substantial activity for India; 45% of the land is used for cultivation and 22% is under forest in this country. Besides, the agricultural sector employs the biggest number (60%) of the working force in India. The development of agriculture is not merely concerned with individual farm households, but also with the majority of the population in India. However, there has been a continuous down-turn of agricultural GDP in the nation (from 34.7% in 1980 to 21.7% in 2004 to 17.8% in 2008) resulting in the wide spread agrarian distress (Purushothaman, et al, 2009). The problems related to the distress include three dimensions, namely ecological, economic social problems. They received wide discussions in media and among scholars (Mathur et al, 2006; Rao et al, 2004; Vasavi, 1999).

Ecological problems include (i) degradation of soil fertility and water quality due to over-use of chemical fertilizers, (ii) degradation of soil in rain-fed cultivated areas due to demolishing of trees and grass cover, (iii) stagnant yields due to unstable monsoons and droughts, and also excessive and unbalanced nutrient use, (iv) and the deterioration of groundwater level which is an important, and often the main source of irrigation.

Economic problems include increasing costs for external inputs; trade liberalization induced volatile crop prices which mainly reflect the international market instead of national harvest level. Farmers are more motivated to grow high-priced crops. For instance, there was a mass shifting to cotton cultivation even in areas without ideal soil and climatic conditions when the cotton price was high in the mid-90s. Unfortunately, the subsequent collapse of the cotton price made a devastating rebound to farmers. In addition, in dry land areas, most of the staple crops like millet or sorghum were replaced by cash crops such as groundnut which needs great use of irrigation. As a result of various shifting, almost 50% of farmers in the country are indebted (Rao, et al, 2004).

Social problems include marginalization and subdivision of land holdings, considerable decline in public investment in the agricultural sector, inaccessibility to the institutional credits and eventually all the problems manifested as severe agrarian distress leading to prevalent farmers' suicides (Ghosh, 2009; Rao, et al, 2004; Swaminathan, 2007; Vaidyanathan, 2006).

The Census of Farmer Suicide Rate (FSR) showed that the number of farmer suicide cases rose sharply from under 14,000 in 1997 to over 17,000 in 2005. Nearly two-third of 150,000 suicidal cases between 1997 and 2005 were happening in four states: Maharashtra, Andhra Pradesh, Karnataka and Madhya Pradesh. On the other hand, while the number of farm suicides keeps increasing, the number of abandoned farms has increased since 2001 (Sainath, 2007).

Although there is no single reason for farmers' suicide, the problems related to agrarian distress in general are the major reasons for it. In addition, the four states with the highest suicide incidences all have common farming conditions which are low rainfall and few irrigation facilities (Sainath, 2007). Even under these conditions, cropping pattern has largely changed from rain-fed dominant cultivation to commercial crops based on high inputs and hybrid seeds. Although productivity is higher for commercial crops than rain-fed ones in good years, the volatile market prices and the dependence on weather conditions make the commercial crops under high risks (Vasavi, 1999).

Figures of the FSR show that households at which suicides took place mainly have (i) a much higher level of total debt, (ii) money greatly comes from non-institutional sources like moneylenders and brokers, (iii) and a high proportion of the debts is used for non-productive purpose (Jeromi, 2007; Sunianchandra et al, 2007; Vasavi, 1999). Another reason that brings most suicide-afflicted households in heavy debt is the well digging activity. A distinct point was that Jeromi (2007) found that nearly 60% of the victims had a land area below one acre which also mentioned by Sunianchandra (2007) that most of the suicide victims were marginal, small or medium level farmers, although there was no significant difference in land holding sizes between suicide victims and farmers in control group. An explanation to this observation of higher FSR of marginal and small farmers is that the resource-poor farmers have little coping capacity to withstand the shock of a crop failure. At the same time, they are considered to be "creditunworthy" and therefore often bypassed by institutional credit agencies (Vasavi, 1999). Concluding the main reasons for debt traps are crop failures and not fetching reasonable prices for their production in the market. In addition, inaccessibility of institutional credit led to the consequence of the suicides.

1.1.2 Description of LUPIS Indian Case Study

This research is part of the EU-project Land Use Policies and Sustainable Development in Developing Countries (LUPIS). LUPIS is a four-year project aiming at developing integrated assessment tools which can be applied to ex-ante assess land use policies. Eventually, the assessment tools and applications are aimed to bring benefits to farming households in developing countries that will resist beyond the lifetime of the project. Among different case studies in selected countries, the Indian case study focuses on assessing the impact of policies related to land use and agriculture on sustainability of small and marginal farmers in the state of Karnataka (Purushothaman, et al, 2009).

Karnataka state is known for its soaring economic growth especially in information technology (IT) industry and severe agrarian distress since market liberalization in the 1990s. The state government deployed several policies supporting commercialization in the agricultural sector (so called sectoral policies) like Intensification policy, National agricultural price policy, and Technology missions, which provided incentives for farmers at all levels to start cultivating specific cash crops. However, as the commercialization and intensification also had adverse impacts as described in Section1.1.1, several policies are currently implemented to reduce agrarian distresses. One of them is the Karnataka State Policy of Organic Farming (KSPoOF) which is in line with National Program for Organic Production (NPOP) standards proposed by Indian Government. NPOP and KSPoOF both pursue the ideas of using internal inputs and maintain self-resilience of the small scale farming households (Purushothaman et al, 2008). In the sense of sustainable development of small and marginal farmers, KSPoOF is selected as a highlight to be assessed in LUPIS Indian case study for its impact on land use and sustainability (Purushothaman, et al, 2009).

1.1.3 Introduction of Karnataka State Policy of Organic Farming (KSPoOF)

There are five strategies ("*Panchasutra*" in local parlance) declared in the Common Agricultural Policy issued by the Government of Karnataka in 2006: (i) protection and improvement of soil health, (ii) conservation of natural resources with special emphasis on water and micro irrigation, (iii) timely availability of credit and other inputs to the farmers, (iv) integrate post harvest processing, (v) and reducing the distance between "Lab to Land" in transfer of technology. Through the strategies implementation, it is expected to double agricultural productions in the next ten years and farmers should get the best price for their production (Khashempur et al, 2006b).

Karnataka State Policy of Organic Farming (KSPoOF) is one of the acts embedded in the five strategies described above. Four central topics have been described in the KSPoOF document including (i) principal requirements of organic farming, (ii) policy objectives on organic farming, (iii) future strategy for promotion, (iv) and revival of this traditional farming system (Karnataka State Policy on Organic Farming, 2004). The interests of the state government towards organic agriculture come from the principles of this farming practice emphasizing on diversifying crop rotation and an intensive partnership with animal husbandry in order to maintain ecosystem balance. Besides, there will be less dependence on financial and external inputs in organic farming. Instead it puts more reliance on natural and human resources which are abundant in India (Khashempur et al, 2006a). The objectives of the KSPoOF are:

- To enhance soil fertility and productivity by increasing life in soil

- To reduce the dependence of farmers for most of the inputs which minimizes the costs of cultivation
- To increase the food security by encouraging traditional crops and traditional food habits
- To facilitate farmer's Self Help Groups (SHG) for meeting their needs
- To equip the farmers to effectively mitigate the drought situation in rain fed and drought prone areas

In order to reach the objectives, the principal requirements for organic crop production are:

- Versatile crop rotation
- Recycling of organic materials
- To avoid the use of synthetic chemical fertilizers and pesticides via wide range of pests and disease control such as habitat development

Meanwhile, the principal requirements for animal husbandry are:

- Providing sufficient good quality organic fodder which can be achieved by on-farm production as much as possible
- Growing forage crops improves crop rotation, diversification and balance of the system
- To ensure animal welfare by providing "keeping system" according to their inherent behavior and provide proper veterinary care

The large part of strategies for promoting organic farming is to establish groups at different levels such as a state-level committee or self help groups (SHGs) or farmers' co-operatives. Among them, SHGs are exclusively set for purpose of production of quality compost/vermicompost or organic seeds/ planting materials. The primary approach to shift current cultivation methods to organic ones is to select at least one village per area for conversion. The criteria for village electing are:

- Least consumption of inorganic fertilizers and pesticides
- The potential for the organic source of inputs in the area
- Existing diversified farming systems comprising agriculture, horticulture, animal husbandry, apiculture etc.
- Intensity of multi-purpose tree coverage
- Crops in the area which are of commercial/industrial/ medical and aromatic/foods and trade importance would be identified for production under organic system

Some other principles for practicing organic farming were also mentioned in the policy document such as to keep one cow per two acres and to enhance biodiversity by planting appropriate tree species.

1.2 Research Objectives

The main aim of this research is to quantitatively analyze the ecological impacts of conversion to organic farming, using agro-ecological indicators. Data have been collected before (2006) and after (2009) launching the KSPoOF. In order to assess to what degree the policy has been implemented and had effects, changes in farming practices in terms of conversion from conventional to organic farming were analyzed. Further, changes of agro-ecological indicators such as soil quality, agrobiodiversity, water quality and crop yield were analyzed as well.

The ultimate goal is to analyze if KSPoOF is able to bring positive influences on farming households, especially small and marginal ones in Karnataka State, and the results of this research were used for ex-ante assessment towards 2015.

1.3 Research Questions

If KSPoOF has been implemented according to its objectives, several outcomes are expected to be seen in the policy implemented villages after some years the policy has been put into practice: (i) better soil quality, (ii) higher planned biota diversity on farm, (iii) better ground water quality and (iv) better quantity of crop production due to better soil fertility. However, to achieve this, farmers need to make several changes of farming practices to achieve the goals, such as (i) to keep more livestock on farm for their manure (ii) to cultivate more fodder crops for livestock feed, (iii) to reduce or abondon application of chemical fertilizers. Therefore, it is assumed that above changes regarding farming practices have been adopted by the farmers in policy implemented villages. Consequently, these will reflect in better results in an agro-ecological impact assessment of farm performances after the policy was implemented compared to before implementation of the policy. There are four research questions based on the hypotheses above:

(i) Were there changes in farming practices between year 2009, 3 years after the policy had been deployed and year 2006, before the policy, in terms of :

a) Types of fertilizer applied on farm
b) Cropping pattern
c) Livestock density

Since one of the objectives of the policy is to reduce dependence on external input which can substantially lower the costs, most beneficial farmers are expected to be marginal and small farmers. It is necessary to examine if small scale farmers were the main beneficiaries from the organic farming policy. Therefore, land holding sizes of farmers will be investigated in this research.

(ii) Are the agro-ecological conditions on farms better in the policy village in year 2009 than in year 2006, in terms of:

a) Soil quality
b) Agrobiodiveristy
c) Water quality
d) Crop yield

(iii) Which are the major factors influencing the changes of agro-ecological conditions on farms? There are two sub-questions related to question (iii) shown below:

a) Are the influential factors related to implementation of KSPoOF?
b) Do any other factors (f.e. biophysical factors) also influence the changes observed on farms?

(iv) Besides to analyze the changes of agro-ecological conditions per taluk (taluk-level), we also like to investigate the trend of changes at state-level[2] to find if there are any differences between two different levels?

Three main statistical analysis methods were applied in order to answer respective research question above. For questions (i), (ii), and land holding size analysis, Analysis of Variance (one-way ANOVA) method was used for analysis. For questions (iii) and (iv), the methods Spearmans' Rho correlation method and multiple regression analysis were used.

[2] State-level analysis will be conducted by integrating all data sets from five taluks within this research.

2. Agro-ecological Indicators selection

Agro-ecological indicators are often used in environmental impact assessment (Bockstaller et al, 1997). Indicators play a role in assessing the state of a system by means of indicative variables as well as transmitting the information from a complex system and make them more comprehensible (Mitchell et al, 1995). The agro-ecological indicators chosen in this research are to fulfill the function as decision aid tool. In this sense, the indicators need to have capability to reveal changes in a system and also show the trends. The first stage of developing the indicators is to define the objectives and potential users (Girardin et al, 1999) where in this case the Karnataka state Government is the potential user, and the objective should correspond to the aim of KSPoOF which is to promote organic farming and reach sustainability in the agricultural sector. Because of the identical objective in the previous (Girardin, et al, 1999) and this research, the procedures of breaking down the main objective into specific quantifiable objectives proposed by Girardin et al. (1999) can be adapted here (Figure 1).

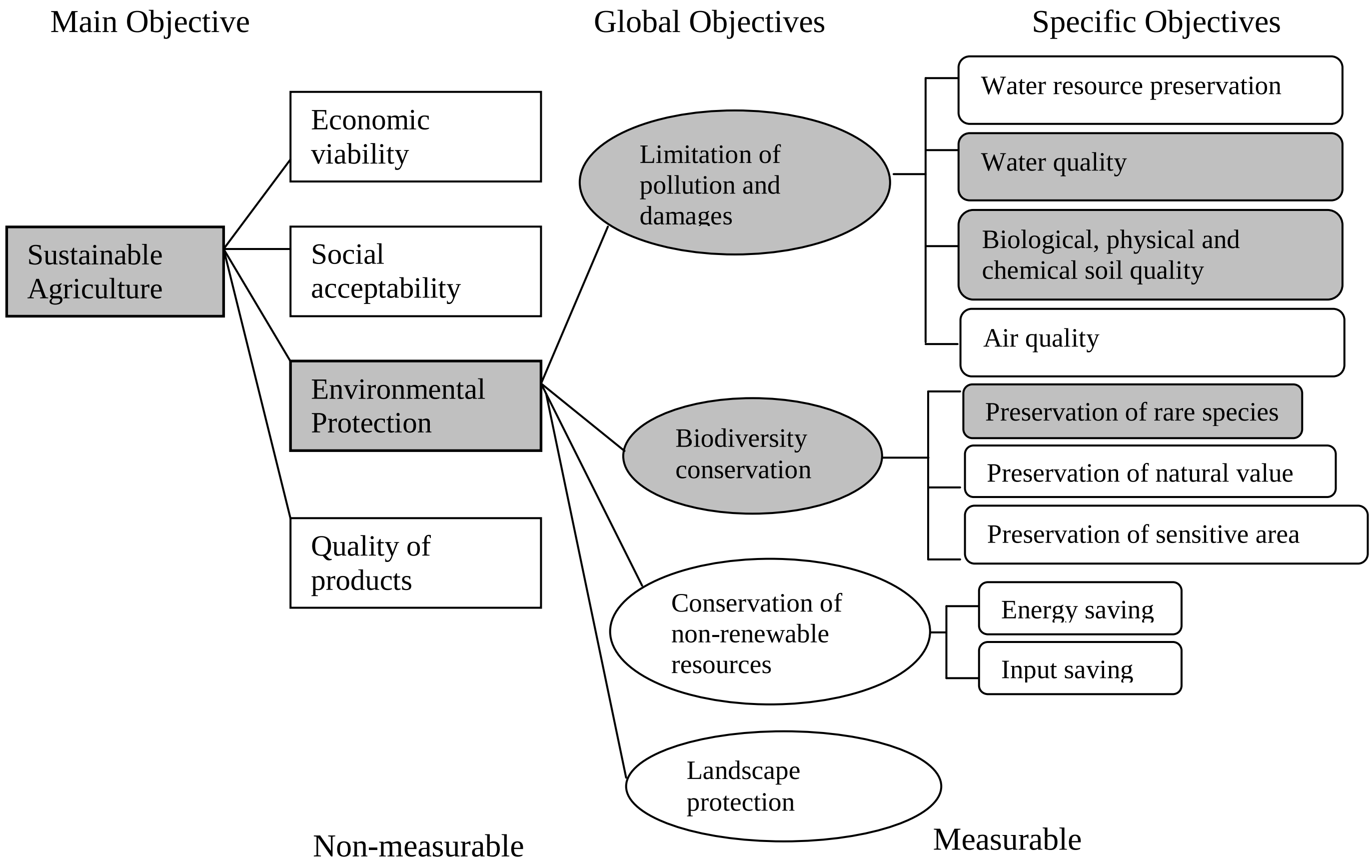


Figure 1. Demonstration of the procedures how to dissect the main objective of sustainable agriculture to specific measurable objectives. Boxes in gray color are the objectives selected for this research.
Source: (Girardin, et al, 1999).

According to Figure 1, the ecological aspect of sustainable agriculture includes five specific objectives which are soil quality, water quality, air quality, preservation of natural area and species, and energy saving. Because the impact of the policy on agro-ecological environment is the target to be assessed in this research, the five specific objectives can be applied as the agro-ecological indicators. Due to the limited data collected, only three agro-ecological indicators are used: (i) soil quality, (ii) water quality and (iii) agrobiodiversity (preservation of natural area and species).

The measurements of these indicators should not include only absolute values but there should be a comparison between the present and the previous one or actual value and a norm. As for this research, data was collected in year 2006 and 2009 respectively which makes it possible to compare the difference between data in benchmark year and the one under policy intervention.

According to the definition of sustainability (United Nations, 1987), social and economic indicators should be selected and analyzed as well to achieve the sustainability impact assessment. In fact, social indicators including conflicts, income and asset disparity; and economic indicators including farm income, percentages of food from farm and outstanding debt are all studied in LUPIS Indian case study. The assessment of agro-ecological indicators of this research can be integrated with social and economic indicators by multi-criteria analysis for sustainability assessment in the future.

2.1 Measurable Indicator and Explanatory Variables for Soil Quality

In order to know which factors influence the changes of our three indicators, some relevant measurements should be identified. Those measurements are also called explanatory variables (Billeter et al, 2008). Those explanatory variables have function of being the independent variable in statistic analysis for explaining the variation of three indicators. Criteria for choosing explanatory variables are greatly determined by literature reviews as well as data availability (Stolze et al, 2000). More detailed descriptions of explanatory variables are provided in following paragraphs.

The definition of soil quality is largely defined by its function (Karlen et al, 1997). To elaborate further, soil quality is the capacity of soil to function for sustaining plant and animal productivity, maintain water and air quality, and support human health and habitation (Doran et al, 1994). With respect to agricultural land, soil quality is especially used to indicate the soil fitness to support crop growth (Karlen, et al, 1997). Therefore, soil fertility is the essential soil function. Other functions like (i) retaining and supplying water to plants, (ii) resisting degradation, (iii) supporting plant growth as the foundation, are also strongly related to soil quality and productivity. Karlen et al. (1997) applied ten measurements (Table 1) to assess potential soil quality indicators.

Table 1 The selected measurements for soil quality assessment and the processes influenced by them.
Source: (Karlen, et al, 1997)

Measurements	Process affected
Soil organic matter	Nutrient cycling, pesticide and water retention, soil structure
Infiltration	Runoff and leaching potential, plant water use efficiency, erosion potential
Aggregation	Soil structure, erosion resistance, crop emergence, infiltration
pH	Nutrient availability, pesticide absorption and mobility
Microbial biomass	Biological activity, nutrient cycling, capacity to degrade pesticides
Forms of N	Availability to crops, leaching potential, mineralization and immobilization rates
Bulk density	Plant root penetration, water-and air filled pore space, biological activity
Topsoil depth	Rooting volume for crop production, water and nutrient availability
Conductivity or salinity	Water infiltration, crop growth, soil structure
Available nutrients	Capacity to support crop growth, environmental hazard

Soil organic matter (SOM) is the essential element for soil fertility, productivity and quality (Katyal et al, 2001). The negative relationship between decline in SOM and present crop productivity as well as sustainability in the future has been validated (Katyal, et al, 2001). Although SOM does not directly influence crop growth, it influences primarily the soil structure physically by stimulating activities of micro-organisms. SOM is decomposed by micro-organisms as food source, and during the process of decomposition from SOM towards humus, the capacity of soil aggregation stability increases which enhances water and nutrient retention. Moreover, the secretion of micro-organisms and their movements help gluing soil particles together for better structure and increasing porosity of the soil (Bot et al, 2005). Better soil structure helps with water infiltration and seed emergence. The other benefit from more SOM and higher micro-organism activity is that the excess nutrients (N, P and S) broken down by micro-organisms can be taken up by plants. In fact, the term SOM refers to organic composition in the soil such as dead plants, animals and products produced when these are decomposed and the microorganism biomass. Organic compounds contain carbon (C), oxygen (O) and hydrogen (H) and also nitrogen (N), phosphorus (P) and sulfur (S) while the majority of C is held as soil organic carbon (SOC) in the soil. On average, SOC comprises 58% of total SOM mass (Dayal, 1978). Therefore, the amount of SOM in the soil can be detected indirectly by measuring SOC content.

Soil degradation is a wide spread problem that leads to SOM depletion, especially in semi-arid and sub-humid tropics (Syers et al, 1996) where larger amounts of organic inputs are needed to maintain organic matter in the state of equilibrium and maintain soil fertility. Organic inputs include livestock manure, green manure, inorganic fertilizers or inclusion of leguminous crops in the cropping system. Soil salinity and extreme soil pH value are two phenomena belonging to soil degradation. The reason why soil salinity and extreme soil pH resulting in the decline of SOM is due to their negative influence on biomass production and also their harmful effects for the survival of micro-organisms. As the consequence, the decomposition of organic material by micro-organisms is poor (Bot, et al, 2005). Ramesh et al. (2007) found soil pH level reduced tremendously over a period of 22 years in the watershed in Karnataka State for soil quality monitoring research. The main reasons for higher soil acidity are the increased amount of horticultural crops cultivation which replaced original cereal crops and high use of inorganic fertilizers like urea and diammonium phosphate (DAP). As for soil salinity, another farming practice, irrigation, especially in arid and semiarid regions is the main cause for soil salinity and waterlogging of agricultural land (Matson et al, 1997). In summary, the choices of land use management and nutrient application pattern are the main factors influencing the changes in soil quality. Besides the factors mentioned above, temperature is a key factor deciding the decomposition rate of plant residues by micro-organisms. The warmer the temperature, higher decomposition rate can be observed. This is the reason why SOM content is commonly more abundant in temperate areas than in the tropics. Soil moisture also affects the amount of soil organic matter. In rain-fed agricultural land, soil moisture is largely determined by the annual rainfall while higher rainfall increases SOM level because of the greater biomass production (Bot, et al, 2005).

Soil organic carbon acts as measurable indicator for soil quality in this research because of its representability of SOM. Based on the descriptions of each factor that is influential on the amount of SOM, those factors are chosen as explanatory variables for assessing variation of soil fertility in which SOM stands for. Explanatory variables are: (i) the intensity of land management including cropping intensity, livestock density, irrigation percentage (ii) nutrient application pattern including annual amount of chemical fertilizer N and the proportion of organic fertilizer application, (iii) annual rainfall. In addition, the chemical, physical and biological properties of soil also represent soil quality, therefore other explanatory variables are: (iv) amount of soil available phosphorus (P) and (v) soil available potassium (K) which directly indicate availability of nutrients to the crops, (vi) electrical conductivity (EC) which indicates the level of soil salinity, (vii) soil pH value which affects the suitability of environment for microorganisms. Temperature is not included as explanatory variable mainly because the temperature records are not available for analysis. Besides, the variation in temperature is much less than rainfall that it will not affect the analysis much.

2.2 Measurable Indicator and Explanatory Variables for Water Quality

Water quality refers to the characteristics of a water supply that will influence its suitability for a specific use while the characteristics can be defined by certain physical, chemical and biological parameters (Ayers et al, 1985). When considering water quality for the agricultural sector, water quality related problems that might cause reduction of production originate from the water source for irrigation. In irrigation water evaluation, only chemical and physical characteristics of the water are considered.

The quality of water used for irrigation is depending on the type and quantity of dissolved salts. The origin of the various salts is mainly from soil weathering processes including dissolution of gypsum, lime, and other slowly dissolved soil minerals. Under general conditions, the dissolutions will leach through soil to underground water and eventually be carried away to the sea by streams or rivers, especially under humid conditions (Chhabra, 1996). Therefore, salt accumulation in soil occurs more under arid and semi-arid conditions. In addition, irrigation without good drainage carries the salts back to the soil surface from deeper layers and salts remain in the rootzone, called secondary salinisations. This phenomenon happened after the introduction of irrigation to the agricultural sector and it has been a major cause of decreased food production in many parts of the world (Chhabra, 1996). Ayers and Westcot (1985) concluded four most common soil problems induced by improper irrigation which can be used as the basis to evaluate water quality (Table 2).

Table 2 Water Quality-Related Problems in Irrigated Agriculture. Source: (Ayers, et al, 1985).

Soil Problems	Explanation	Consequences
Salinity	Salts in soil or water reduce water availability to the crop	Above certain threshold, crop yields will decrease
Water infiltration rate	Relatively high sodium or low calcium content of soil or water reduce the rate at which irrigation water enters soil	Above certain threshold, water infiltration is insufficient for adequate crop consumption. Prolonged irrigation may cause crusting the seedbeds, excessive weeds and rotting of seeds, etc.
Specific ion toxicity	Certain ions (sodium, chloride or boron) from soil or water accumulate in sensitive crops	Above certain concentrations, crops will be damages or the yields decreased
Excessive Nutrients	Excessive nitrate	Crop yield decreases and less marketability due to unsightly deposit on fruit or foliage reduce

Concluding from description above and Table 2, salinity is a serious issue for quality of irrigation water. The total salt concentration is the most important criteria for understanding the harmful level of salinity to the plants. According to Richards (1954), total salt concentration of water has a direct correlation with electrical conductivity of waters (W_EC). Hence, to measure W_EC is a method to understand the level of salinity of the irrigation water. Water salinity is also a factor that influences the water infiltration rate as well as the sodium content relative to the calcium and magnesium content (Ayers, et al, 1985). Chhabra (1996) concluded two useful parameters for expressing exchangeable sodium hazards of irrigation water which are (i) sodium adsorption ratio (SAR) and (ii) residual sodium carbonate (RSC). SAR stands for the ratio between the concentrations of sodium (Na) and calcium (Ca) plus magnesium (Mg) in the water. At the same time, when more bicarbonate (HCO_3^-) exists in the water, the tendency is that more Ca^{+2} and Mg^{+2} will be precipitated as carbonate which then increases the sodicity hazards of irrigation water (Chhabra, 1996). Besides, soil organic matter also accounts for water infiltration for its ability to maintain soil structure. The water infiltration problem occurs mostly in the soil surface (few centimeters from the top) in which the soil structure can be damaged by high sodium water dispersed into smaller particles. The small particles can then block the pores of the soil and hinder the infiltration.

The major concerns of specific ion toxicity are chloride (Cl), sodium (Na) and boron (B). These ions can be already detrimental at relatively low amounts for certain sensitive plants. Although the degree of damage depends greatly on the sensitivity of the crops, almost all crops will be affected if concentrations of ions are sufficiently high. If the Na content exceeds 60% of total cations in irrigation water, the effect is that either the leaf-tips will be burned or the soil physical conditions will be deteriorated. Higher Ca content is welcomed as it can alleviate the harmful extent of Na. Instead, high Cl content will be harmful to some chloride-sensitive crops when the concentration exceeds 5-10me/l. In addition, fruit plants (f.e citrus, deciduous trees) are especially sensitive and leaf-damages can happen when Cl^- concentration is around 2-3me/l. According to the description above, water salinity is a problem that links with other water quality-related problems to a great extent.

Last soil problem induced by improper irrigation is the excess nutrients in irrigation water caused by high nitrates concentration in groundwater. The intensive application of inorganic fertilizer that is readily available for plant uptake increases the Nitrogen (N) loss (Matson, et al, 1997). Rasmussen and Parton (1994) indicated that around 40% to 60% of the applied N is taken up by the plants and the rest is left in the soil or lost. When practicing organic farming, less nitrate can be found leaching as less N is in the inorganic form which is more vulnerable for leaching. When there is huge amount of nitrate contained in irrigation water, it can result in higher vegetative growth and poor grain production for crops such as wheat, maize, barley and gram.

Based on the objective of KSPoOF, farmers are encouraged to grow more traditional crops suited for the rain-fed condition. Under this circumstance, irrigation percentages are expected to be reduced and water salinity problem will be mitigated. W_EC**,** which represents the level of water salinity, is therefore taken as the measurable indicator for water quality assessment in this research. Another objective of KSPoOF is to reduce inorganic fertilizer application and replace by organic fertilizers in organic farms. It is assumed that the benefits brought by the policy are reduction of nitrate content in ground water and better water infiltration rate resulted from better soil structure. It is also important to investigate whether the conversion has impact on water quality in terms of excess nitrate leaching. However, in this research the focus is on salinity.

Two main aspects are taken into account when selecting explanatory variables for water quality indicator, namely farming practices which influence the problems listed in Table 2 and the properties of irrigation water. Explanatory variables for water quality indicator are: (i) the amount of chemical fertilizer N application, (ii) the proportion of organic fertilizer N application which shows the degree of conversion, (iii) irrigation percentage, (iv) cropping pattern for that different crops possess different lengths of rooting system and evapotranspiraion rates that will determine the rate of salts accumulation (Maas et al, 1977). Explanatory water properties including (v) sodium content, (vi) calcium content, (vii) chloride content, (viii) bicarbonate content, (ix) SAR, (x) RSC and (xi) water pH value. Last, (xii) Soil organic carbon is considered as explanatory variable for its positive contribution to soil structure and water infiltration rate.

2.3 Measurable Indicator and Explanatory Variables for Agrobiodiversity

Compared to pure natural ecosystems, agroecosystems are manipulated by human intervention where much of the original vegetation has disappeared. Especially during the post-World War II period, the trend of losing biodiversity soared drastically due to introducing modern farming practices which are dependent on chemical inputs and high yield varieties. Agrobiodiversity is a vital subset of biodiversity comprising the variety and variability of crops, livestock, forestry or fisheries that directly or indirectly used for food and agriculture (Anonymous, 2004). Therefore, agrobiodiversty, is greatly determined by anthropogenic management. Edwards and Hilbeck (2001) distinguished three components of agrobiodiversity: planned biota, unplanned biota and natural, semi-natural biota. The planned biota include the crop plants and livestock (Matson, et al, 1997); the unplanned biota comprise other organisms living in agricultural landscapes; and the biota of natural and semi-natural areas is the fragmentation of the natural vegetation related to agricultural land. Among these three components, planned biota is the most prominent one in most agroecosystems and it is an important determinant of the total agrobiodiversity (Matson, et al, 1997). Therefore, the higher the numbers of crop species during crop-rotation together and more livestock species are considered as enhancing factors of agrobiodiversity. For example, traditional arable rotation systems and on-farm orchards ensure high agrobiodiversity within the agroecosystem (Edwards, et al, 2001).

Billeter et al. (2008) demonstrated the positive relationship between habitat heterogeneity, connectivity or area of semi-natural elements and species richness. Similarly, Edwards and Hilbeck (2001) indicated that the habitat patches like woodland fragments or hedgerows are important for agrobiodiversity. It is found that unplanned biota such as birds and mammals, take natural or semi-natural habitat patches as their refuges when their habitat is damaged. In the previous study, it was proved that many traditional cacao and coffee plantations in the tropics provide the habitats for migrant or forest birds

(Matson, et al, 1997). Therefore, the numbers of on-farm tree species are positive related to agrobiodiveristy (Edwards, et al, 2001).

Matson et al. (1997) mentioned another less visible but essential community consisting of the agrobiodiveristy, i.e. the soil biota. This group comprises the community of microbes and invertebrate animals which matters to soil nutrient cycling and soil structure. Being part of them, the soil fauna community is also the food source for birds and it is changed substantially by various farming practices such as subsequent tillage, removal of plant residues and substitution of the biological function by chemical fertilizer (Matson, et al, 1997). The intensity of farming practices are regarded as the essential factor influencing agrobiodiversity in agricultural landscapes. Hence Billeter et al. (2008) took crop diversity, livestock density, fertilizer and pesticide usage to represent the intensity of agriculture when studying the relationship between the species richness and the management of the agricultural landscape (Table 3).

Table 3 Explanatory variables used in research of studying correlation between species richness and the management of the agricultural landscape. The variables belonging to landscape structure are removed because they are not taken into consideration in this research. Source: (Billeter, et al, 2008)

Variable name	Explanation
Land-use intensity parameters	
Crop diversity	Average number of crop cultivated on a farm
Fertilizer input ha UAA[1]	Average nitrogen input scaled to the UAA
Intensely fertilized land	Share of intensively fertilized arable area (>150kg N ha^{-1} $year^{-1}$) scaled to the UAA
Livestock units	Average amount of livestock units per farm in study site, scaled to the UAA
Pesticide application	Average number of pesticide application per field in study site. scaled to the UAA

1. UAA=utilized agricultural area

The total numbers of species of planned biota (field crops, plantation crops, livestock) and unplanned biota (trees) are taken as measurable indicators for agrobiodiversity assessment in this research. As for explanatory variables selection, the factors related to farming intensity and practices (corresponding to Table 3) are used as explanatory variables including (i) cropping intensity, (ii) cropping pattern, and (iii) amount of chemical fertilizer N application. Besides, based on the objectives of KSPoOF, farmers are encouraged to integrate husbandry system to their cropping system in organic farming. Therefore higher numbers and species of livestock are expected to be observed in converted farms. That is the reason that the proportion of organic fertilizer application which shows the degree of conversion and livestock density index are used as explanatory variables for agrobiodiversity assessment as well. Last, land holding size is also included because it can indicate the resources a farmer has which will influence the cropping pattern of his/hers.

3. <u>Methods</u>

3.1 Case Study Area: Karnataka State, India

Karnataka is located in the western half of the Deccan plateau surrounded by Andhra Pradesh in the east, Maharashtra in the north and Tamil Nadu and Kerala to the south and bordered by Arabian Sea to the west (Figure 2a). The area of the state accounts for 5.8% of the nation's total geographic area. The population of the state is 52 million with 71% of total population being agricultural dependent according to provisional census 2001 (KarnatakaOnline.in). Karnataka is characterized by the diversity of its agro-climatic zones (Ramachandra et al, 2005). Taking the rainfall pattern in terms of quantity and distribution, soil types, texture, depth and elevation, major crops and type of vegetation into consideration, Karnataka state is divided into 10 agro-climatic zones (Figure 2b).

(a)

(b)

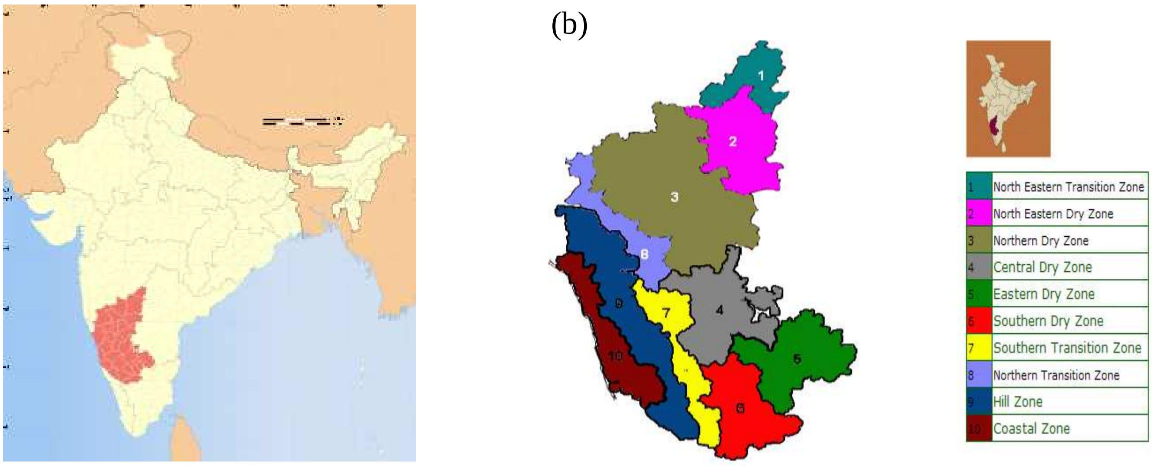


Figure 2. (a) Geographic location of Karnataka state in India. Karnataka state is labeled in red. (b) Ten agro-climatic zones in Karnataka state are displayed in different colors. Legends of each agro-climate zone are listed in table to the right. Sources: (a) <u>http://www.skyscrapercity.com/index.php</u> (b) <u>http://www.uasbangalore.edu.in/asp/stations.asp</u>

The average rainfall in Karnataka is around 1139 mm per year. The monsoon (Kharif) starts at the beginning of June and continues for 4-5 months. June to September is the period with most extensive rainfall which accounts for more than 70% rainfall for the state. The post-monsoon period (Oct-Dec) receives 12% of total rainfall while the period from Jan-May (winter to summer) only receives 8%. Although the average rainfall is reasonable, droughts have been a serious problem in the state with about two-third of the state having 750mm or less annual rainfall (Ramachandra, et al, 2005). Especially when rainfall is late or short than average in the monsoon period, problems occur.

More than 70% of the agricultural sector is rain-fed. The major crops grown in the state are: rice, sorghum, finger millet, maize, and pulses besides oilseeds and a number of cash crops. Cashewnut, coconut, areca nut, cardamom, chili, cotton, sugarcane and tobacco are among the other crops produced in the state. Maize is grown only in the northern tip of the state. Coconut and arecanut are grown in the southern districts. The weather conditions in coastal areas make cultivation of fruit orchards favorable and rice is grown mostly in the coastal districts.

3.2 Overview of Case Study Districts

Five out of 26 districts of Karnataka state were chosen for the LUPIS Indian case study based on the extent of land use changes during a 30 year period and incidences of agrarian distress (Purushothaman, et al, 2009) (Table 4). Five chosen districts (Bijapur, Chitradurga, Kolar, Mysore, and Udupi) spread out in different part of the state (Figure 3). The different locations represent different agro-climatic zones of the state. The major agricultural crops in the five districts differ (Table 5).

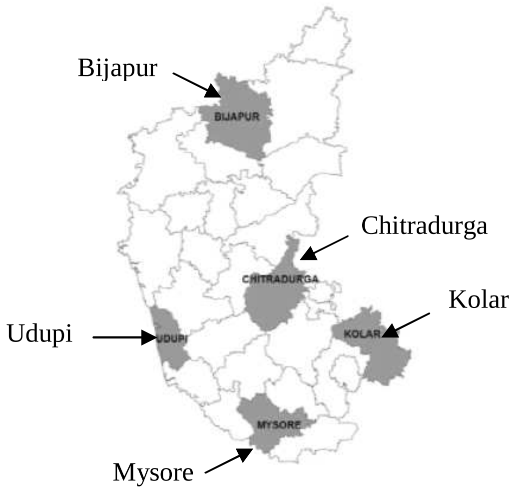


Figure 3. Geographic positions of 5 case study districts in Karnataka state in this research.
Source : (Purushothaman, S. , et al, 2009)

Table 4 Land use changes, agrarian distress and physio-chemical properties of 5 case study districts.
Source: (Ramachandra, et al, 2005)

District	Agro-climatic zone	Soil type	Rainfall (mm/yr)	Sample type
Bijapur	Northern dry zone	Major-shallow to deep black clay	464-785	LUC[1], distress
Chitradurga	Central dry zone	Major-red sandy loams Minor- shallow to deep black	453-717	LUC, distress
Kolar	Eastern dry zone	Major- red loamy Minor- lateritic	679-888	LUC, no distress
Mysore	Southern dry zone	Major-red sandy loam Minor-red loamy	670-888	LUC, distress
Udupi	Coastal zone	Red latertic and coastal alluvial	3010-4694	No LUC

1. LUC stands for Land Use Change

Table 5The major agricultural crops for five case study districts per season.
Source:(Karnataka State Department of Agriculture, 2010)

District	Kharif (Monsoon season)	Rabi (Winter)	Summer
Bijapur	Pearl millet, Sunflower, Ground nut, Maize, Horse gram, , Cotton, Sugar cane	Sorghum, Sunflower, Wheat, Chickpea, Safflower, Linseed, Cotton,	Ground nut, Sunflower, Maize
Chitradurga	Ground nut, Finger millet, Maize, Sorghum, Sunflower, pigeon pea, Field bean, Paddy, Sesame, Horse gram, Cotton	Sorghum, Sunflower, Horsegram	Paddy, Ground nut, Sunflower, Finger millet
Kolar	Finger millet, Ground nut, Field bean, Maize, Paddy, Castor, Niger, Horse gram	Horsegram	Paddy, Finger millet, Maize, Ground nut
Mysore	Paddy, Finger millet, Sorghum, Maize, pigeon pea, Horse gram, Cowpea, Field bean, Ground nut, Sesame, Sunflower, Castor, Niger, Cotton, Tobacco, Sugar cane	Finger millet, Maize, Horse gram, Cowpea	Paddy, Finger millet
Udupi	Paddy	Paddy, Black gram, Horsegram	Paddy, Ground nut

3.3 Sampling Methods

KSPoOF is meant to promote organic farming and it was proposed to select certain area in the State to convert to organic farming (Karnataka State Policy on Organic Farming, 2004). Therefore, one village per taluk was selected and several farms within the selected villages were encouraged to convert to organic farming. The sampling method for the LUPIS project was to have farm surveys conducted in the selected villages. Several farming households (HH) were interviewed with questions using a pre-designed questionnaire. Per distict, 2-3 taluks were chosen and ended up with 14 taluks (villages) in total that involved in the LUPIS project. However, these 14 villages were converted from intensive to organic farming at various pace and extent (Purushothaman, et al, 2009).

The farm surveys were carried out by several Indian Non Governmental Organizaions (NGOs). The data in 2006 were collected by one local NGO per taluk. In 2009, all the data were collected by the same NGO, Ashoka Trust for Research in Ecology and Environment (ATREE) located in Bangalore. The data sets were collected in three different situations which are defined as (i) situation 2006, the data were collected in year 2006 in the villages that were selected for conversion, however, conventional farming was practiced when the data were collected, (ii) situation 2009_P, the data were collected in year 2009 in the same village as 2006, only that the sampling farms were having KSPoOF implemented (however, the interviewees were not the same as the ones in 2006 because the data were collected by different NGOs in both years), (iii) situation 2009_N, the data were collected in year 2009 in a neighboring village of situation 2009_P. The interviewees in 2009_N were still practicing conventional farming without the influences from KSPoOF. Nevertheless, in Bijapur and Kolar, the same villages were interviewed for both 2009_P and 2009_N. Data collected from situation 2006 represent as benchmark data which can be compared with its counterparts in 2009_P and 2009_N The ultimate sampling sizes are 576 households (HHs) for 2006, 133 HHs for 2009_P and 71HHs for 2009_N (Table 6).

Table 6 Names of sampling districts, taluks, villages and the sampling sizes for each village in three situations in LUPIS project. Five selected taluks/villages in this research are shown in black.

Districts	Taluks' Name	Villages' Name	Situations – Sampling size		
			2006	**2009_P**	**2009_N**
Bijapur	Bijapur	Somadevarahatti	31	10	5
	Indi	Gundavana	52	10	5
	Sindgi	Harnal	26	10	5
Chitradurga	Hiriyur	Yalagondanahalli	42	10	
	Hiriyur	Chillahalli			3
	Holalkere	Dogganala.	31	5	10
	Molkalmuru	Mogalahalli	24	10	5
Kolar	Gowirbidnur	Namgondlu	25	11	5
	Bagepalli	Devareddypalli	18	9	5
	Chintamani	Nandiganahalli	47	9	4
Mysore	HD Kote	Mosaralla	49	10	
	HD Kote	Hosakere Sunda			5
	Mysore	SKallahalli	67	9	4
	Hunsur	Hosur Kodagu Colony	46	10	5
Udupi	Udupi	Avarse	43	11	
	Udupi	Nencharu			5
	Karkala	Kervashe	75	9	5
Total	14 Taluks	14 Villages	576 HH	133 HH	71 HH

Concerning the limited period of time for data analysis, only five out of 14 taluks are included in this research. The selection criteria are mainly based on the intactness of the data set. The reason for keeping one taluk per district is to cover five different agro-climatic zones also the different status of land use changes. The five selected taluks_Districts are Bijapur_Bijapur (B_B), Chitradurga_Hiriyur (C_H), Kolar_Gowribdinur (K_G), Mysore_ HD Kote (M_HK) and Udupi_Udupi (U_U).

3.4 Data Computing

Before analyzing the data, raw data sets need to be sorted and computed. This is essential for further statistical analysis, as converting the different units of various data into uniformity, makes them comparable. According to Billeter *et al*. (2008), all the parameters applied in their research were scaled to per hectare of utilized agricultural area (UAA). All variables are categorized into 7 catagories, namely agro-ecological indicators, crop yields, land use and farming practices, soil quality parameters, water quality parameters, climate, and cropping pattern. The descriptions of each variable used in this research including their units and computing processes are described below. All variables are listed in Table 10.

<Agro-ecological Indicators>

- ***Soil Organic Carbon (SOC)***

Soil organic carbon is expressed as percentage by weight (g C/kg soil %). Soil samples were collected on farm during farm surveys and were sent to soil labratory for testing. Test results were used in statistical analysis directly. The unit for SOC is percentage (%).

- ***Planned Biota per hectare (PlBio)***

The data of field crop species, tree species, livestock species and plantation crops species on farm is available in our data sets. According to Purushothaman *et al*.(2009), the numbers of each species should be scaled to total area under cultivation in order to get species specific diversity per unit of farm land (e.g.10 tree species/ 5 ha=2 tree species/ha). However the numbers of each type of species are rather small to get a meaningful computation. Therefore, species numbers of four different categories of planned biota were summed up and scaled to total cropping area resulting in total species diversity per unit area. The unit for planned biota per ha is number of total species/ha (species no. /ha).

- ***Water Electrical conductivity (W_EC)***

Water electrical conductivity is the measurement for water salinity. The unit is in deciSiemens per meter (ds/m) at 25ºC (Ayers, et al, 1985). Like SOC, the raw data were used for statistical analysis.

<Crop Yields>

- ***Crop Yield (Y_Crop)***

The data of total weight for annual harvesting for each crop grown on farm is available for crop yield computation. The amounts of production for each crop (kg) are divided by the total area on which this crop had been cultivated, resulting in the yield. The unit for crop yield is kg $ha^{-1}yr^{-1}$.

< Land Use and Farming Practices >

- ***Land Holding Size***

This means the total area of arable land possessed by farmers. The unit is in hectare (ha).

- ***Land under cultivation***

To sum up all the area under cultivation in one year is the area of land under cultivation. Since there are 3 cropping seasons in southern India, the land under cultivation includes all cultivations in one year. The unit is in hectare (ha).

- ***Organic N Proportion (OFrNP)***

The variable can be used for indicating the level of conversion for each farm. The computation process is to divide amount of annual organic fertilizer N to the total amount of N-input from both organic and chemical fertilizers. The unit of OFrNP is percentage (%).

- ***Organic Fertilizer Input (OFrN)***

Farm yard manure (FYM) is the most commonly used organic manure in India as well as the most valuable organic matter (Krishiworld.com). Corresponding to the previous statement, interviewed farmers in thie research also indicated that FYM has always been the main organic input. Meanwhile, vermicompost is still under technique transferring from local NGOs (pers. comm. 05 March 2010). However, the nutrient content for FYM is generally low in India due to improper handling procedure. The N, P, K content of FYM in this research was adopted from Indian official agricultural information website (Krishiworld.com) which took into account the improper handling procedure (Table 7). Phosphorus and potassium usually exist in manure as phosphorus oxide (P_2O_5) and potassium oxide (K_2O). In order to retrieve the value for phosphorus and potassium in element form, it is necessary to multiply the amount of P_2O_5 and K_2O with 0.44 and 0.83 respectively in order to get the amount of P and K in elementary form.

Table 7 The percentages of N, P, K contents contained in farm yard manure in India.

	Total N(%)	Total P_2O_5 (%)	Total K_2O (%)
FYM[1]	0.3	0.15	0.3
		Total P(%)	**Total K(%)**
FYM[2]		0.066	0.249

Source: (Krishiworld.com)
Source : (Clemson University Extension Service)

- ***Chemical Fertilizer Input (CFrN)***

It was not specified which kind of chemical fertilizer the farmers applied on farms but only the total amount was investigated. However, according to Ramesh Kumar (2007), acid forming fertilizers like diammonium phosphate (DAP- $(NH_4)_2HPO_4$) and urea (NH_2CO) were the two fertilizers mostly observed in Bangalore rural district because of their low prices and also the concept of farmers believing in the robust ability of nitrogen. The N, P, K contents of chemical fertilizers were calculated based on the component of DAP in this research (Table 8).

Table 8 The contents of N, P, K (%) in chemical fertilizer (DAP) used in this research.

	Total N (%)	Total P_2O_5 (%)	Total K (%)
DAP[1]	18	46	0
		Total P (%)	**Total K (%)**
DAP[2]		20.24	0

[1]. Source: Rego *et al.* (2003)
[2]. Source:(Bob Lippert's Frequently Asked Questions Regarding Soil Testing)

- ***Livestock Density Index (LDI)***

Sufficient numbers of livestock is essential for organic farming, as the livestock is the main source of farm yard manure. KSPoOF also urged converted farms to integrate animal husbandry into the farming systems. Based on the definition of Eurostat (Eurostat, 2010), livestock density index (LDI) provides the number of livestock unit (LSU) per hectare of utilized agriculture area (UAA) in order to analyze the livestock system quantitatively. When computing LDI for each farming household, the numbers of livestock on farm were multiplied with different LSU conversion factors (Table 9) depending on which types of livestock were analyzed (Chilonda, 2005). LSU was then divided by total cropping area (ha) to get LDI (LSU/ha).

Table 9 Livestock unit conversion factors for different kind of livestock on farm

Livestock catalogue	Cattle	Buffalo	Sheep-goat	Pig	Poultry
LSU conversion factor	0.5	0.5	0.1	0.2	0.01

Source: Livestock sector Brief-India (Chilonda, 2005)

- ***Irrigation percentage (Irr%)***

It was indicated that the more inputs of land, labor and irrigation water, the higher the cropping intensity (Dayal, 1978) which means irrigation percentage could be an indirect indicator for crop intensity. During the farm survey, farmers were asked for size of the land that is under irrigation. The area under irrigation was summed-up and divided by the area of land holding to get the irrigation percentage. The unit for irrigation percentage is percent (%).

- ***Cropping Intensity (CI%)***

To calculate the ratio of cropland to total agricultural land or the ratio of gross cropping area to net cropping area are two traditional methods to measure the cropping intensity (Dayal, 1978). The former ratio is adopted in this research when computing the cropping intensity for every farm. It can occur that cropping land is larger than farmer's total land holding area, because there are 3 main seasons for cultivation per year, hence the value of cropping intensity can be more than 100%. The other explanation is that some farmers were farming also on the leased land. The unit for cropping intensity is percentage (%).

< **Soil Quality Parameters>**

Four soil quality parameters are soil pH value (S_pH), soil available P (S_P), soil available K (S_K), soil electrical conductivity (S_EC). The soil samples were collected on farm by the NGOs during farm surveys (Patil, S., 2010. pers. comm.) and all the samples were tested in Krishi Vigyan Kendra (Agriculture Research Centre).

<Water Quality Parameters>

Seven water quality parameters are water pH (W_pH), water Sodium (W_Na), water Calcium (W_Ca), water bicarbonate (W_Bic), water chloride (W_Cl), water SAR (W_SR), water RSC (W_RC). The water samples were collected from the tube well on farm by the NGOs in charge of farm surveys (Patil, S., 2010. pers. Comm.).

<Climate>

- ***Rainfall (Rfl)***

The amount of rainfall in 2006 came from the records of weather monitoring stations close to the studies taluks. However, the rainfall data in 2009 was retrieved from the official government website, Karnataka State Natural Disaster Monitoring Center (Anonymous, 2010c). The unit is mm/yr.

<Cropping pattern>

From the questionnaire with which the farmers were interviewed, the types of crops cultivated in three growing seasons (pre-monsoon, post-monsoon, and summer) in one year were investigated including areas used for certain crops. Based on the classification by Pushpalatha (1992), different crops were categorized into six crop groups: i) cereals/millets, ii) pulse/legumes, iii) nuts/oilseeds, iv) roots/tubers, v) fruits and vi) others. Appendix I displays the major crops in Karnataka and the crop group they belong to, as well as crops' names in English, Latin and Kannada. Besides, various crops cultivated in studied taluks in this research are listed in Appendix II.

The area of cropland under certain crop group was divided by land under cultivation for every interviewed farmer, resulting in percentage of area for particular crop group. The unit for cropping pattern is percentage (%).

3.5 Statistical Analysis

Certain variables of land use and farming practices and agro-ecological indicators and crop yields were analyzed among three situations (2006, 2009_P, 2009_N) using a statistical method: Analysis of Variance (one-way ANOVA). The variables-to-be-analyzed of land use and farming practices comprise land holding size, fertilizer application and livestock density index in order to investigate if KSPoOF will positively influence the amount of organic fertilizers application and livestock density. In addition, by analyzing land holding size for three situations, it is aimed to know if the beneficiaries of KSPoOF are mainly small-scaled farmers. As for agro-ecological indicators, three indicators were analyzed namely soil organic carbon, planned biota per hectare and water EC in order to investigate if KSPoOF can bring the positive effects to soil quality, agrobiodiversity and water quality. Besides, if there are higher crop yields in the farms under the policy implementation, it may reflect the better soil fertility and water quality brought by the policy. One-way ANOVA can be used for comparing the mean value among more than two groups of samples. If the results of ANOVA show a large F-ratio, it means the differences among analyzed groups are significantly different. Further, pair-wise comparison methods can be used to analyze which two groups among all have the significant differences (Field, 2009). Because the sample sizes for each variable are unequal in three situations, Games-Howell was chosen as the pair-wise comparison method in this research because it is the most powerful and accurate method when dealing with unequal sample sizes (Field, 2009).

In order to analyze the correlations between all variables (Table 10), Spearman's rho correlation method was applied at taluk and state-level. The analysis at state-level was done by pooling all data collected in 5 taluks. The reason for applying Spearman's rho correlation method is due to unequal sample sizes in three situations (Field, 2009). The purpose is to investigate the relationship between each of two variables and have a preliminary screening for multicollinearity when there is a strong correlation (e.g $r>0.9$) existing between two variables. Besides, if a strong correlation coefficient is found between variables, it may indicate the sufficiency of one variable explaining changes in agro-ecological indicator. However, it is impossible to conclude the causality relationship merely by the results of correlation analysis.

For identifying which factors influencing the changes of agro-ecological indicators in different situations, multiple regression analysis was conducted to build the models to find the explanatory variables that can explain the variances of three agro-ecological indicators. Two methods of multiple regression analysis were used which are forced entry (entry) and backward method. Sound theoretical reasons are necessary for choosing which variables to be entered for both methods.The principle of entry method is to include all the input variables simultaneously regardless the significance level of them. In the backward method, the statistical program will filter out less significant variables step by step according to the stepping method criteria (entry 0.05/removal 0.1) until the most significant ones are left in the model (Field, 2009). Three agro-ecological indicators, namely SOC, water_Ec and PlBio (Table 10) were used as dependent variables. When selecting independent variables for each indicator, we followed the theoretical background described in Section 2.1.1, 2.1.2 and 2.1.3 for individual indicators. All the independent variables included in the regression model for each indicator are listed in Table 11. In addition, in order to know if the differences between situations resulted from policy implementation have influences of the variance of indicators, two dummy variables 2009_P and 2009_N were set to represent the differences between 2009_P and 2006 also 2009_N and 2006 in SOC (Equation 1) and PlBio (Equation 2) model. However, the dummy variable 2009_P in W_EC model (Equation 3) represents the difference between situation 2009_P and 2009_N because we do not have data for water quality parameters in 2006. Same as correlation analysis, regression analysis was done at both taluk and state level.

SOC = **(Equation 1)**

$$b_0 + b_1(2009\_P) + b_2(2009\_N) + b_3(S\_P) + b_4(S\_K) + b_5(S\_EC) + b_6(S\_pH) + b_7(CI\%) + b_8(LDI) + b_9(Irri\%) + b_{10}(Ldhd) + b_{11}(CFrN) + b_{12}(OFrNP) + b_{13}(A\_Crl) + b_{14}(A\_Pls) + b_{15}(A\_Olsd) + b_{16}(A\_Rt) + b_{17}(A\_Frt) + b_{18}(A\_Veg) + b_{19}(A\_Othr)$$

W_EC= **(Equation 2)**

$$b_0 + b_1(2009\_P) + b_2(SOC) + b_3(CFrN) + b_4(OFrNP) + b_5(Irr\%) + b_6(A\_Crl) + b_7(A\_Pls) + b_8(A\_Olsd) + b_9(A\_Rt) + b_{10}(A\_Frt) + b_{11}(A\_Veg) + b_{12}(A\_Othr)$$

Plbio= **(Equation 3)**

$b_0 + b_1(2009\_P) + b_2(2009\_N) + b_3(Ldhd) + b_4(CI\%) + b_5(CFrN) + b_6(OFrNP) + b_7(LDI) + b_8(A\_Crl) + b_9(A\_Pls) + b_{10}(A\_Olsd) + b_{11}(A\_Rt) + b_{12}(A\_Frt) + b_{13}(A\_Veg) + b_{14}(A\_Othr)$

When conducting regression analysis, attention was put on the multicollinearity between the variables. If an independent variable has variance inflation factor (VIF) >10 meaning that it has high degree of multicollinearity with other independent variable in the regression model. Multicollinearity shows high correlation between two variables which results in unreliable estimation of regression coefficients for those variables. Hence, they will be excluded during analysis. Besides, when dealing with the missing cases in our data sets, pair-wise exclusion is used. For example, if the data for S_EC were missing in two farms in one village, all other data related to the variance of soil organic carbon from those two farms would still be used for constructing regression model for SOC, but the missing ones.

All the analyses were operated by the software SPSS version 17.

Table 10 List of all variables used in the bivariate correlation analysis classified into 7 categories.

Categories	No. in matrix	Description (United Nations)	Acronym
Ecological Indicators	1	Soil organic carbon (%)	SOC
	2	Planned biota ratio (spec. no./ha)	PlBio
	3	Water EC (ds/m)	W_EC
Crop Yields	4a – 4n	Yield_Wheat (kg/ha/yr)	Ywht
		Yield_Sorghum (kg/ha/yr)	Ysgm
		Yield_Pearl millet (kg/ha/yr)	Ypmt
		Yield_Figer millet (kg/ha/yr)	Yfmt
		Yield_Rice (kg/ha/yr)	Yrc
		Yield_Maize (kg/ha/yr)	Ymiz
		Yield_Horse gram (kg/ha/yr)	Yhsg
		Yield_Ground nut (kg/ha/yr)	Ygnt
		Yield_Sun flower (kg/ha/yr)	Ysfl
		Yield_Potato (kg/ha/yr)	Yptt
		Yield_Grape (kg/ha/yr)	Ygrp
		Yield_Areca (kg/ha/yr)	Yarc
		Yield_Cotton (kg/ha/yr)	Yctn
		Yield_Mulberry (kg/ha/yr)	Ymlry
Farming practices & Land use	5	Organic fertilizer N proportion (%)	OFrNP
	6	Organic fertilizer N (kg/ha/yr)	OFrN
	7	Chemical fertilizer N (kg/ha/yr)	CFrN
	8	Livestock density index (LSU/ha)	LDI
	9	Irrigation percentage (%)	Irr%
	10	Cropping intensity (%)	CI%
	11	Land under cultivation (ha)	LdCul
	12	Land holding size (ha)	Ldhd
Soil quality parameters	13	Soil_pH Value	S_pH
	14	Soil_Available P (kg/ha/yr)	S_P
	15	Soil_Available K (kg/ha/yr)	S_K
	16	Soil_EC (ds/m)	S_EC
Water quality parameters	17	Water_pH value	W_pH
	18	Water_Sodium (me/l)	W_Na
	19	Water_Calcium (me/l)	W_Ca
	20	Water_Bicarbonate (me/l)	W_BiC
	21	Water_Chloride (me/l)	W_Cl
	22	Water_SAR(me/l)	W_SR
	23	Water_RSC(me/l)	W_RC
Climate	24	Rainfall(mm/yr)	Rfl
Cropping pattern	25a	Area_Cereals (%)	A_Crl
	25b	Area_Pulses (%)	A_Pls
	25c	Area_Oilseed(%)	A_Olsd
	25d	Area_Roots(%)	A_Rt
	25e	Area_Fruits(%)	A_Frt
	25f	Area_Vegetables(%)	A_Veg
	25g	Area_Other(%)	A_Othr

Table 11 List of all dependent and independent variables used in the multiple regression analysis displayed in order of agro-ecological indicators. All acronyms can be referred back to Table 10.

Dependent variables	SOC	W_EC	PlBio
Independent Variables	2009_P 2009_N S_P S _K S_EC S_pH CI% LDI Irri % Ldhd CFrN OFrNP A_Crl A_Pls A_Olsd A_Rt A_Frt A_Veg A_Othr	2009_P SOC CFrN OFrNP Irri % A_Crl A_Pls A_Olsd A_Rt A_Frt A_Veg A_Othr	2009_P 2009_N Ldhd CI% CFrN OFrNP LDI A_Crl A_Pls A_Olsd A_Rt A_Frt A_Veg A_Othr

4. Results

4.1 Land Use and Farming Practices

This section shows the results of analysis on the variables related to land use and farming practices including land holding size, fertilizer application, livestock density and cropping pattern for each taluk. All variables were analyzed using ANOVA except for cropping pattern where the percentages for each crop group were analyzed. The differences among the three situations (2006, 2009_P, 2009_N) are described in detail per taluk in the following paragraphs.

4.1.1 Bijapur_Bijapur (B_B*)*

4.1.1.1 Land holding size

Significant differences regarding to land holding sizes (Ldhd) existed among three situations in B_B ($p<0.05$) (Table 12). The size was significantly larger in 2006 compared to 2009_P and 2009_N. The average size in 2006 was 2.34 ha followed by 0.82 ha in 2009_N and 0.78 ha in 2009_P. The values of standard deviations in three situations suggest that the variances of data differed between three treatments. The differences between three situations are mainly due to different farmers were interviewed during farm surveys. The results indicate that the farmers who converted to organic farming practice are mostly marginal (<2 ha) in B_B.

Table 12 Land holding sizes analyzed by one-way ANOVA in Bijapur_Bijapur for three situations

Land Holding Size	Descriptive Statistics					ANOVA	
Situation	**N**	**Min.**	**Max.**	**Mean[1]**	**Std. Deviation**	**F**	**P.**
2006	31	0.49	6.40	2.34[a]	1.32	9.71	0.00
2009_P	10	0.40	1.20	0.78[b]	0.20		
2009_N	5	0.44	1.27	0.82[b]	0.29		
Total	46						

1. The mean values with differentsuperscript English alphabets have significant differences between each other, analyzed by pair-wise comparison (Games-Howell method).

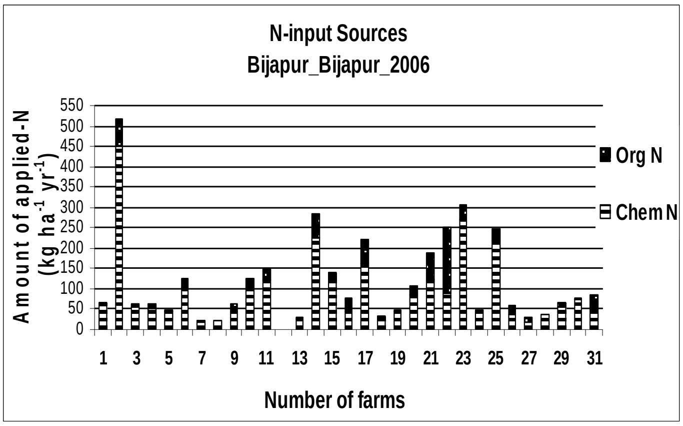
4.1.1.2 Organic and Chemical Fertilizer Application

An overview of the amounts of chemical and organic fertilizer application is listed in Appendix III where range, mean and standard deviation are shown for each of the five taluks in three situations. The description of fertilizer application is dissected into three parts, N, P, K contents respectively.

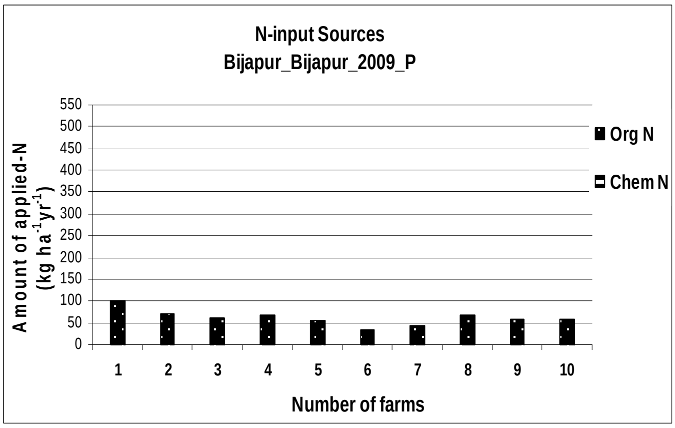
N-input

In year 2006, both chemical and organic fertilizers were applied in B_B. However, chemical fertilizer was the main source for nitrogen. Only one household had more than half share of organic fertilizer in annual N-input. The highest annual N-input appeared in year 2006 with average 116 kg $ha^{-1}yr^{-1}$; 38% of total farms had N-input more than 100 kg $ha^{-1}yr^{-1}$. Instead, the amount decreased greatly towards 2009, when 2009_P had 61.7 kg $ha^{-1}yr^{-1}$ and 2009_N had 68.8 kg $ha^{-1}yr^{-1}$. The overview of the N-input situation in B_B is shown in Figure 4.

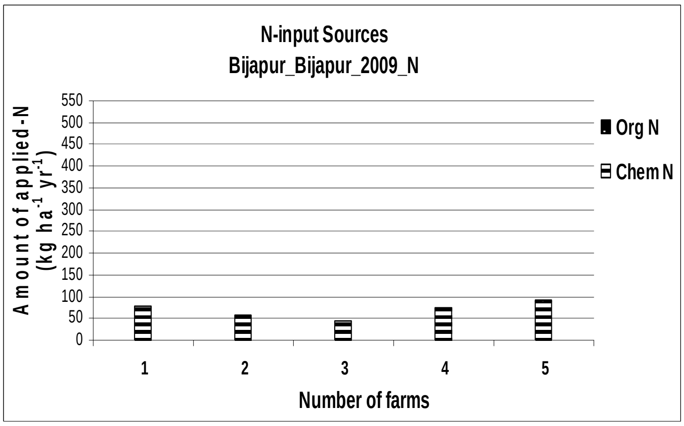
The segregation of chemical and organic fertilizer application was very distinct in B_B. As shown in Figure 4b, none of the farms had a record of using chemical fertilizer in 2009_P where KSPoOF was implemented. Vice versa, none of the famrs in 2009_N had organic fertilizer applied except for farm no.5 with 4 kg of organic N-input. Nevertheless, mixed fertilization seems a common farming practice in 2006, it was not logical to have zero organic fertilizer input observed in 2009_N.



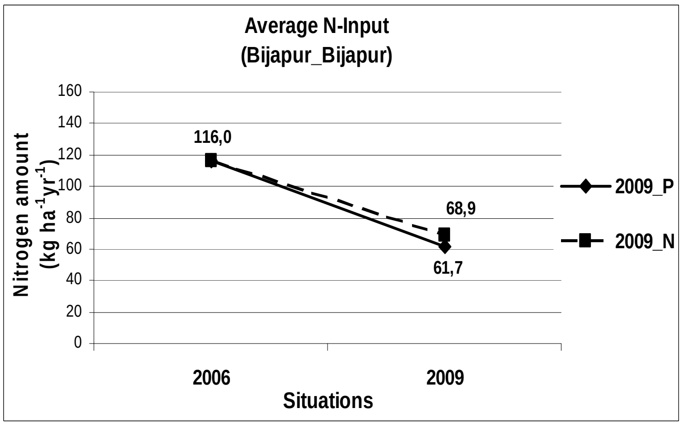
(a) 2006



(b) 2009_P



(c) 2009_N

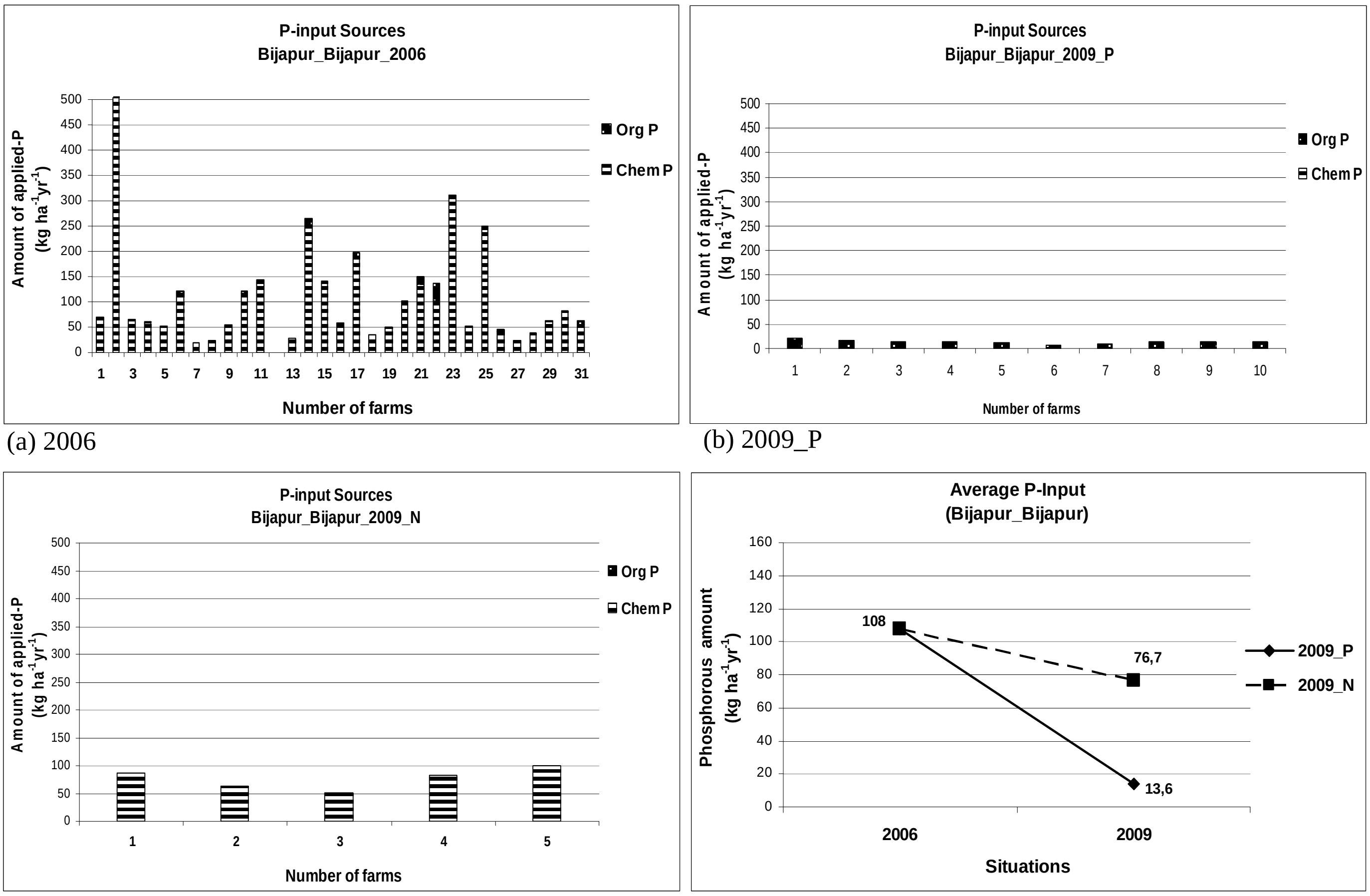


(d) Average N-input in three situations

Figure 4. N-input sourced from organic and chemical fertilizer in Bijapur_Bijapur in three situations: (a) 2006 (b) 2009_P (c) 2009_N and (d) Average N-input in three situations

P-input

Although the fertilizer application pattern of each farm is the same as N-input (Figure 4), the total P-input came predominantly from chemical fertilizer due to the lower P contents in farm yard manure. The average P-input was 108 kg $ha^{-1}yr^{-1}$ in 2006; 76.6 kg $ha^{-1}yr^{-1}$ in 2009_N and only 13.5 kg $ha^{-1}yr^{-1}$ in 2009_P (Figure 5).



(a) 2006 (b) 2009_P

(c) 2009_N (d) Average P-input in three situations

Figure 5. P-input sourced from organic and chemical fertilizer in Bijapur_Bijapur in three situations: (a) 2006 (b)2009_P (c)2009_N (d) Average P-input in three situations

K-input

Because chemical fertilizer DAP contains zero percent of K, K-input was only through organic fertilizer. Therefore, the K-input content can indicate indirectly the proportion of organic fertilizer applied on farm. In 2006, the average K-input was lower (20.5 kg $ha^{-1}yr^{-1}$) but it increased in 2009_P (51 kg $ha^{-1}yr^{-1}$). The situation in 2009_N was an extreme case; only one farm had a small amount of organic fertilizer applied resulting in 0.7 kg $ha^{-1}yr^{-1}$ K-input from organic fertilizer (Figure 6).

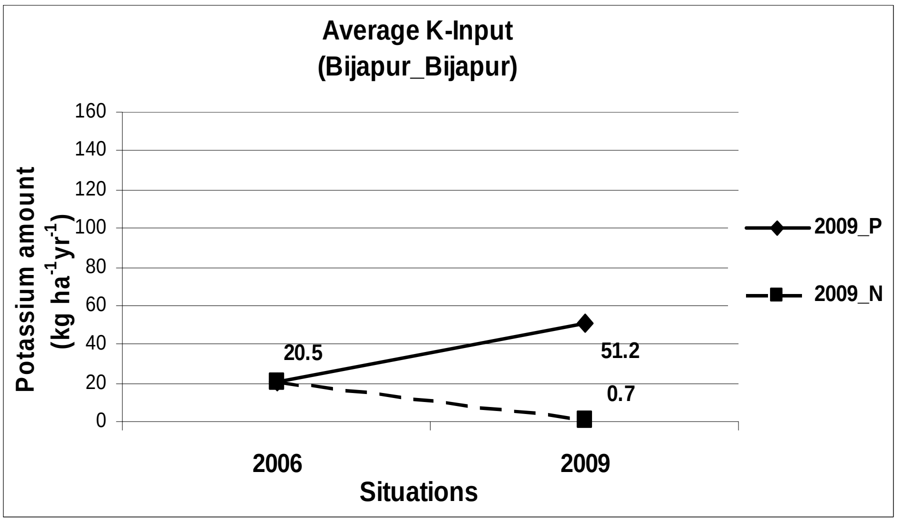


Figure 6. Average K-input sourced from organic fertilizer in Bijapur_Bijapur in three situations

4.1.1.3 Livestock density Index

There was no significant difference (p>0.05) of the livestock density index (LDI) among three situations in B_B (Table 13) while the largest mean appeared in 2009_P (LDI=2.48) and smallest in 2006. However, the results of pair-wise comparison showed that LDI was significantly higher in 2009_P than 2006. This suggests that the policy has influences on livestock densities.

Table 13 Livestock density index analyzed by one-way ANOVA in Bijapur_Bijapur for three situations

Livestock density index	Descriptive Statistics					ANOVA	
Situation	**N**	**Min.**	**Max.**	**Mean[1]**	**Std.Deviation**	**F**	**P.**
2006	31	0.25	6.75	1.4[a]	1.29	2.9	0.06
2009_P	10	1.56	4.75	2.4[b]	1.06		
2009_N	5	0.94	3.25	1.9[ab]	0.88		
Total	46						

1. The mean values with differentsuperscript English alphabets have significant differences between each other, analyzed by pair-wise comparison (Games-Howell method).

4.1.1.4 Cropping pattern

An overview of the cropping pattern in B_B is shown in Figure 7. Cereals/millets were the main crop group cultivated in B_B; in situation 2006, this group occupied 61% of total annual cropping area. The major grains were finger millet, maize, wheat and sorghum sequenced from the most abundant to the least one. The similar pattern happened in 2009_P that almost 60% of total cropping area was under cereals/millets production and the major grains were the same as 2006 (see Appendix II). However, in 2009_N, much less area was under cereal cultivation. Instead both areas for oilseeds and vegetables increased tremendously compared to 2006. The cultivation area for oilseeds and vegetables was also increased in 2009_P but with lower degree than 2009_N. The crops for oilseeds were sunflowers and groundnuts in all situations. Grape was the only fruit grown in B_B, only the cropping area decreased in 2009. These observations suggest that farmers in year 2009 were more commercial than 2006 especially in 2009_N.

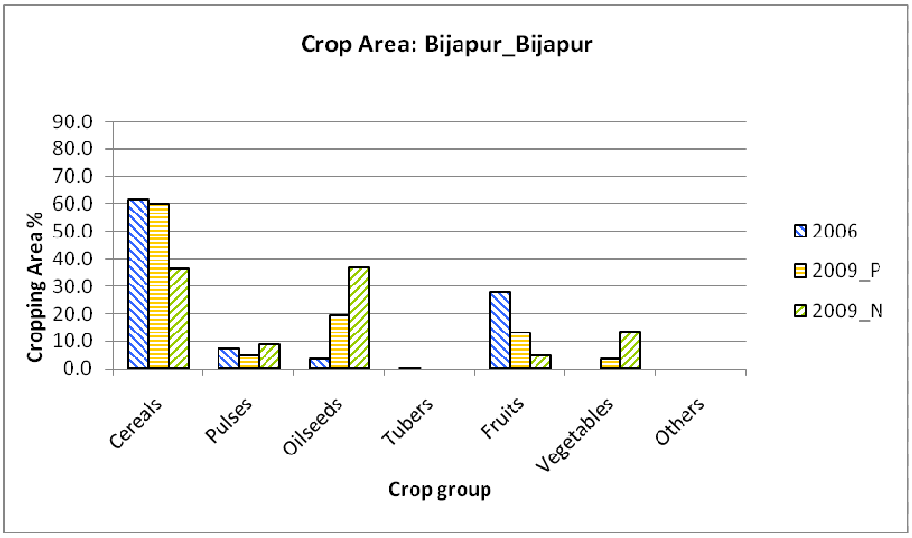


Figure 7. Cropping pattern in Bijapur_Bijapur in three situations: 2006, 2009_P and 2009_N

4.1.2 Chitradurga_Hiriyur (C_H)

4.1.2.1 Land Holding Size

Land holding sizes were significantly different between 2006 and 2009_P ($p<0.05$) (Table 14). Average land holding size was 0.5 ha in 2006, 4.8 ha in 2009_P and 11.7 ha in 2009_N. However, the small sample size in 2009_N (N=3) made the average land holding size in 2009_N not representative. Opposite to B_B, farmers in 2006 were categorized as marginal and small scaled farmers, while they were small to medium scaled in 2009_P.

Table 14 Land holding sizes analyzed by one-way ANOVA in Chitradurga_Hiriyur for three situations

Land Holding Size	Descriptive Statistics					ANOVA	
Situation	N	Min.	Max.	Mean[1]	Std.Deviation	F	P.
2006	42	0.14	1.12	0.5^{a}	0.25	112.8	0.00
2009_P	10	1.20	9.20	4.8^{b}	2.63		
2009_N	3	7.20	16.00	11.7^{ab}	4.41		
Total	55						

1. The mean values with differentsuperscript English alphabets ($^{a.b.c}$) have significant differences between each other, analyzed by pair-wise comparison (Games-Howell method).

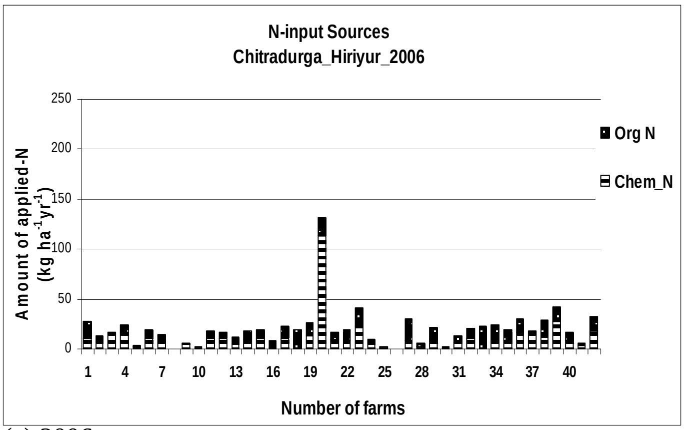
4.1.2.2 Organic and Chemical Fertilizer Application

N-input

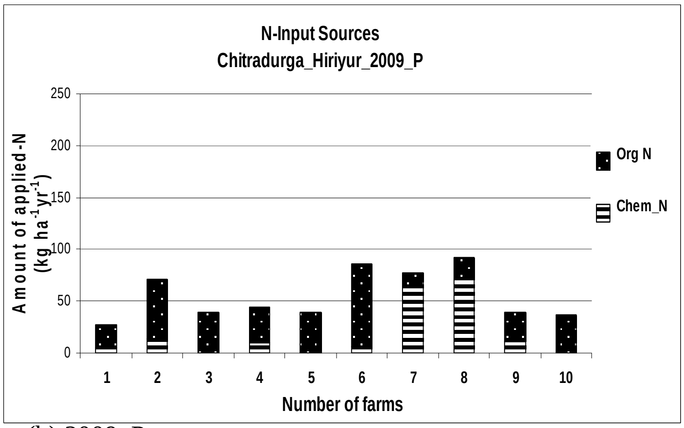
In year 2006, almost all the farmers applied half organic and the other half chemical fertilizers with average low N-input, 20.6 kg $ha^{-1}yr^{-1}$ (Figure 8). This was different from B_B where little organic fertilizer was used in 2006. There was only one farmer out of 40 applying more than 100 kg $ha^{-1}yr^{-1}$ N greatly contributed from chemical fertilizers.

P-input

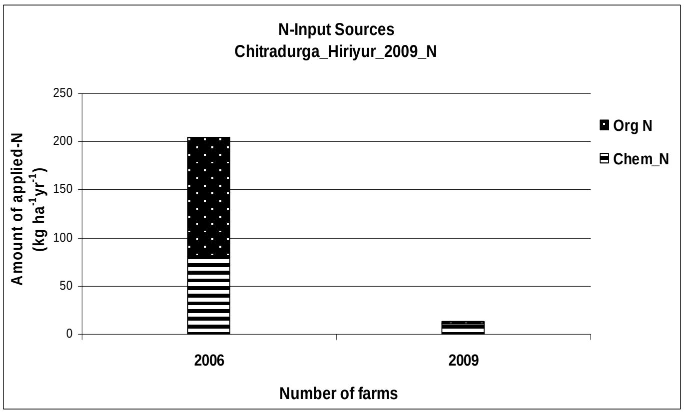
The least average P-input (14.5 kg $ha^{-1}yr^{-1}$) appeared in 2006 (Figure 9) while one extreme farm with more than 120 kg $ha^{-1}yr^{-1}$. None of the other 39 sampling farms had more than 40 kg $ha^{-1}yr^{-1}$ P-input. In 2009_P, 71% of P-input came from chemical fertilizers. The average P-input was 28.6kg $ha^{-1}yr^{-1}$ and 65.6 kg $ha^{-1}yr^{-1}$ for 2009_P and 2009_N respectively. Contracdictory to B_B where both N and P input reduced from 2006 to 2009, in C_H both N and P input increased in 2009. However, there was a large variability among different farms.



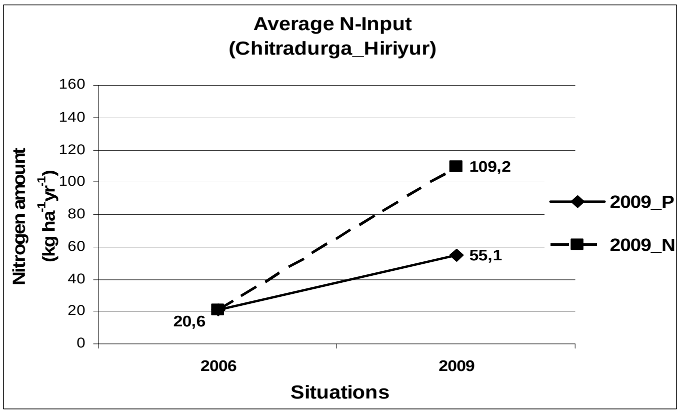
(a) 2006



(b) 2009_P

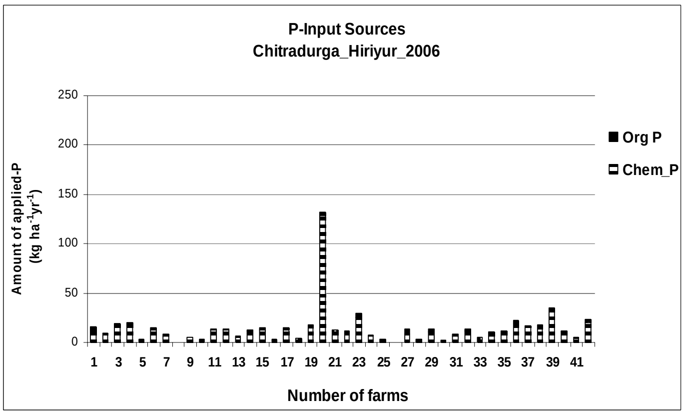


(c) 2009_N

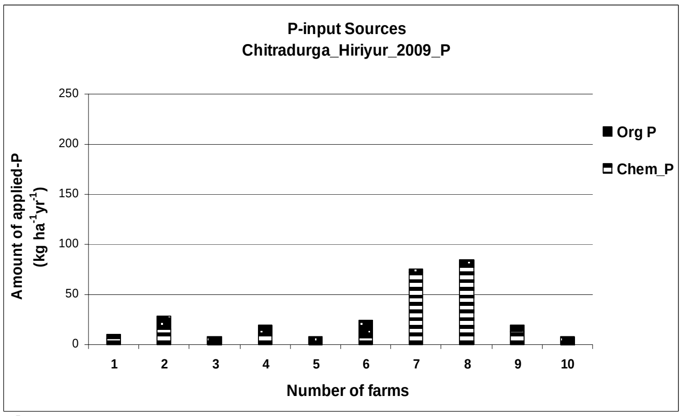


(d) Average N-Input in three situations

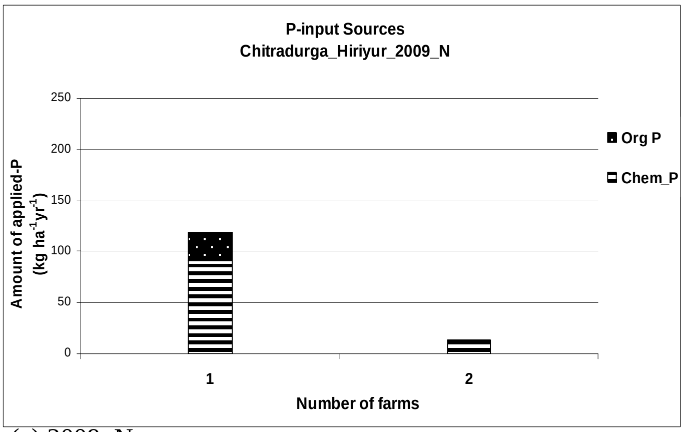
Figure 8. N-input sourced from organic and chemical fertilizer in Chitradurga_Hiriyur in three situations: (a) 2006 (b)2009_P (c) 2009_N (d) Average N-input in three situations



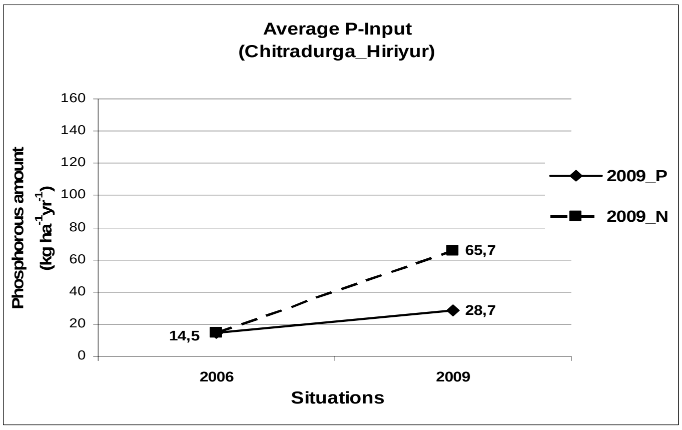
(a) 2006



(b) 2009_P



(c) 2009_N



(d) Average P-input in three situations

Figure 9. P-input sourced from organic and chemical fertilizer in Chitradurga_Hiriyur in three situations: (a) 2006 (b) 2009_P (c) 2009_N (d) Average P-input in three situations

K-input

Due to the prevalence of chemical fertilizer usage in our samples, average K-input turned out to be quite low in 2006 (7.8 kg $ha^{-1}yr^{-1}$) (Figure 10). Although the highest amount appeared in 2009_N, small sampling size (N=3) and high variation among samples (S.D=58.5) made the value unlikely be representative to 2009_N situation as a whole. In 2009_P, more organic fertilizers brought in higher amount of K-input where average K-input was 30.5 kg $ha^{-1}yr^{-1}$.

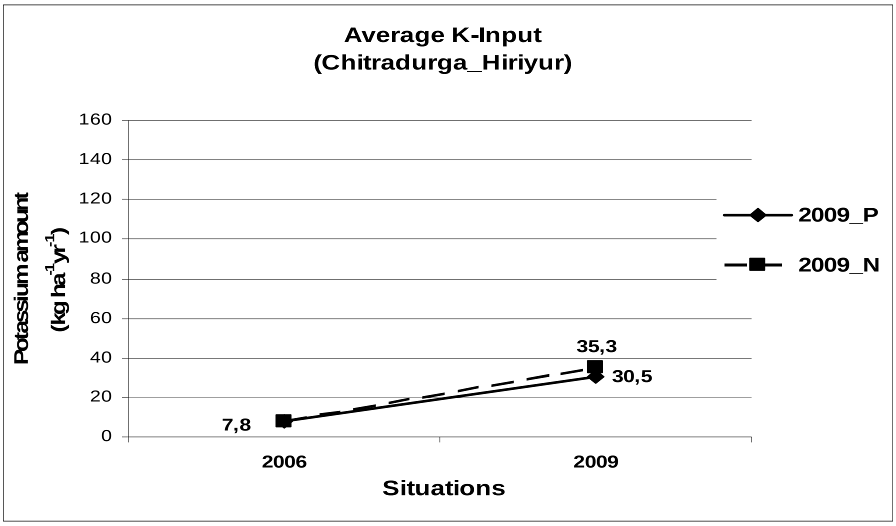


Figure 10. Average K-input sourced from organic fertilizer in Chitradurga_Hiriyur in three situations

4.1.2.3 Livestock Density Index

The highest average LDI was in 2006 and lowest in 2009_P(Table 15). Similar to B_B, there was no significant difference ($p<0.05$) found in livestock density index (LDI) among three situations by ANOVA analysis. The main cause for the lower LDI in both 2009_P and 2009_N was the larger cropping area of the sampling farms. The average cropping area was 4.5 and 5.7 ha in 2009_P and 2009_N respectively whereas the average was only 1.3 ha in 2006. It suggests that farmers did not increase the numbers of livestock corresponding to their cropping area. However, organic fertilizer was still available to increase the organic N and P-inputs in 2009_P. The possible reason is that the manure was better managed in 2009_P because under KSPoOF, there were local NGOs providing advises and assistances for helping farmers to improve their farming practices. As for the result from pair-wise comparison, it showed the significant higher LDI in 2006 than 2009_P ($p <0.05$).

Table 15 Livestock density index analyzed by one-way ANOVA in Chitradurga_Hiriyur for three situations

Livestock density index	Descriptive Statistics					ANOVA	
Situation	**N**	**Min.**	**Max.**	**Mean[1]**	**Std. Deviation**	**F**	**P.**
2006	31	0.00	5.0	1.4[a]	1.35	2.9	0.06
2009_P	10	0.24	0.8	0.49[b]	0.19		
2009_N	3	0.10	1.6	0.6[ab]	0.83		
Total	54						

1. The mean values with differentsuperscript English alphabets ([a.b.c]) have significant differences between each other, analyzed by pair-wise comparison (Games-Howell method).

4.1.2.4 Cropping Pattern

Oilseed was the dominant crop group in C_H for all the three situations, especially in 2009_N. The cropping pattern was more similar between 2006 and 2009_P than 2006 and 2009_N. It maybe due to the samples of 2009_N were collected from different villages. The cereal production was prominent for this taluk as it possessed 28% and 31% of total cropping area in 2006 and 2009_P respectively. However, in 2009_N, there was only 5% for cereals. Another similarity between 2006 and 2009_P was that mulberry and areca were grown in both situations. Meanwhile there were two interesting phenomena observed in 2009: tobacco started to be grown in 2009_P and as also cultivated in the neighboring village (2009_N); fruits like papaya and banana were cultivated in 2009_P and 2009_N, while not in 2006. Nevertheless, pulses were only cultivated in year 2006 with a small percentage of the cropping area (3%). Similar to B_B, the farms in C_H were more commercialized in 2009, but 2009_P had more resistance to commercialization than 2009_N.

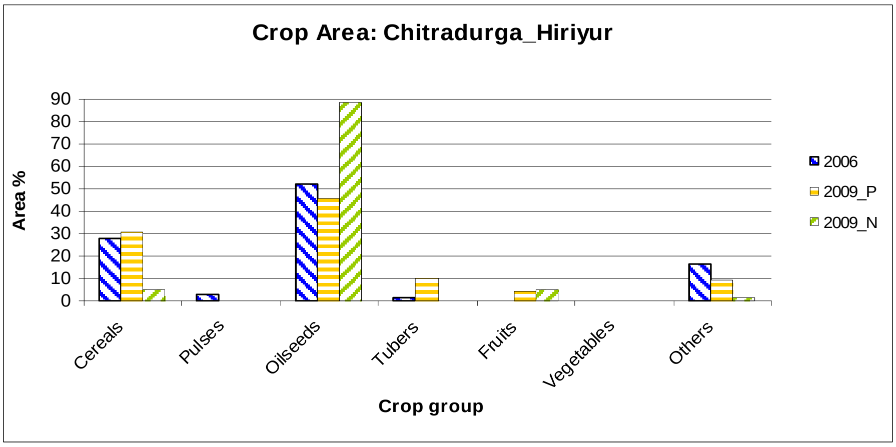


Figure 11. Cropping pattern in Chitradurga_Hiriyur in three situations: 2006, 2009_P and 2009_N.

4.1.3 Kolar_Gowribdinur (K_G)

4.1.3.1 Land Holding Size

Land holding sizes were not significantly different ($p<0.05$) among three situations in K_G (Table 16). The average sizes were 2.26 ha in 2006, 2.42 ha in 2009_P and 1.52 ha in 2009_N indicating that there were predominately small-scaled farmers in K_G. According to similar standard deviation, the sizes of farms in three situations were more homogenous in K_G than other taluks. There were 10 farms larger than 3 ha in 2006 and the rests were smaller than 2 ha. The analysis of land holding size showed that mostly the small-scaled farmers were influencing by the policy in K_G.

Table 16 Land holding sizes analyzed by one-way ANOVA in Kolar_Gowribdinur for three situations

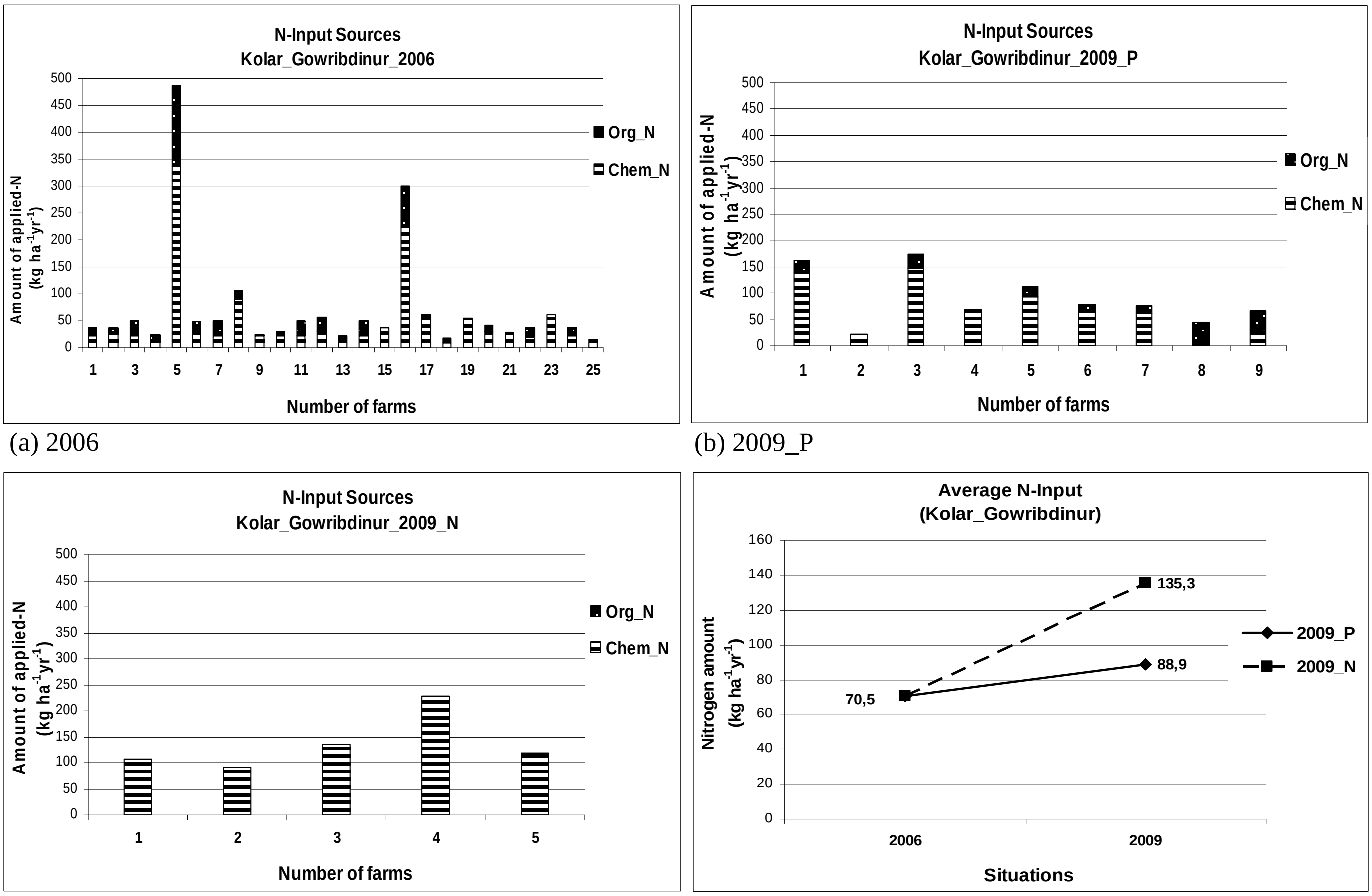
Land Holding Size	Descriptive Statistics					ANOVA	
Situation	N	Min.	Max.	Mean[1]	Std.Deviation	F	P.
2006	25	0.04	5.93	2.26[a]	1.56	0.69	0.5
2009_P	9	1.00	4.00	2.42[a]	1.10		
2009_N	5	0.80	3.60	1.52[a]	1.21		
Total	39						

1. The mean values with differentsuperscript English alphabets ([a,b,c]) have significant differences between each other, analyzed by pair-wise comparison (Games-Howell method).

4.1.3.2 Organic and Chemical Fertilizer Application

N-Input

Chemical fertilizer was predominantly applied in 2006 where 71% of total N-input came from chemical fertilizers (Figure 12). Average N-input was 70.5 kg $ha^{-1}yr^{-1}$ in 2006 while two farmers out of 25 applied more than 300 kg $ha^{-1}yr^{-1}$. Compared to previous two taluks, there was no organic fertilizer used in 2009_N in K_G , same as B_B; but in 2009_P, much higher proportion of chemical fertilizer was applied in K_G than the other two taluks as well as the amount of total N-input (88.9 kg $ha^{-1}yr^{-1}$). The observation indicates that farmers in K_G were more used to use external input or had easier access to it, even in the policy village. It seems that farmers in the policy village did not follow one of the principles of organic farming which is zero chemical fertilizer usage.

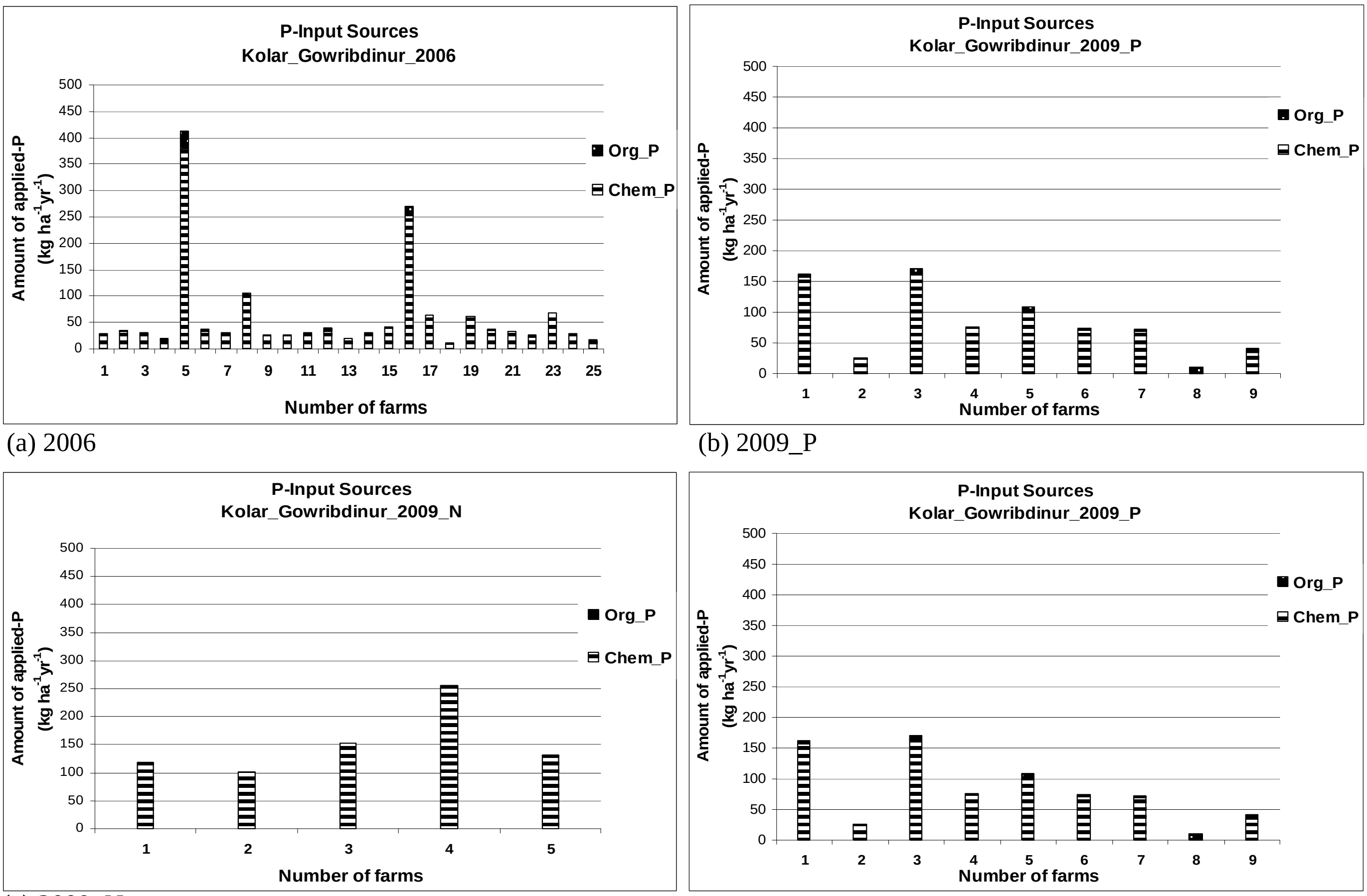


(a) 2006 (b) 2009_P (c) 2009_N (d) Average N-Input in three situations

Figure 12. N-input sourced from organic and chemical fertilizer in Kolar_Gowribdinur in three situations: (a) 2006 (b) 2009_P (c) 2009_N (d) Average N-Input in three situations

P-Input

Chemical fertilizers contributed greatly to the total P-input in all three situations (Figure 13). Basically, K_G still depended greatly on chemical fertilizer input in the agricultural sector even after the deployment of KSPoOF. The average P-input in 2006 was 61 kg $ha^{-1}yr^{-1}$ and higher amount of P was applied in 2009 as 82 kg $ha^{-1}yr^{-1}$ in 2009_P and 152 kg $ha^{-1}yr^{-1}$ in 2009_N.



(a) 2006

(b) 2009_P

(c) 2009_N

(d) Average P-Input in three situations

Figure 13. P-input sourced from organic and chemical fertilizer in Kolar_Gowribdinur in three situations: (a) 2006 (b) 2009_P (c) 2009_N (d) Average P-Input in three situations

K-Input

The average K-input was the same in 2006 and 2009_P with 16 kg $ha^{-1}yr^{-1}$ (Figure 14) indicating that the average organic fertilizer application stayed at the same level in 2009_P as 2006. No K-input was shown in 2009_N due to zero records of organic fertilizer application. However, in K_G where chemical fertilizers were widely used, farmers supposed to use more kinds of chemical fertilizers than merely DAP. Therefore, it is highly possible that K-input came from other chemical fertilizer sources, which were taken into account in this case.

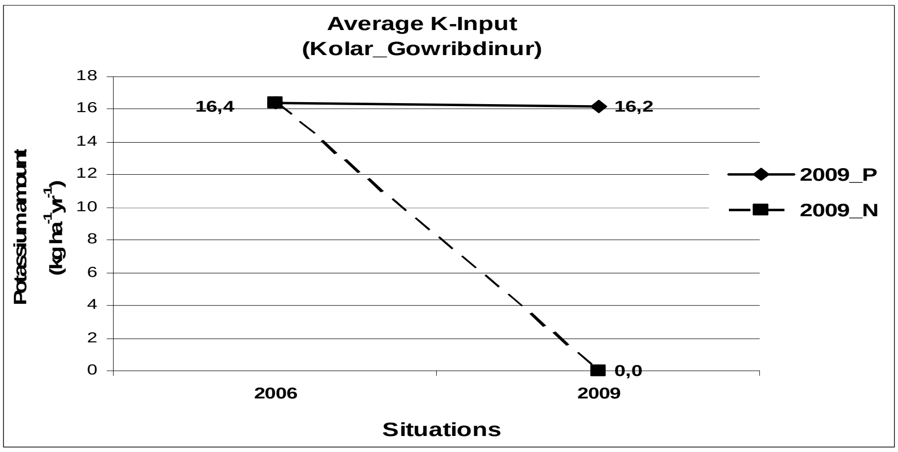


Figure 14. K-input sourced from organic fertilizer in Kolar_Gowribdinur in three situations

4.1.3.3 Livestock density Index

There was no significant difference of livestock density index (LDI) among three situations. The highest average LDI was in 2009_N, followed by 2009_P and 2006 (Table 17). The reasons for lower average LDI in 2006 are: (i) half of the famers kept no livestock on farm (12 out of 25), (ii) cattle were more commonly kept in 2009, while more sheep/goat in 2006 and hence the smaller LSU conversion factor was applied.

Table 17 Livestock density index analyzed by one-way ANOVA in Kolar_Gowribdinur for three situations

Livestock density index	Descriptive Statistics					ANOVA	
Situation	**N**	**Min.**	**Max.**	**Mean[1]**	**Std. Deviation**	**F**	**P.**
2006	25	0.00	12.05	0.78[a]	2.42	0.56	0.57
2009_P	9	0.00	2.08	1.01[a]	0.71		
2009_N	5	1.28	2.50	1.83[a]	0.54		
Total	39						

1. The mean values with differentsuperscript English alphabets ([a,b,c]) have significant differences between each other, analyzed by pair-wise comparison (Games-Howell method).

Some facts were observed in K_G related to livestock density and fertilizer application. The 5th and 16th farmers in 2006 applied the largest amounts of organic fertilizers among all sampling farms but neither of them had a record of livestock keeping. On the other hand, some farmers applied relatively lower amounts of organic fertilizers than two farms above, have higher LDI, for example: the 18th farmer kept 3 cows and 34 sheep while the 19th farmer kept 5 cows and 8 chickens. In addition, in 2009_N when the highest average LDI was observed, no organic fertilizer was applied. The results suggested that farmers in K_G did not take livestock manure as the main source of nutrients input and this was reflected on the fertilizer application pattern.

4.1.3.4 Cropping pattern

Cereals and millets were the most popular crop group in K_G in all three situations, especially in 2009_P, where 76% of total cropping area was under cereal production (Figure 15). In 2006, the major grains were finger millet and sorghum and also a bit of rice. However, maize turned out to be the most produced grain in both 2009_P and 2009_N. Like the cereals and millets crop group, oilseeds group was also found cultivated in all three situations with a similar cropping area between 2006 and 2009_P. Regarding to crop types, sunflowers were grown in 2009 while groundnut and coconut in 2006. Pulses were only grown in 2006. Instead, vegetables and flowers were grown exclusively in 2009_N which resulted in high percentage of cash crop cultivation.

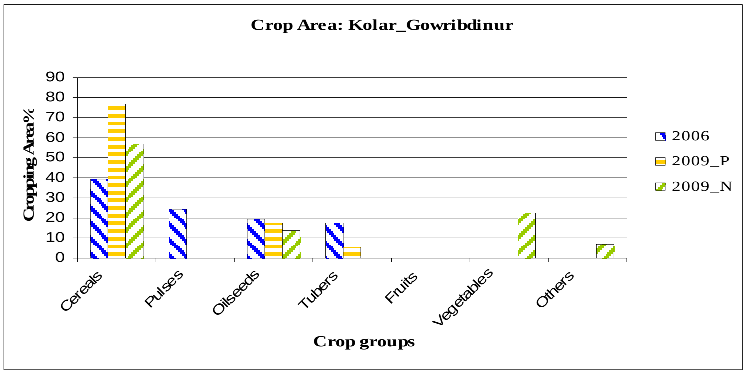


Figure 15. Cropping pattern in Kolar_Gowbdinur in three situations: 2006, 2009_P and 2009_N

4.1.4 Mysore_HD Kote (M_H)

4.1.4.1 Land Holding Size

In M_HK, the largest average land holding size occurred in 2009_P as 2 ha. The other two situations both had an average size of 0.8 ha. The difference between 2006 and 2009_P was significant (Table 18). Although the standard deviation was relatively higher in 2009_P than other two situatons, almost all sampling farms had area ranging from 1.2 to 2.4 ha, belonging to smallholders. The same as C_H, the farms under KSPoOF implementation were prone to have larger size, however, to a less extent in M_HK.

Table 18 Land holding sizes analyzed by one-way ANOVA in Mysore_HD Kote for three situations

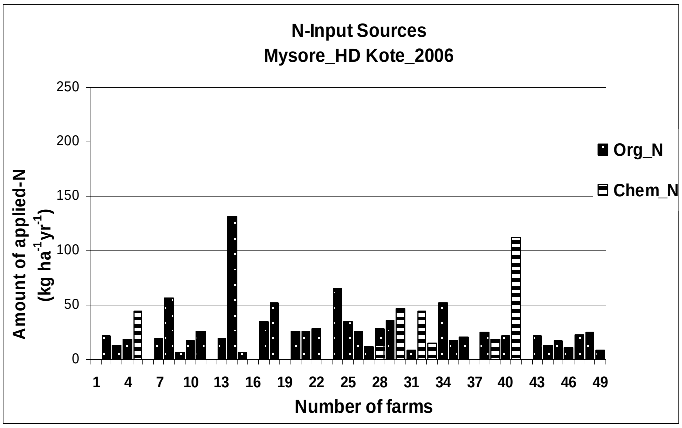
Land Holding Size	Descriptive Statistics					ANOVA	
Situation	N	Min.	Max.	Mean[1]	Std. Deviation	F	P.
2006	49	0.16	3.50	0.8[a]	0.63	10.27	0.00
2009_P	10	0.40	4.80	2.0[b]	1.31		
2009_N	5	0.40	2.00	0.8[ab]	0.72		
Total	64						

1. The mean values with differentsuperscript English alphabets ([a,b,c]) have significant differences between each other, analyzed by pair-wise comparison (Games-Howell method).

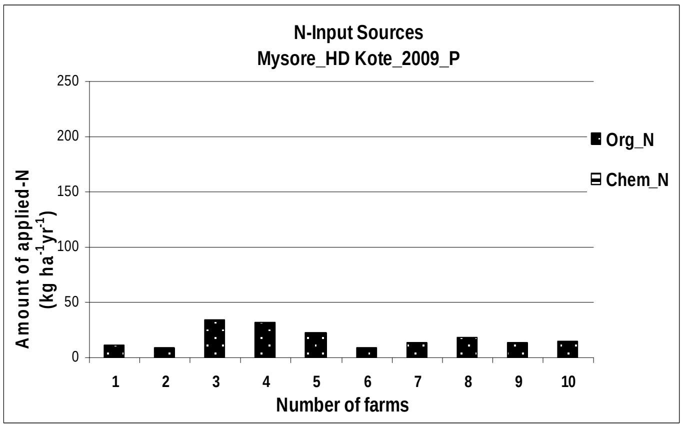
4.1.4.2 Organic and Chemical Fertilizer Application

N-Input

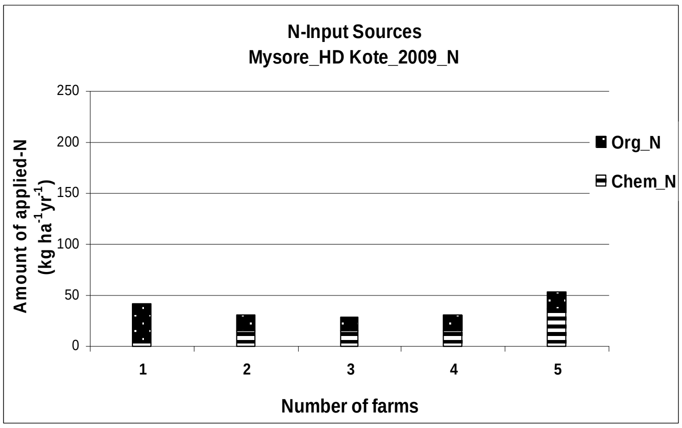
Mysore_HD Kote was distinct from the previous three taluks, as the major N-input was from organic fertilizer in 2006 (Figure 16). In addition, farmers applied either pure organic or chemical fertilizers in 2006. Although two farmers used more than 100 kg $ha^{-1}yr^{-1}$ N-input in 2006, the average N-input was low with 25.6 kg $ha^{-1}yr^{-1}$, as 75% of sampling farmers applied less than 20 kg $ha^{-1}yr^{-1}$ N. In 2009_N, the amount of N-input was homogenized (N=5) and the average N-input was 37 kg $ha^{-1}yr^{-1}$. K_G and B_B are only two taluks among other 5 having pure organic fertilizer applied in 2009_P. This indicates that the farmers followed the organic farming principles of using no chemical fertilizer in 2009_P. But the average amount of N-input was only 17 kg $ha^{-1}yr^{-1}$ in 2009_P. Similar to B_B, average N-input decreased in 2009_P when only organic fertilizer was applied. In general, if compared M_HK to other taluks, the N-input was relatively low in M_HK, as was also the case in C_H. In C_H, N-input however increased from 2006 to 2009_P, while in M_HK, it decreased.



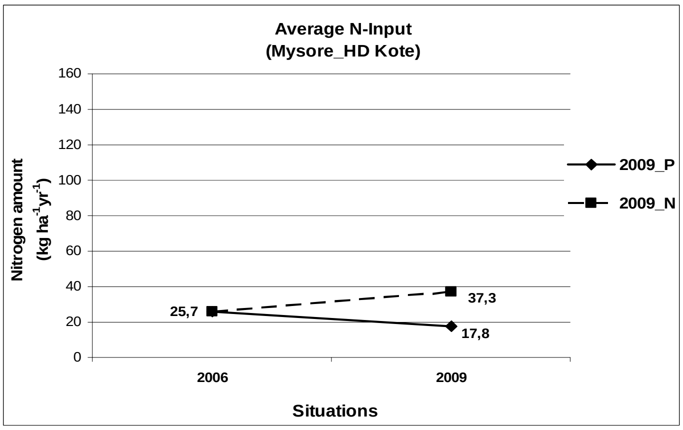
(a) 2006



(b) 2009_P



(c) 2009_N

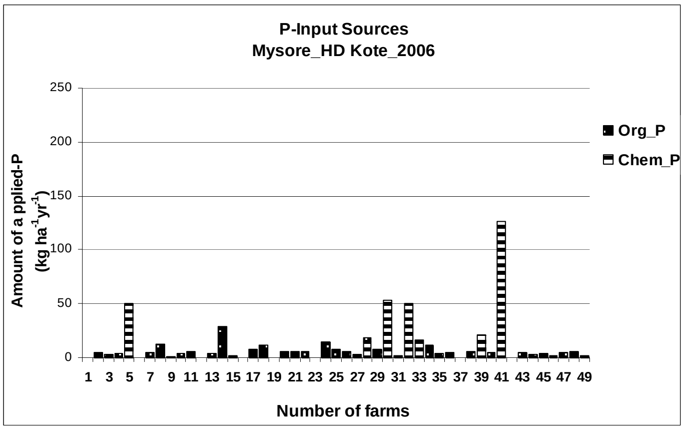


(d) Average N-input in three situations

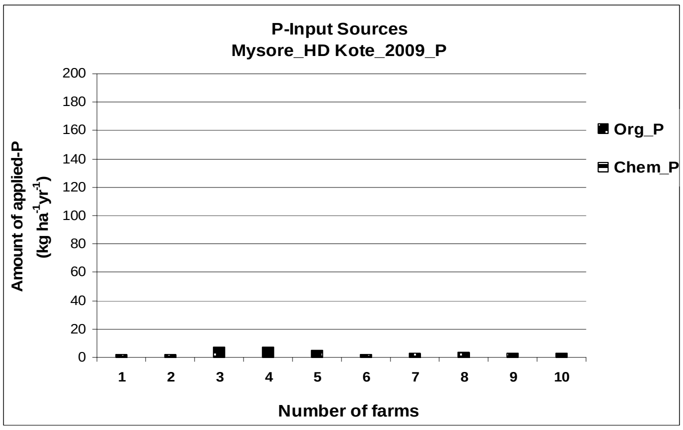
Figure 16. N-input sourced from organic and chemical fertilizer in Mysore_HD Kote in three situations: (a) 2006 (b) 2009_P (c) 2009_N (d) Average N-Input in three situations

P_Input

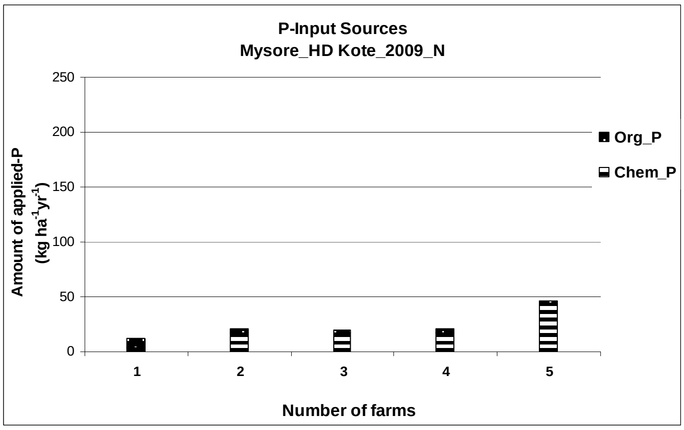
The four highest amounts of P were applied by the 5th, 30th, 32nd and 41st farmers (Figure 17) in 2006, which were fully dependent on chemical fertilizers. Although almost all sampled farmers in 2006 and 2009_P used only organic fertilizer, the total amount of fertilizer application needed to be increased to reach the required level of P. The average P-input was lowest in 2009_P with 4 kg ha^{-1}yr^{-1} and higher in 2006 (11 kg ha^{-1}yr^{-1}) and 2009_N (23 kg ha^{-1}yr^{-1}).



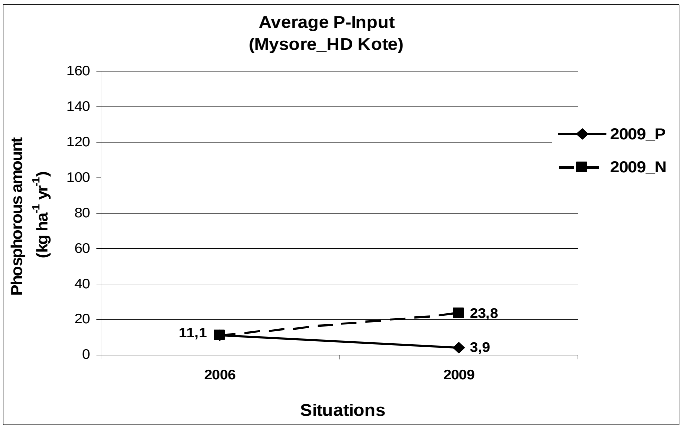
(a) 2006



(b) 2009_P



(c) 2009_N



(d) Average P-Input in three situations

Figure 17. P-input sourced from organic and chemical fertilizer in Mysore_HD Kote in three situations: (a) 2006 (b) 2009_P (c) 2009_N (d) Average P-Input in three situations

K-Input

The average K-input was 16 kg ha^{-1}yr^{-1} in both 2006 and 2009_N and a bit lower (14 kg ha^{-1}yr^{-1}) in 2009_P (Figure 18) which means similar amount of organic fertilizers were applied in three situations. There were 42 out of 49 sampling farms in 2006 having zero chemical fertilizer application, which explains the low P-input also before the policy. However, the average amounts of K-input for all three situations were low due to the averagely low inputs.

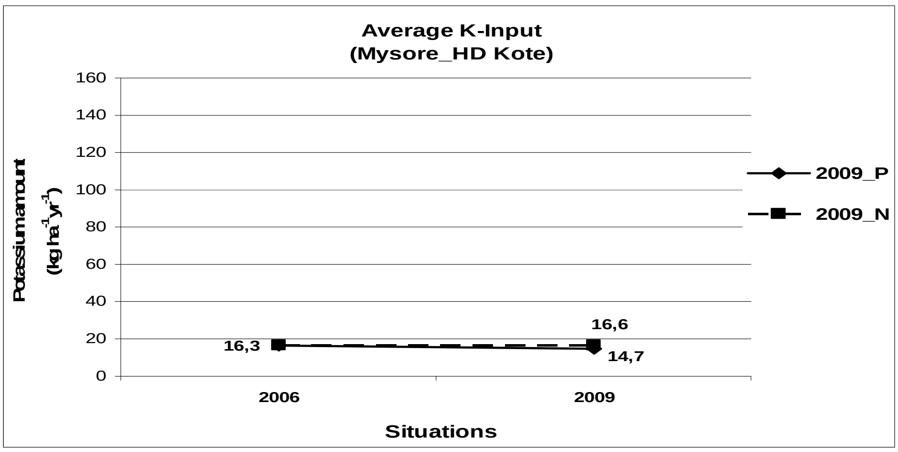


Figure 18. K-input sourced from organic fertilizer in Mysore_HD Kote in three situations.

4.1.4.3 Livestock Density Index

The highest livestock density index (LDI) occured in 2009_N with 2 LSU/ha and followed by 1.8 LSU/ha in 2006 and 0.88 LSU/ha in 2009_P (Table 19). The significant difference was shown between 2006 and 2009_P by pair-wise comparison. The significant lower LDI in 2009_P than in 2006 indicated that the policy did not stimulate livestock density in M_HK.

Table 19 Livestock density index analyzed by one-way ANOVA in Mysore_HD Kote for three situations

Livestock density index	Descriptive Statistics					ANOVA	
Situation	**N**	**Min.**	**Max.**	**Mean[1]**	**Std. Deviation**	**F**	**P.**
2006	46	0.00	6.25	1.8^{a}	1.80	1.47	0.23
2009_P	10	0.17	1.75	0.88^{b}	0.50		
2009_N	5	0.00	5.00	2.0^{ab}	1.89		
Total	61						

[1.] The mean values with differentsuperscript English alphabets ([a,b,c]) have significant differences between each other, analyzed by pair-wise comparison (Games-Howell method).

4.1.4.4 Cropping Pattern

Cereals/millets and other crops were the two most prominent crop groups in M_HK and no tubers and vegetables were being cultivated (Figure 19). Situation 2006 and 2009_N had the same cropping pattern for cereals production (both are 38%) while 2009_P had it slightly higher (49%). Pulses were grown more in 2009_P (15%) and 2009_N (24%) than in 2006 (8%). However, it was the other way around regarding to fruits cultivation which was more in 2006 than 2009 with banana and watermelon grown in M_HK. Compared to above three taluks, oilseeds received not only less attention but also only groundnut was cultivated. In addition, cotton was the important cash crop in all three situations which shared almost half of cropping area with cereals and millets.

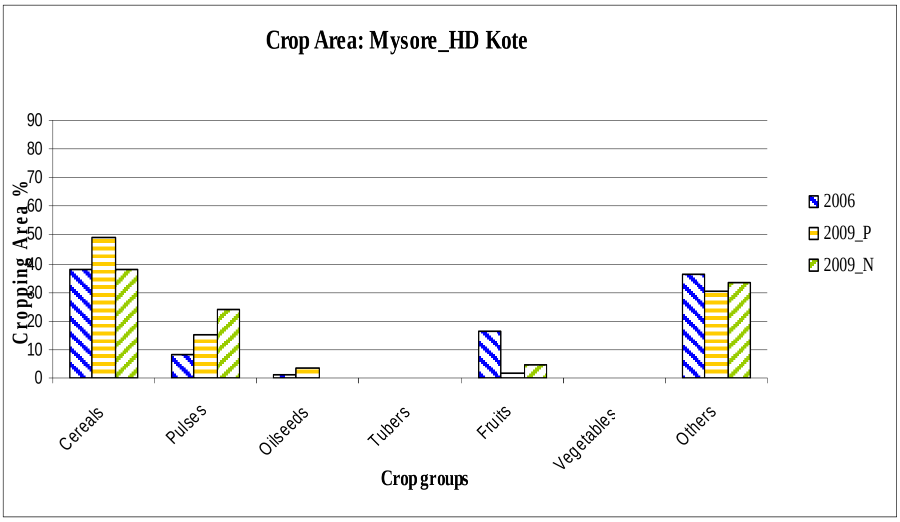


Figure 19. Cropping pattern in Mysore_HD Kote for three situations: 2006, 2009_P and 2009_N

4.1.5 Udupi_Udupi (U_U)

4.1.5.1 Land Holding Size

The average land holding sizes were small in all three situations; none of them exceeded 2 ha. It was 0.8 ha in 2006, 1.2 ha in 2009_P and 1.7 ha in 2009_N, and 2009_P had significantly higher area than 2006 (Table 20). Only one farm had larger land with 4 ha in 2009_N which elevated the standard deviation. The results suggested that there were homogeneous small holders in U_U. Even though the land sizes increased in 2009_P, they still belonged to small scaled farms.

Table 20 Land holding sizes analyzed by one-way ANOVA in Udupi-Udupi for three situations

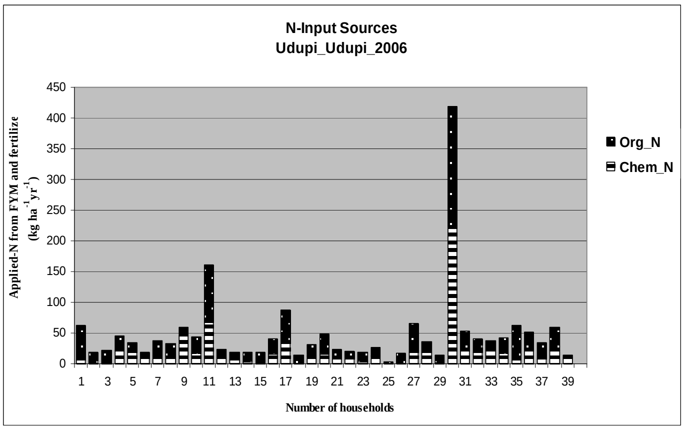
Land Holding Size	Descriptive Statistics					ANOVA	
Situation	N	Min.	Max.	Mean[1]	Std. Deviation	F	P.
2006	35	0.12	1.84	0.8^{a}	0.38	7.77	0.00
2009_P	11	0.75	1.80	1.2^{b}	0.37		
2009_N	5	0.72	4.00	1.7^{ab}	1.36		
Total	51						

[1.] The mean values with differentsuperscript English alphabets (^{a,b,c}) have significant differences between each other, analyzed by pair-wise comparison (Games-Howell method).

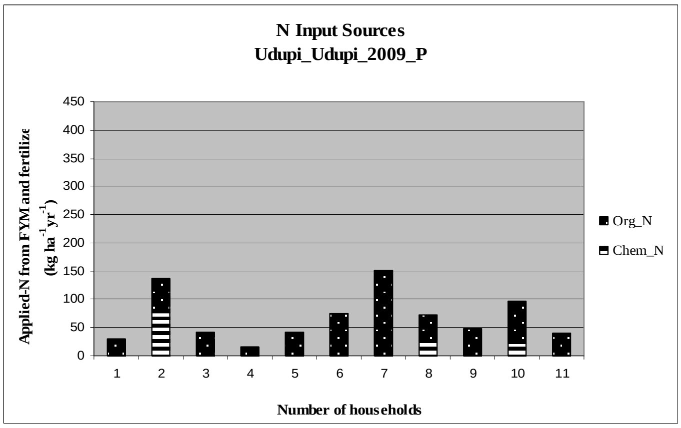
4.1.5.2 Organic and Chemical Fertilizer Application

N-Input

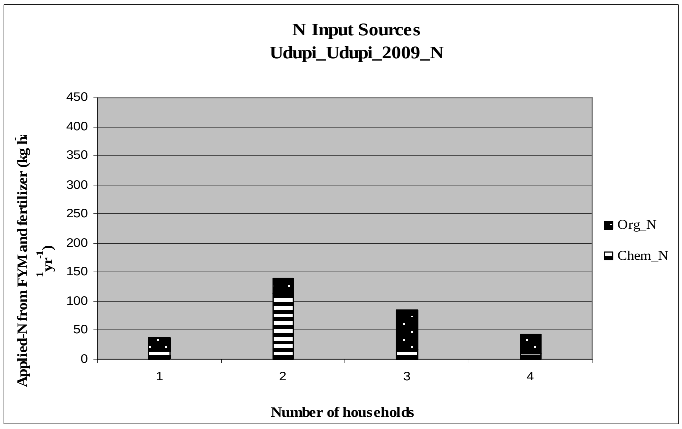
In general, chemical and organic fertilizers were evenly used in 2006, and almost every farmer used both organic and chemical fertilizer (Figure 20). The average annual N-input was 48 kg $ha^{-1}yr^{-1}$ in 2006 while 75% of the total sampling farms applied less than 50 kg $ha^{-1}yr^{-1}$ N on farm. In 2009_N, the average N-input was 76 kg $ha^{-1}yr^{-1}$while only one farm had more chemical fertilizer applied than organic one. The majority of farms in 2009_P used only organic fertilizer whereas the average N-input was 68.5 kg $ha^{-1}yr^{-1}$. Both situations in 2009 had higher average N-input than in 2006. Besides B_B and M_HK, U_U was the taluk with the third highest proportion of organic fertilizer application, but in U_U, farmers applied higher amount of organic fertilizer than B_B and M_HK. It is possible that farmers in U_U had more sources for organic input of better utilization of animal manure.



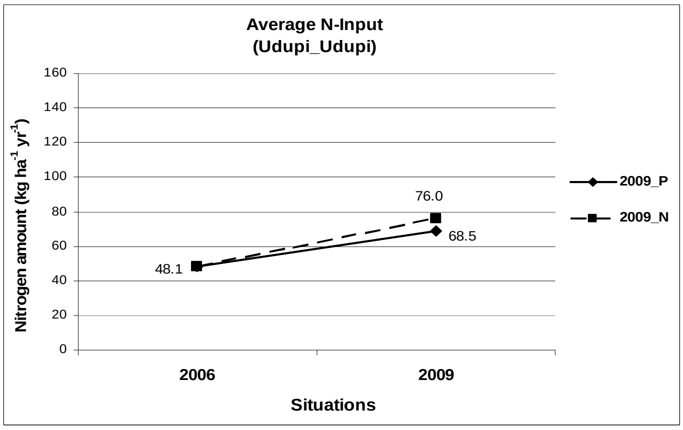
(c) 2006



(a) 2009_P



(f) 2009_N

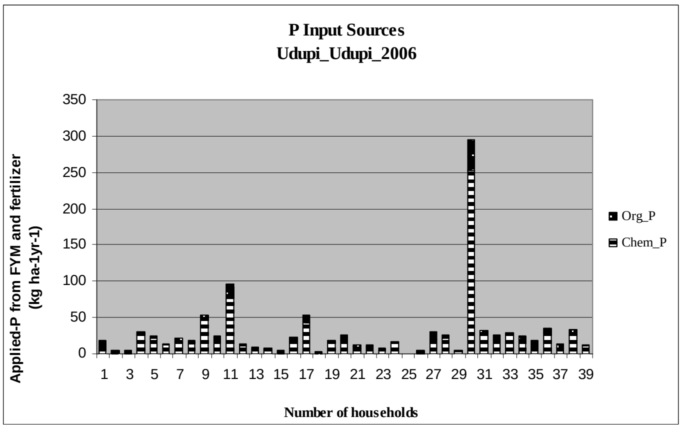


(d) Average N-input in three situations

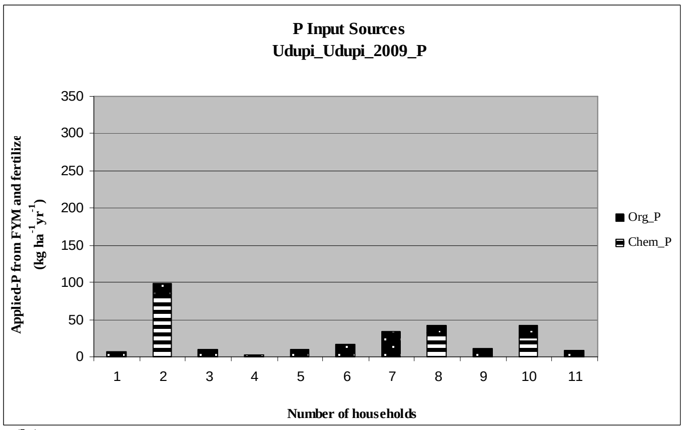
Figure 20. N-input sourced from organic and chemical fertilizer in Udupi_Udupi in three situations: (a) 2006 (b) 2009_P (c) 2009_N (d) Average annul N-input in three situations

P-Input

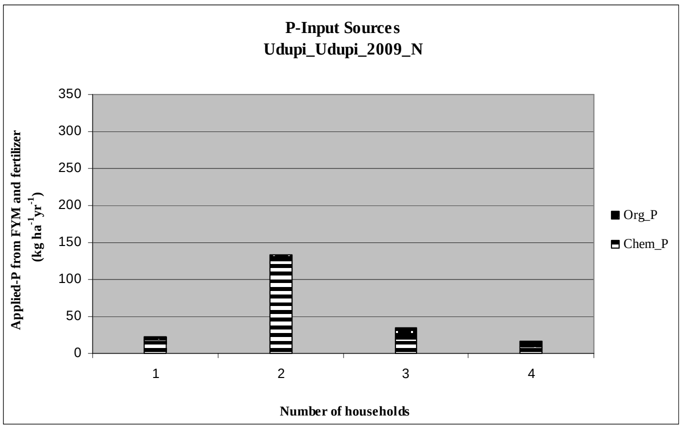
The average P-input was 21 kg ha^{-1}yr^{-1} in 2006, which mostly came from chemical fertilizers (Figure 21). Six farms applied zero chemical fertilizer but small amount of organic fertilizer resulting in low average P-input in 2006. In 2009_N, the average amount of P-input was the highest with 44 kg ha^{-1}yr^{-1}. However, again the small sampling size in 2009_N made the results unlikely to be representative. In 2009_P, higher proportion of organic fertilizers were applied on farm bringing in more organic P-input than 2006, however, the amount of P (25 kg ha^{-1}yr^{-1}) was still a bit lower than 2006 due to low P content contained in farm yard manure.



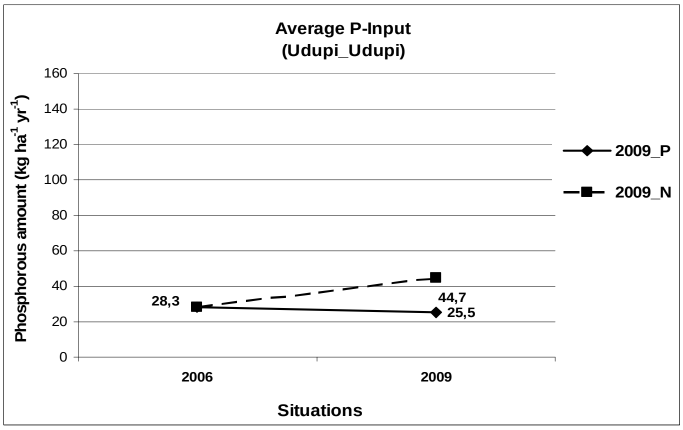
(a) 2006



(b) 2009_P



(d) 2009_N



(c) Average P-input in three situations

Figure 21. P-input sourced from organic and chemical fertilizer in Udupi_Udupi in three situations: (a) 2006 (b) 2009_P (c) 2009_N (d) Average P-input in three situations

K-input

Substantially higher amount of K provided by organic fertilizers was observed in U_U compared to other 4 taluks (Figure 22). Average K-input was 23, 47 and 37 kg $ha^{-1}yr^{-1}$ in 2006, 2009_P and 2009_N respectively. Because of the higher amount of organic fertilizer input in 2009_P, the only source taken for K-input calculation in this study, the average amount of K-input is higher than the other two situations, also higher than other taluks except for B_B in situation 2009_P.

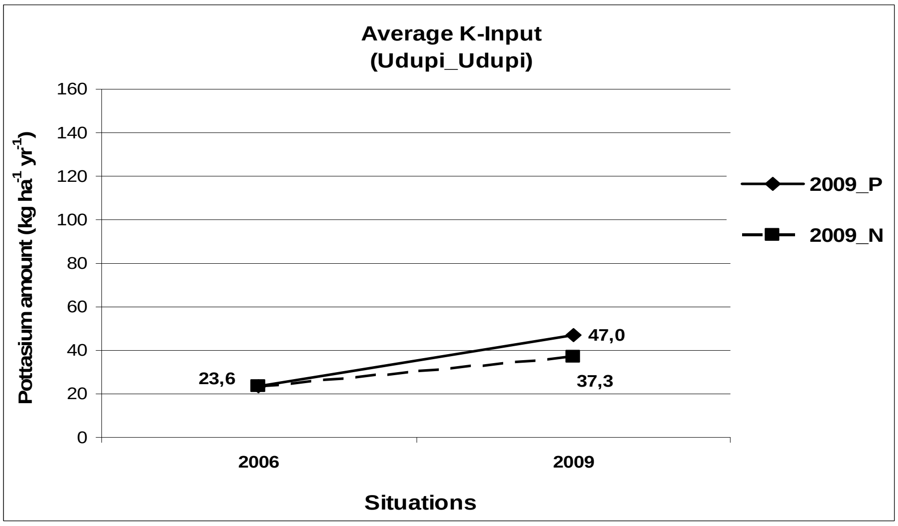


Figure 22. K-input sourced from organic fertilizer in Udupi_Udupi in three situations

4.1.5.3 Livestock Density Index

No significant differences among 3 situations regarding to livestock density index (LDI) were observed (Table 21). Situations 2009_N and 2009_P had similar livestock keeping record. Compared to other 4 taluks, U_U had higher average LDI for all three situations and this corresponds to the findings in fertilizer applications, that the farmers in U_U used both higher proportion and quantity of organic fertilizer. The result also suggested that the policy did not significantly influence the number of livestock on farm.

Table 21 Livestock density index analyzed by one-way ANOVA in Udupi-Udupi for three situations

Livestock density index	Descriptive Statistics					ANOVA	
Situation	**N**	**Min.**	**Max.**	**Mean[1]**	**Std. Deviation**	**F**	**P.**
2006	35	0	20	4.1[a]	4.22	0.22	0.79
2009_P	11	0.45	15.1	3.4[a]	4.01		
2009_N	5	0.89	6.58	3.1[a]	2.26		
Total	51						

[1.] The mean values with differentsuperscript English alphabets ([a,b,c]) have significant differences between each other, analyzed by pair-wise comparison (Games-Howell method).

4.1.5.4 Cropping Pattern

Cereals possessed most of the cropping area in U_U and the only cereal cultivated was rice. Rice had been grown in 82% of the total cropping area in 2006, while 70% in 2009_N and 66% in 2009_P. Besides the cereals/millets group, there were only another three crop groups cultivated in U_U (Figure 23). Coconuts were the main oilseeds production though they were not grown in 2009_P. Instead, vegetables were grown only in 2009_P. This is due to a demand for organic vegetables, while for other crops, there may be less demand for organic products yet.

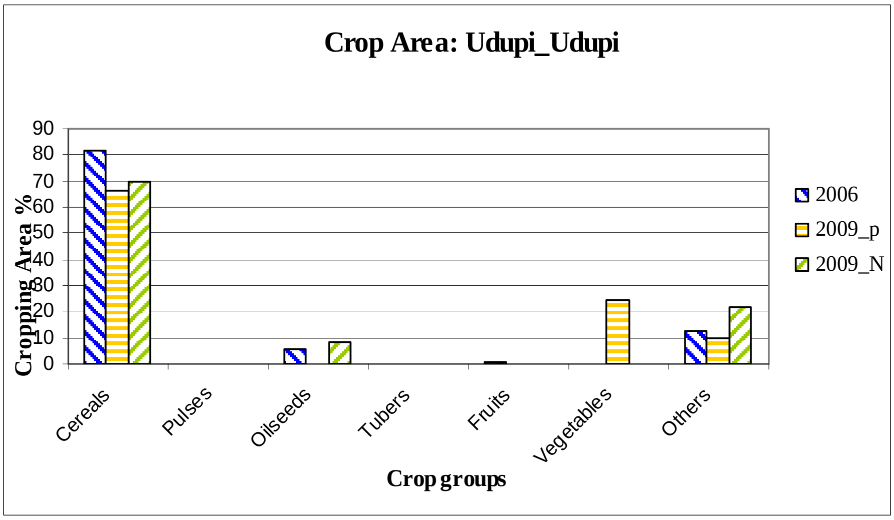


Figure 23. Cropping pattern in Udupi_Udupi in three situations: 2006, 2009_P and 2009_N.

4.2 One-way ANOVA Analysis: Crop Yield, Soil Organic Carbon, Planned Biota per hectare and Water Electrical Conductivity

Three agro-ecological indicators, namely soil organic carbon, water electrical conductivity and planned biota per hectare were analyzed using one-way ANOVA analysis comparing the differences among three situations (2006, 2009_P, 2009_N). Crop yield was also analyzed, as achieving good yields is a major aim of farmers, and it was influenced by or influenced the agro-ecological indicators selected for this research. In order to investigate the differences of crop yields among three situations, it is only possible to analyze the crops that were cultivated in all three situations. If the crop was only cultivated in two situations, independent T-test was used for comparing the yield differences. The following sections contain the descriptions of the results for all analyses mentioned above.

4.2.1 Bijapur_Bijapur (B_B)

4.2.1.1 Crop Yield

Three major grains, i.e, wheat, sorghum, and pearl millet, were cultivated in all three situations. The average wheat yields were 2915, 2479 and 1818 kg $ha^{-1}yr^{-1}$ in 2006, 2009_P and 2009_N. As for sorghum, the average yields were 2757, 2188 and 1442 kg $ha^{-1}yr^{-1}$ following situation sequence above (Table 22). There was no significant difference in yields observed for both wheat and sorghum among three situations. However, the small sample size (N) in 2009_P and 2009_N led to a less representative result. Yields of pearl millet reached 1276 (2006), 2000 (2009_P) and 1625 (2009_N) kg $ha^{-1}yr^{-1}$. This was the only cereal of which significantly higher yields were observed in 2009_P than 2006 ($p<0.05$).

Regarding to the oilseed crop, the average yields of groundnut were 2063 (2006), 1352 (2009_P) and 1873 (2009_N) kg $ha^{-1}yr^{-1}$ without significant differences among each other. As for the fruits crop, grape was recorded being cultivated in three situations, but no yield data was recorded in 2009_N. Therefore, grape yields were analyzed for 2006 and 2009_P using T-test and the result showed no significant difference between two situations. Except for the yields of pearl millet which was higher in 2009_P than 2006, all the other 4 corps had the highest average yields in 2006 then decreased in 2009_P and the lowest in 2009_N. The observation suggested that although the yields were lower in year 2009 in gerenal, farmers in the policy village seemed having better ability to attain higher crop production.

Table 22 Crop yields analyzed by one-way ANOVA or independent T-test in Bijapur_Bijapur for three situations

	Average Crop Yield (kg $ha^{-1}yr^{-1}$)[1]				
Situation	**Wheat**	**Sorghum**	**Pearl millet**	**Groundnut**	**Grape**
2006	2915^{a} (N=22)	2756^{a} (N=25)	1276^{a} (N=13)	2063^{a} (N=2)	24001^{a} (N=21)
2009_P	2469^{a} (N=4)	2187^{a} (N=2)	2000^{b} (N=6)	1873^{a} (N=3)	13333^{a} (N=3)
2009_N	1818^{a} (N=1)	1442^{a} (N=1)	1625^{ab} (N=2)	1352^{a} (N=4)	-

[1.] The mean values with differentsuperscript letter (^{a,b,c}) are statistically significant (P.<0.05)

4.2.1.2 Soil Organic Carbon

The highest average SOC content (1.3%) appeared in 2009_P with the widest data range (0.6-3.6%) (Figure 24); in 2006 and 2009_N, the average SOC content were 0.83 % and 1.1%, respectively. There was significant higher SOC content in 2009_N compared with 2006 (Appendix IV). Although the average SOC content is higher in 2009_P than 2009_N, no significant difference was observed between 2009_P and the other two situations. The reason could be the high standard deviation existing in data sets of 2009_P. In general, SOC contents are higher in B_B than the other studied taluks in all situations. However, the influence from the policy can not be observed from the results.

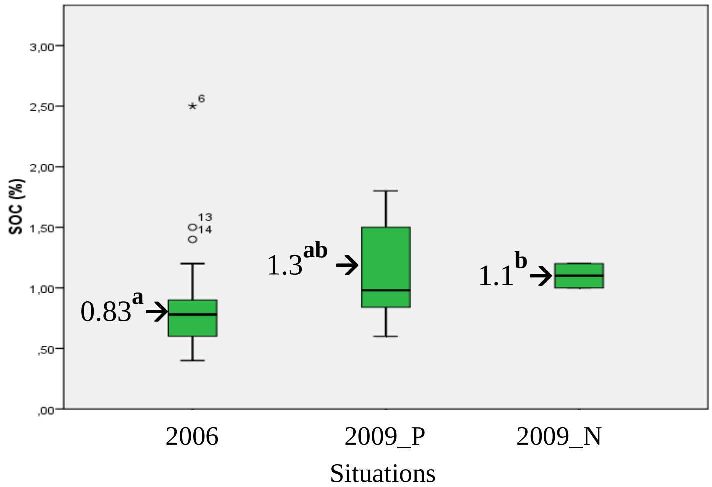


Figure 24. Soil organic carbon contents in three situations in Bijapur_Bijapur shown in box and whisker plot. Median and mean values are indicated by horizontal lines within each box and arrow outside each box, respectively. The mean values with differentsuperscript English alphabets ([a,b,c]) have significant differences between each other

4.2.1.3 Planned Biota per Hectare

The planned biota per ha was significantly higher in 2009_P compared to 2006 (Table 23). The results indicated that higher numbers of crop or livestock species were supposed to be cultivated or kept on farm after the policy was introduced. However, a strong negative correlation between land holding size and planned biota per ha was observed (Table 38). It may be that the same amount of species were present on farm, but that the number per ha increased as farm sizes were much smaller in 2009 compared to 2006.

Table 23 Planned biota per ha analyzed by one-way ANOVA in Bijapur_Bijapur for three situations

Planned Biota per ha (species no./ha)	Descriptive Statistics					ANOVA	
Situation	N	Min.	Max.	Mean[1]	Std. Deviation	F	P.
2006	31	1.53	16.2	6.1[a]	3.15	10.4	0
2009_P	10	7.50	16.6	11.2[b]	3.13		
2009_N	5	5.52	18.1	10.2[ab]	5.06		
Total	46						

[1.] The mean values with differentsuperscript English alphabets ([a,b,c]) have significant differences between each other, analyzed by pair-wise comparison (Games-Howell method).

4.2.1.4 Water Electrical Conductivity

According to Ayers and Westcot (1985), water salinity can be represented by water electrical conductivity (W_EC) and classified into three degrees in terms of restriction of use: none (W_EC < 0.7), slight to moderate (W_EC = 0.7-3.0), and severe (W_EC > 3.0). Based on the classification, B_B had a W_EC level belonging to slight to moderate degree in 2009_P and 2009_N. There was no significant difference in terms of W_EC level between two situations. However, the ground water samples were collected in the same village as well as the same year, so little differences were expected.

Table 24 Water electrical conductivity analyzed by independent T-test in Bijapur_Bijapur for 2009_P and 2009_N

Water EC (dS/m)	Descriptive Statistics			T-test	
Situation	**N**	**Mean[1]**	**Std. Deviation**	**T**	**P.**
2009_P	10	1.24[a]	0.59	1.80	0.09
2009_N	5	0.73[a]	0.29		
2006	-	-	-	-	-

[1.] The mean values with differentsuperscript English alphabets ([a,b,c]) have significant differences between each other

4.2.2 Chitradurga_Hiriyur (C_H)

4.2.2.1 Crop Yield

Rice was grown in all three situations with the average yields 5383 (2006), 5000 (2009_P) and 2380 (2009_N) kg ha^{-1}yr^{-1} (Table 25) and no significant difference was observed among three situations. Finger millet was the other cultivated cereal crop with average yield 8280 (2006) and 1870 (2009_P) kg ha^{-1}yr^{-1}. Although the average yields of finger millet seemed very different between two situations, no significant difference was found. It may be due to the extreme data (i.e, 28,750 kg ha^{-1}yr^{-1}of farm no.29 in 2006) which led to high standard deviation.

The most prosperously cultivated oilseed crop was groundnut followed by sunflowers. The average yields for groundnuts were 1071(2006), 731 (2009_P) and 1042 (2009_N) kg ha^{-1}yr^{-1} without significant differences among three, neither the yields of sunflowers. Besides, mulberry and areca were two popular cash crops in 2006 and 2009_P. Mulberry serves as the fodder for silkworms. Areca was the only crop having significant higher yields in 2009_P than 2006 ($p = 0.05$), but there was only one sample collected in 2009_P which made the result impossible to be generalized.

Except for areca, the average yields were decreasing from 2006 to 2009, but there were no significant differences. Therefore, the influence from the policy can not be observed.

Table 25 Crop yields analyzed by one-way ANOVA or independent T-test in Chitradurga_Hiriyur for three situations

	Average Crop Yield (kg ha^{-1}yr^{-1})[1]					
Situation	**Rice**	**Finger millet**	**Groundnut**	**Sunflower**	**Areca**	**Mulberry**
2006	5383[a] (N=21)	8280 [a] (N=5)	1071 [a] (N=23)	2187 [a] (N=2)	4666 [a] (N=3)	1850[a] (N=15)
2009_P	5000[a] (N=8)	1870 [a] (N=9)	731 [a] (N=6)	1291 [a] (N=3)	16666[b] (N=1)	1099 [a] (N=4)
2009_N	2380[a] (N=1)	-	1042 [a] (N=2)	1107 [a] (N=4)	-	-

[1.] The mean values with differentsuperscript English alphabets ([a,b,c]) have significant differences between each other

4.2.2.2 Soil Organic Carbon

Half of the farms in 2006 had SOC content below 0.53% (the median). The average SOC contents were 0.49%, 0.43% and 0.45% in 2006, 2009_P and 2009_N (Figure 25), respectively. C_H was the only taluk without significant differences among three situations in terms of SOC contents. Although higher proportion of organic fertilizer was used in 2009_P than 2006, the quantity of N-input stayed low. The farmers continuously used chemical fertilizer from 2006 to 2009 may be also a reason resulting in insignificant changes of SOC content.

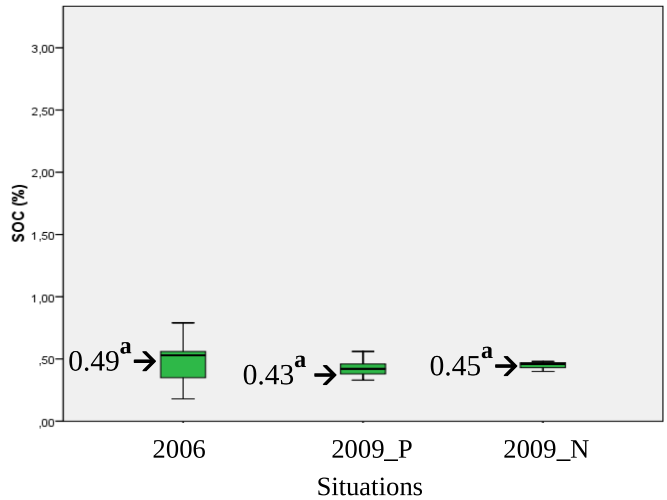


Figure 25. Soil organic carbon contents in three situations in Chitradurga_Hiriyur shown in box and whisker plot. Median and mean values are indicated by horizontal lines within each box and arrow outside each box, respectively. The mean values with differentsuperscript English alphabets ([a,b,c]) have significant differences between each other

4.2.2.3 Planned Biota per Hectare

The planned biota per ha was the highest in 2006, followed by 2009_P and 2009_N (Table 26) with significant differences among three. The policy seemed not resulting in more species no./ha in this taluk. Nevertheless, the negative correlation between land holding size and planned biota per ha was also observed (Table 38) here suggesting the interdependent relationship between land holding size and planned biota per hectare.

Table 26 Planned biota per ha analyzed by one-way ANOVA in Chitradurga_Hiriyur for three situations

Planned Biota per ha (species no./ha)	Descriptive Statistics					ANOVA	
Situation	N	Min.	Max.	Mean[1]	Std. Deviation	F	P.
2006	42	1.25	37.5	11.5[a]	6.33	13.7	0.0
2009_P	10	1.36	5.0	2.7[b]	1.35		
2009_N	3	0.31	0.8	0.6[c]	0.27		
Total	55						

[1.] The mean values with differentsuperscript English alphabets ([a,b,c]) have significant differences between each other, analyzed by pair-wise comparison (Games-Howell method).

4.2.2.4 Water Electrical Conductivity

According to the description in Section 4.2.1.4, water salinity levels in two situations in C_H belonged to slight to moderate (W_EC = 0.7-3.0) class (Table 27). No significant difference was found between 2009_P and 2009_N. However, the general W_EC was higher in C_H than B_B in 2009 where a higher proportion of organic fertilizers were applied.

Table 27 Water electrical conductivity analyzed by independent T-test in Chitradurga_Hiriyur for 2009_P and 2009_N

Water EC (dS/m)	Descriptive Statistics			T-test	
Situation	**N**	**Mean[1]**	**Std. Deviation**	**T**	**P.**
2009_P	8	1.52[a]	0.51	0.32	0.75
2009_N	3	1.42[a]	0.11		
2006	-	-	-	-	-

[1.] The mean values with differentsuperscript English alphabets ([a,b,c]) have significant differences between each other

4.2.3 Kolar_Gowribdinur (K_G)

4.2.3.1 Crop Yield

Finger millet was the only cereal crop cultivated in all three situations with average yields of 1350 (2006), 3833 (2009_P), and 1812 (2009_N) kg ha^{-1}yr^{-1}(Table 28). Significantly higher finger millet yields were found in 2009_P compared to 2006 which was similar to B_B in terms of pearl millet yields. The other cereal crop, maize, had similar average yields around 2000 kg ha^{-1}yr^{-1} in both 2009_P and 2009_N. Oilseeds crop, sunflower, was cultivated only in year 2009 with the average yields 1187 (2009_P) and 1750 (2009_N) kg ha^{-1}yr^{-1}. Tuber crop, potato was cultivated in both 2006 and 2009_P with average yields, 12607 (2006) and 11600 (2009_P) kg ha^{-1}yr^{-1}. There were no significant differences found for either sunflowers or potatoes.

The yields of millet crop were significantly higher in 2009_P compared to 2006 in B_B and K_G, while almost all other crops had lower or no differenct yields in 2009_P. The results suggested that millet crop may have better performance under the policy.

Table 28 Crop yields analyzed by one-way ANOVA or independent T-test in Kolar_Gowribdinur for three situations

	Average Crop Yield (kg ha^{-1}yr^{-1})[1]			
Situation	**Finger Millet**	**Maize**	**Sunflower**	**Potato**
2006	1350^{a} (N=12)	-	-	12607 ^{a} (N=7)
2009_P	3833^{b} (N=3)	2063 ^{a} (N=7)	1187 ^{a} (N=2)	11666 ^{a} (N=2)
2009_N	1812^{ab} (N=2)	2000 ^{a} (N=3)	1750 ^{a} (N=4)	-

[1.] The mean values with differentsuperscript English alphabets (^{a,b,c}) have significant differences between each other

4.2.3.2 Soil Organic Carbon

The average SOC contents were lower in K_G than all other taluks ranging from 0.12% (2006), 0.30% (2009_N) to 0.37% (2009_P) where 2009_N had significantly higher SOC content than 2006 (Figure 26). Since there was only little higher quantity of organic input applied in 2009_P and 2009_N compared to 2006, it is not likely to be the reason of increased SOC content. However, more area using for maize cultivation in 2009 may generate lots of crop residues to be incorporated on farm as potential nutrient supply (Rajkumara et al, 2009). It seemed that KSPoOF did not influence the difference.

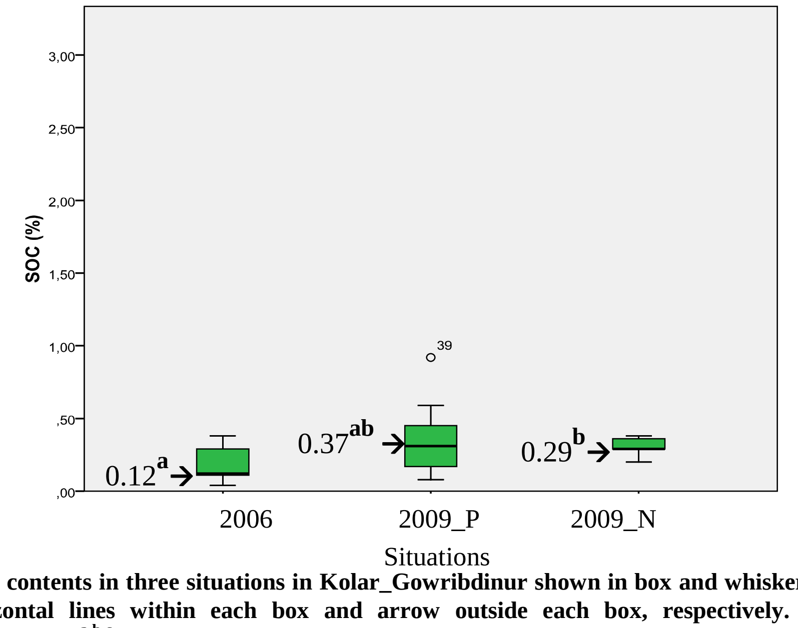


Figure 26. Soil organic carbon contents in three situations in Kolar_Gowribdinur shown in box and whisker plot. Median and mean values are indicated by horizontal lines within each box and arrow outside each box, respectively. The mean values with differentsuperscript English alphabets (^{a,b,c}) have significant differences between each other

4.2.3.3 Planned Biota per Hectare

The average planned biota per ha was the lowest in 2009_P (Table 29), opposite to the expectations. However, the same situation was found here as B_B and C_H, the larger the land holding size, the smaller the planned biota per ha. The influence of the policy is not obvious for planned biota per ha.

Table 29 Planned biota per ha analyzed by one-way ANOVA in Kolar_Gowribdinur for three situations

Planned Biota per ha (species no./ha)	Descriptive Statistics					ANOVA	
Situation	N	Min.	Max.	Mean[1]	Std. Deviation	F	P.
2006	25	0.20	25.0	3.1[a]	4.83	1.85	0.17
2009_P	9	1.00	4.38	2.8[a]	1.19		
2009_N	5	2.50	13.75	7.0[a]	4.73		
Total	39						

[1.] The mean values with differentsuperscript English alphabets ([a,b,c]) have significant differences between each other, analyzed by pair-wise comparison (Games-Howell method).

4.2.3.4 Water Electrical Conductivity

Water salinity was not a problem in K_G (W_EC < 0.7). An identical average W_EC was found in 2009_P and 2009_N and there was no significant difference between 2009_P and 2009_N (**Table 30**)

Table 30**Table 30 Water electrical conductivity analyzed by independent T-test in Kolar_Gowribdinur for 2009_P and 2009_N**

[1.] The mean values with differentsuperscript English alphabets ([a,b,c]) have significant differences between each other

4.2.4 Mysore_HD Kote (M_HK)

4.2.4.1 Crop Yield

Cereal crop, finger millet had average yield of 1750 (2006), 1870 (2009_P) and 2100 (2009_N) kg $ha^{-1}yr^{-1}$(Table 31). Different from B_B and K_G, the yields of finger millet did not differ significantly among three situations. Horsegram and cotton were the other two crops analyzed. The average yields of horsegram were 500 (2006), 265 (2009_P) and 812 (2009_N) kg $ha^{-1}yr^{-1}$ with significant higher yield in 2009_N compared to 2009_P ($p<0.005$). Cotton, as the major cash crop, had the average yields 2500 (2006), 480 (2009_P) and 1033 (2009_N) kg $ha^{-1}yr^{-1}$ with significant difference among three situations. Although the significances were observed for yields of horsegram and cotton, the zero standard deviation found within their yield data in 2006 revealed the problematic data processing. In M_HK, most significantly higher yields occurred in 2009_N which indicated that the policy did not effectively increase the yields. Instead, yields were averagely lower in 2009_P where the policy was implemented.

Table 31 Crop yields analyzed by one-way ANOVA in Mysore_HD Kote for three situations

	Average Crop Yield (kg $ha^{-1}yr^{-1}$)[1]		
Situation	**Finger Millet**	**Horsegram**	**Cotton**
2006	1750^{a}(N=44)	500^{ab}(N=8)	2500^{a}(N=23)
2009_P	2283^{a} (N=10)	265^{a} (N=4)	480^{b} (N=8)
2009_N	2100^{a} (N=5)	812^{b} (N=4)	1033^{c} (N=5)

[1.] The mean values with differentsuperscript English alphabets (^{a,b,c}) have significant differences between each other

4.2.4.2 Soil Organic Carbon

The average SOC contents were 0.58% (2006), 1.06% (2009_P) and 0.87% (2009_N) in M_HK (Figure 27). Both 2009_P and 2009_N had significantly higher SOC content than 2006 ($p< 0.05$). When there were half of the farms in 2006 with SOC contents lower than 0.6%, none of the farms in 2009_P having SOC content lower than 0.6%. This indicated that the sampling farms in 2009_P were having higher SOC content inherently, especially when the nutrient input in 2009_P was low. Direct influence from the policy can not be told.

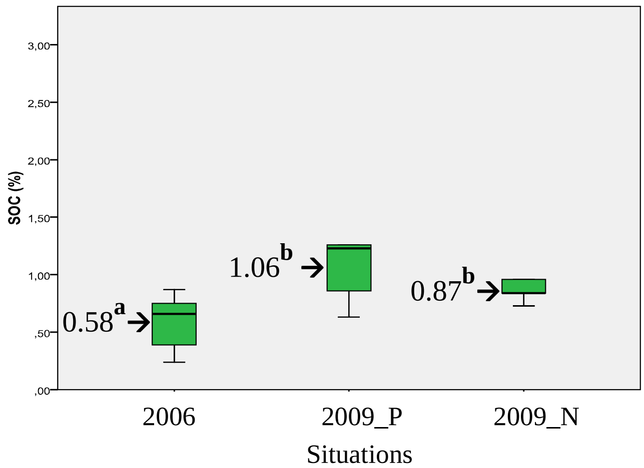


Figure 27. **Soil organic carbon contents in three situations in Mysore_HD Kote shown in box and whisker plot. Median and mean values are indicated by horizontal lines within each box and arrow outside each box, respectively. The mean values with differentsuperscript English alphabets (^{a,b,c}) have significant differences between each other**

4.2.4.3 Planned Biota per Hectare

The highest planned biota per ha appeared in 2009_N, followed by 2006 and 2009_P (Table 32), with the significant lower value in 2009_P compared to both 2006 and 2009_N. In the policy village, higher numbers of crop and livestock species were not found.

Table 32 Planned biota per ha analyzed by one-way ANOVA in Mysore_HD Kote for three situations

Planned Biota per ha (species no./ha)	Descriptive Statistics					ANOVA	
Situation	N	Min.	Max.	Mean[1]	Std. Deviation	F	P.
2006	49	0.5	25.0	6.6[a]	5.17	6.84	0.00
2009_P	10	0.4	6.6	3.8[b]	1.79		
2009_N	5	7.5	17.5	13.6[a]	5.34		
Total	64						

[1.] The mean values with differentsuperscript English alphabets ([a,b,c]) have significant differences between each other, analyzed by pair-wise comparison (Games-Howell method).

4.2.4.4 Water Electrical Conductivity

The average water salinity in M_HD was higher than in the other previous 4 taluks, though it still belonged to the slight to moderate (W_EC = 0.7-3.0) class in both 2009_P and 2009_N. No significantly difference was observed for W_EC (Table 33).

Table 33 Water electrical conductivity analyzed by independent T-test in Mysore_HD Kote for 2009_P and 2009_N

Water EC (dS/m)	Descriptive Statistics			T-test	
Situation	**N**	**Mean[1]**	**Std. Deviation**	**T**	**P.**
2009_P	6	1.4[a]	0.20	-2.02	0.07
2009_N	5	1.6[a]	0.09		
2006	-	-	-	-	-

[1.] The mean values with differentsuperscript English alphabets ([a,b,c]) have significant differences between each other

4.2.5 Udupi_Udupi (U_U)

4.2.5.1 Crop Yield

Udupi_Udupi was characterized with prevalent rice production in all situations with average yields, 3840 (2006), 2916 (2009_P) and 4331 (2009_N) kg $ha^{-1}yr^{-1}$ without significant difference among them. Areca was the second commonly planted crop in all three situations with average yields, 1026.8 (2006), 2291(2009_N) and 2433 (2009_P) kg $ha^{-1}yr^{-1}$. The same to rice yields, no significant difference occurred among three situations. It seemed that the policy did not have affect on either cropping pattern or the crop yields.

Table 34 Crop yields analyzed by one-way ANOVA in Udupi_Udupi for three situations

	Average Crop Yield (kg $ha^{-1}yr^{-1}$)[1]	
Situation	**Rice**	**Areca**
2006	3840[a] (N=30)	1026[a] (N=15)
2009_P	2915[a] (N=10)	2433[a] (N=5)
2009_N	4330[a] (N=5)	2291[a] (N=3)

[1.] The mean values with differentsuperscript English alphabets ([a,b,c]) have significant differences between each other

4.2.5.2 Soil Organic Carbon

The data of SOC content was available only for 2006. The average SOC content (0.74%) in 2006 was higher than all other taluks except for Bijapur_Bijapur. However, according to a KvK researcher, the farm yard manure increased the SOC contents in 2009 (Purushothaman et al, 2010).

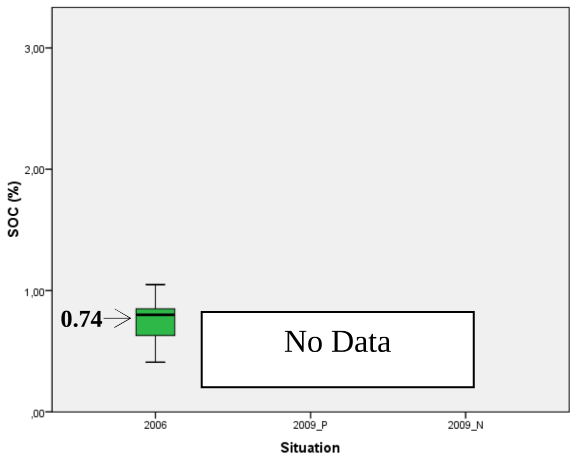


Figure 28. Soil organic carbon contents in three situations in Mysore_HD Kote shown in box and whisker plot. Median and mean values are indicated by horizontal lines within each box and arrow outside each box, respectively

4.2.5.3 Planned Biota per Hectare

The biggest planned biota per ha was in 2006, and the significant difference appeared between 2009_P and 2009_N (Table 35). The extreme small land holding size of farm no. 21 in 2006 resultng in the extreme value of planned biota per ha (72.6 species no./ha).

Table 35 Planned biota per ha analyzed by one-way ANOVA in Udupi_Udupi for three situations

Planned Biota per ha (species no./ha)	Descriptive Statistics					ANOVA	
Situation	N	Min.	Max.	Mean[1]	Std. Deviation	F	P.
2006	35	1.25	72.6	8.8[ab]	12.6	0.42	0.6
2009_P	11	4.64	12.95	7.9[a]	2.55		
2009_N	5	1.75	6.00	4.2[b]	1.94		
Total	51						

[1.] The mean values with differentsuperscript English alphabets ([a,b,c]) have significant differences between each other, analyzed by pair-wise comparison (Games-Howell method).

4.2.5.4 Water Electricity Conductivity

Although the average W_EC values were very low in 2009_P and also 2009_N, U_U was the only taluk with significant difference between two situations (Table 36). Rice was the most common cereal crop in U_U in every situation. When it comes to organic rice cultivation, the rice fields were irrigated instead of flooded. This change in farming practice could be the major factor for the differences in two situations.

Table 36 Water electrical conductivity analyzed by independent T-test in Udupi_Udupi for 2009_P and 2009_N

Water EC (dS/m)	Descriptive Statistics			T-test	
Situation	**N**	**Mean[1]**	**Std. Deviation**	**T**	**P.**
2009_P	11	0.07[a]	0.02	2.24	0.04
2009_N	5	0.05[b]	0.01		
2006	-	-	-	-	-

[1.] The mean values with differentsuperscript English alphabets ([a,b,c]) have significant differences between each other

4.3 Bivariate Correlation Analysis

The results of bivariate correlation of the agro-ecological indicators and their explanatory variables are described. The correlation analysis was performed at taluk-level and also at state-level. The results will be described in the sequence of each agro-ecological indicator to understand with which explanatory variables they got the significant correlation. All variables included in the correlation matrix are listed in Table 10. The complete Spearman's rho correlation matrixes for each agro-ecological indicator and every variable are displayed in Appendix V.

4.3.1 Soil Organic Carbon

Regarding to crop yields, soil organic carbon was only correlated with the yields of two crops: pearl millet in B_B and cotton in M_HK, but correlated in different direction (Table 37). There was a negative correlation between land holding size and SOC in B_B and C_H and state-level, indicating that generally the larger the land holding size, the lower the SOC content. Water quality variables did not include at taluk-level analysis, because the data for 2006 was missing.

Table 37 Bivariate correlation analysis between soil organic carbon and other variables at taluk-level and state-level; correlation coefficients are shown in bracket

Soil Organic Carbon	Correlated variables (correlation coefficient)
B_B	Yield_pearl millet (0.47*), Land holding size (-0.32*), Soil_ava ilable K (0.41**)
C_H	Land under cultivation (-0.39*), Land holding size (-0.32*), Water_Sodium (0.38*), Water_Calcium (0.35*)
K_G	Soil_available K (0.34*), Area_cereal (0.41**), Area_pulse (-0.39*), Area_root (-0.32*)
M_HK	Yield_cotton (-0.78**), Livestock density index (-0.25*), Soil_available P (0.35**), Area_pulse (0.24*), Area_fruit (-0.30*)
U_U	Irrigation percentage (0.37*), Soil_available P (0.52**), Area_cereal(0.38*), Area_other(-0.37*)
State-level	Planned biota per ha (0.19**), Water_EC (0.39**), Chemical fertilizer N (-0.15*), Livestock density index (0.22**), Cropping intensity (0.43**), Land holding size(-0.13*), Soil_EC (0.14*), Water_pH value (-0.31**), Water_Calcium (0.65**), Water_Bicarbonate (0.40**), Water_Chloride (0.55**), Water_SAR (-0.60**), Water_RSC (-0.58**), Area_cereal (0.22**), Area_oilseed (-0.17**), Area_root (-0.31**), Area_fruit(0.14*)

** Correlation is significant at the 0.01 level (2-tailed)
* Correlation is significant at the 0.05 level (2-tailed)

4.3.2 Planned biota per hectare

There were some similarities between the results at taluk-level and at state-level. Livestock density index appeared positively correlated with planned biota per ha in almost all taluk except for M_HK (Table 38). Cropping intensity was also a common variable positively correlated with planned biota per ha. Based on our data computing, higher the cropping intensity means that more lands are used for cultivation purpose. Since planned biota per ha stands for the numbers of crop species and livestock species on farm, higher cropping intensity are related to more numbers of species. Land holding size was negatively correlated to planned biota per ha in every taluk and state-level, corresponding to the results of ANOVA analysis of planned biota per ha. Besides, there is a positive correlation between organic fertilizer N-input and planned biota per ha spatially but not temporally since the correlation only happened at the state-level.

Table 38 Bivariate correlation analysis between planned biota per ha and other variables at taluk-level and state-level. correlation coefficients are shown in brackets

Planned biota ratio	Correlated variables (correlation coefficient)
B_B	Organic fertilizer N (0.31*), Livestock density index (0.50**), Irrigation percentage (0.35*), Cropping intensity (0.51**), Land under cultivation (-0.71**), Land holding size (-0.88**), Water pH value (-0.58*)
C_H	Yield finger millet (0.64*), Yield mulberry (-0.51*), Livestock density index (0.41**), Cropping intensity (0.61**), Land under cultivation (-0.69**), Land holding size (-0.83**), Soil available P (0.49**), Soil EC(-0.60**), Area_oilseed (-0.32*), Area_root (-0.31*), Area_fruit (-0.28*)
K_G	Livestock density index (0.46**), Land under cultivation (-0.44**), Land holding size (-0.67**), Water pH value (0.62*), Area_other (0.36*)
M_HD	Yield_horsegram (0.67**), Organic fertilizer N proportion (-0.34**), Chemical fertilizer N (0.37**), Cropping intensity (0.64**), Land holding size (-0.69**)
U_U	Water EC (0.51*), Livestock density index (0.31*), Irrigation percentage (-0.36**), Land holding size (-0.31*), Water_Sodium (0.64**), Water SAR(0.55*), Area_cereal (-0.28*)
State-level	SOC (0.19**), Water EC(-0.33**), Organic fertilizer N proportion (0.39**), Organic fertilizer N (0.26**), Livestock density index (0.52**), Irrigation percentage (0.24**), Cropping intensity (0.16**), Land under cultivation (-0.12*), Land holding size (-0.47**), Soil available P (0.26**), Soil available K (0.26**), Soil EC(-0.20**), Water RSC(-0.37**), Area_pulse (-0.14*), Area_oilseed (0.16**), Area_vege (0.15*)

** Correlation is significant at the 0.01 level (2-tailed)
* Correlation is significant at the 0.05 level (2-tailed)

4.3.3 Water Electrical Conductivity

Water salinity is a detrimental issue for crop growth. Water electrical conductivity (W_EC) had highly significant correlation with 7 other water parameters (see Table 10) in almost all taluks (Table 39). Perfect correlations (r=1) between 6 water parameters and W_EC revealed the high risk for multicollinearity when conducting multiple regression analysis. As for other variables, organic fertilizer N had positive correlation with W_EC in B_B and M_HK at a 0.05 significance level.

At the state-level analysis, besides water quality parameters, other variables such as soil pH, soil_P, soil_ K and soil_EC were correlated with W_EC. Besides, variables related to farming practices such as livestock density index, cropping intensity were correlated with water EC either negatively or positively.

Table 39 Bivariate correlation analysis between water EC and other variables at taluk-level and state-level. Correlation coefficients are shown in brackets.

Water EC	Correlated variables (correlation coefficient)
B_B	Organic fertilizer N (0.52*), Cropping intensity (-0.57*), Water SAR (0.60*), Water RSC (-0.88**)
C_H	Water Sodium (1.0**), Water Calcium (1.0**), Water Bicarbonate (1.0**), Water Chloride (1.0**), Water SAR (1.0**), Water RSC (1.0**), Area_oilseed (-0.32*), Area_root (-0.31*), Area_fruit (-0.28*)
K_G	Water Sodium (0.90**), Water Calcium (0.87**), Water Bicarbonate (0.84**), Water Chloride (0.83**), Water SAR (0.76**), Water RSC (0.63*), Area_other (0.36*)
M_HD	Organic fertilizer N (0.66*),Water pH value (-0.76**)
U_U	Planned biota ratio (0.51*), Water sodium (0.86**), Water SAR (0.66**), Area cereal (-0.41**), Area pulse (0.31**), Area oilseed (0.28*), Area fruit (0.28*), Area vege (-0.47**)
State-level	SOC (0.39**), Planned biota ratio (-0.33**), Livestock density index (-0.50**), Cropping intensity(0.44**), Land under cultivation (0.25*), Soil pH (0.49**), Soil P (-0.34), Soil K(0.29*), Soil EC(0.68**), Water pH value (0.46**), Water sodium (0.94**), Water calcium (0.94**), Water bicarbonate (0.93**), Water chloride (0.94**), Water SAR (0.54**), Water RSC (-0.37**), Rainfall (0.51**), Area Cereal (-0.41**), Area pulse (0.31**), Area oilseed (0.28*), Area fruit (0.28*), Area vege (-0.47**)

** Correlation is significant at the 0.01 level (2-tailed)
* Correlation is significant at the 0.05 level(2-tailed)

4.3.4 Crop yield

4.3.4.1 Bijapur_Bijapur

In B_B, the comparison of crop yield was done to wheats, sorghums, pearl millets, groundnuts and grapes (Table 40). Pearl millet was the only crop that had significant higher yield in 2009_P (Section 4.2.1.1) as well as significant correlation with soil organic carbon. Livestock density index and irrigation percentage both had positive correlation with the yields of wheat, sorghum, and pearl millet at various degrees.

However, the yields of grapes had different correlation from other crops to which soil pH value, soil EC and water pH were significantly correlated.

Table 40 Bivariate correlation analysis between crop yields and other variables in Bijapur_Bijapur; correlation coefficients are shown in brackets

B_B	Correlated variables (correlation coefficient)
Yield_Wheat	Yield_sorghum (0.48*), Yield_pearl millet (0.61*), Organic fertilizer N (0.56**), Livestock density index (0.53**), Irrigation percentage (0.45*), Area_fruit(0.40*)
Yield_Sorghum	Yield_wheat (0.48*), Organic fertilizer N (0.58**), Chemical fertilizer N (0.46*), Livestock density index (0.41*), Irrigation percentage (0.41*), Water SAR(1.00**), Area_fruit(0.44*)
Yield_Pearl millet	Soil organic carbon (0.47*), Yield_wheat (0.61*), Livestock density index (0.43*), Irrigation percentage (0.47*)
Yield_Groundnut	Cropping intensity(- .69*)
Yield_Grape	Soil pH (-0.56**), Soil EC (0.53**), Water pH value (-1.0**)

** Correlation is significant at the 0.01 level (2-tailed)
* Correlation is significant at the 0.05 level (2-tailed)

4.3.4.2 Chitradurga_Hiriyur

In C_H, the crop yields of rices, finger millets, groundnuts, sun flowers, arecas and mulberry were used for correlation analysis while none of them had significant differences among three situations. Livestock density index was positively correlated with the Y_finger millet and Y_sunflower also in B_B, but negatively correlated with Y_mulberry. As a matter of fact, mulberry had all opposite signs of correlation coefficients with variables: planned biota per ha, organic fertilizer proportion and livestock density index. When looking into the data, most farms had records for mulberry cultivation but missing yields data which were replaced by average yields from the data of other farms. This may impair the analysis.

Y_finger millet was negatively correlated with organic fertilizer N proportion, organic fertilizer N, irrigation percentage. The organic fertilizer proportion was again negatively correlated with Y_groundnut, which implied that the higher amount and percentage of organic fertilizer N did not influence crop yields positively. This phenomenon is different from B_B. Y_areca had nothing in correlation with because the insufficient data for Y_areca.

Table 41 Bivariate correlation analysis between crop yields and other variables in Chitradurga_Hiriyur; correlation coefficients are shown in brackets

C_H	Correlated variables (correlation coefficient)
Yield_Rice	Yield_groundnut (0.63*)
Yield_Finger millet	Planned biota per ha (0.64*), Organic fertilizer N proportion (-0.64*), Organic fertilizer N (-0.72**), Livestock density index (0.78**), Irrigation percentage (-0.60*), Land holding size (-0.65*), Soil P (0.58*), Water calcium (-0.65*), Water chloride (-0.73*), Area_root (-0.57*)
Yield_Ground nut	Yield_rice (0.63*), Organic fertilizer N proportion (-0.36*), Water pH (- 0.45*)
Yield_Sunflower	Livestock density index (0.9*), Land under cultivation (-0.90*), Soil P(0.97**)
Yield_Areca	-
Yield_Mulberry	Planned biota ratio (-0.51*), Organic fertilizer N proportion (0.51*), Chemical fertilizer N (-0.48*), Livestock density index (-0.47*), Area_other(-0.53*)

** Correlation is significant at the 0.01 level (2-tailed)
* Correlation is significant at the 0.05 level (2-tailed)

4.3.4.3 Kolar_Gowribdinur

In K_G, 4 crops were analyzed, namely finger millet, maize, sunflower, and potato while Y_finger millet was significantly higher in 2009_P. The result showed that no correlation can be found except for Y_sunflower with negative correlation with organic fertilizer N, and Y_finger millet was correlated with area_root (Table 42). Sunflowers were not cultivated in 2006 therefore the results came from yields in 2009_P and 2009_N.

In 2009_N only chemical fertilizer and in 2009_P small amounts of organic fertilizers were applied, but the main inputs were still chemical fertilizers. The total amount of organic input may not be sufficient enough to have a positive effect.

Table 42 Bivariate correlation analysis between crop yields and other variables in Kolar_Gowribdinur. Correlation coefficients are shown in brackets.

K_G	Correlated variables (correlation coefficient)
Yield_Finger millet	Area_root (-0.58*)
Yield_Maize	
Yield_Sunflower	Organic fertilizer N (-0.83*)
Yield_Potato	

* Correlation is significant at the 0.05 level (2-tailed)

4.3.4.4 Mysore_HD Kote

In M_HK, the yields of three crops were analyzed, namely finger millets, horsegrams, and cottons. Among them, horsegrams and cottons had significant differences among 3 situations (Section 4.2.4.1). The yields of horsegrams were negatively correlated with organic fertilizer N proportion; and the yields of cottons were negatively correlated with soil organic carbon (Table 43). However, the results here can only reflect more the situation between 2009_P and 2009_N because most of the crop yields data in 2006 were missing and replaced by estimated values. Although there was 100% organic fertilizer application proportion in 2009_P, total amount of N was lower than in 2009_N. Therefore higher organic fertilizer proportion did not necessarily increase the yields because the amount also counts.

Table 43 Bivariate correlation analysis between crop yields and other variables in Mysore_HD Kote; correlation coefficients are shown in brackets

M_HK	Correlated variables (correlation coefficient)
Yield_Finger millet	-
Yield_Horse gram	Planned biota ratio (0.67**), OrgFer N proportion (-0.65**), Chemical fertilizer N (0.64**), Land under cultivation (-0.65**), Land holding size (-0.78**), Soil _ (-0.56*), Soil available K (0.52*)
Yield_Cotton	Soil organic carbon (-0.78**), Land holding size (-0.35*), Soil P (-0.78**), Water pH (-0.65*), Area pulse (-0.37*), Area fruit (0.47**)

** Correlation is significant at the 0.01 level (2-tailed)
* Correlation is significant at the 0.05 level (2-tailed)

4.3.4.5 Udupi_Udupi

The yields of two crops, rices and arecas, were analyzed in correlation analysis. The correlations were quite different between rice and areca (Table 44). Y_areca was positively correlated with organic fertilizer N, land holding size, and soil P. On the other hand, the yield of rice was negatively correlated with land holding size and land under cultivation. Compared to rice, areca, as a plantation crop, received less attention in terms of fertilization. Assumably, more organic fertilizer were applied on areca but more chemicals on rice, therefore organic fertilizer and inherent soil quality were more related to yields of areca.

Table 44 Bivariate correlation analysis between crop yields and other variables in Udupi_Udupi; correlation coefficients are shown in brackets

U_U	Correlated variables (correlation coefficient)
Yield_Rice	Livestcok density index (0.34*), Cropping intensity (-0.43**), Land under cultivation (-0.46**), Land holding size(-0.31*)
Yield_Areca	Organic fertilizer (0.56**), Land holding size (0.45*), Soil pH (-0.51*), Soil P(0.41*), Soil EC (-0.81**), Area_Vege (0.48*)

** Correlation is significant at the 0.01 level (2-tailed)
* Correlation is significant at the 0.05 level (2-tailed)

4.4 Multiple Regression Analysis of Three Agro-ecological Indicators

Multiple regression analysis was performed to give a better indication of the influences of the variables to the three agro-ecological indicators in this research. The influencial variables can be linked to policy drivers related to KSPoOF.

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4.4.1 Soil Organic Carbon

There were only few common variables having significant contributions ($p < 0.05$) to SOC model among taluks, when using enter method (Table 45). The dummy variable 2009_P and 2009_N, taking situation 2006 as a benchmark data, were included in the model. The purpose of dummy variables 2009_P and 2009_N is to reflect the differences between year 2006 and 2009 with and without the policy. Since the dummy variable 2009_P only had a significant positive effect in K_G and M_HK but not 2009_N, the results indicate a positive effect of the policy for SOC. However, both dummy variables had positive effects in B_B showing the increasing of SOC also without the policy. For C_H however, the b-values appeared to be negative for both 2009_P and 2009_N indicating a negative relationship between SOC and year 2009, though the effect did not differ significantly.

In general, only few variables forming the basis of model had significant contributions. Although the selection of variables was based on previous studies and causality concern, it is possible that variables alleviated the contributions of each other, especially when there were correlations between them.

Table 45 Multiple regression model by enter method explaining the variance of soil organic carbon in 5 taluks; the significance values are in bold if they are below 0.05

SOC	B_B			C_H			K_G			M_HK			U_U		
	B	Beta	P.	B	Beta	P.	B	Beta	P.	B	Beta	P.	B	Beta	P.
Constant	3.87		0.13	-0.16		0.65	-0.57		0.76	-0.33		0.68			
2009_P	0.81	0.60	**0.04**	-0.40	-1.36	0.13	0.20	0.52	**0.05**	0.59	0.80	**0.00**			
2009_N	0.67	0.38	**0.03**	-0.39	-0.67	0.30	0.16	0.32	0.31	0.87	0.87	0.36			
S_P	0.01	0.17	0.14	-0.00	-0.22	0.42				-0.00	-0.37	0.65			
S _K	0.00	0.17	0.16	0.00	0.33	0.22	0.00	-0.28	0.35	0.00	-0.07	0.83			
S_EC	1.96	0.61	**0.00**	0.30	1.04	0.07	-0.17	-0.07	0.81	-0.04	-0.02	0.81			
S_pH	-0.48	-0.23	0.09	0.05	0.47	0.23	0.14	0.15	0.60	0.13	0.23	0.25			
CI%	-0.00	-0.06	0.70	0.05	0.33	0.41	-0.05	-0.19	0.39	0.01	0.10	0.43			
LDI	0.00	0.01	0.93	-0.00	-0.04	0.84	-0.00	-0.11	0.62	-0.01	-0.10	0.44			
Irri %	0.00	0.05	0.79	0.00	0.09	0.82	0.00	0.09	0.71						
Ldhd	0.01	0.03	0.80	-.005	-0.13	0.80	-0.04	-0.40	0.07	0.00	0.00	0.97			
CFrN	0.00	0.04	0.72	0.00	0.17	0.70	-0.00	-0.25	0.25	0.00	0.25	0.19			
OFrNP	-0.00	-0.30	0.22	0.00	0.38	0.55	0.00	0.04	0.85	0.00	0.14	0.47			
A_Crl	0.00	0.06	0.68	-0.00	-0.44	0.20									
A_Pls	0.00	0.09	0.41	-0.00	-0.04	0.92	-0.00	-0.13	0.55	-0.00	-0.04	0.73			
A_Olsd	-0.00	-0.12	0.41				-0.00	-0.12	0.56	-0.01	-0.18	0.12			
A_Rt	-0.10	-0.11	0.26	-0.00	-0.10	0.74	-0.00	-0.19	0.39						
A_Frt				-0.00	-0.11	0.75				-0.00	-0.17	0.20			
A_Veg	-0.00	-0.02	0.82				0.00	0.18	0.78						
A_Othr				-0.00	-0.57	0.36	-0.00	-0.12	0.82	-0.00	-0.11	0.38			
R-square	(p<0.05)		0.77	(p<0.05)		0.46	(p<0.05)		0.65	(p<0.05)		0.56			
Adj. R-sqr			0.63			-0.07			0.42			0.39			
ANVA F			5.68			0.86			1.01			3.33			
ANVA sig.			0.00			0.62			0.48			0.00			

The backward method drastically reduced the number of explanatory variables (Table 46). The dummy variables 2009_P and 2009_N had significant contributions to the variance of SOC in 4 taluks and higher influence by 2009_P was with higher influence than 2009_N, except for B_B (see beta-value underlined). The same as to enter model, in C_H the effects of both 2009_P and 2009_N were negative, indicating that SOC was lower in 2009 compared to 2006.

Effects of the policy were influenced by few other variables. Soil EC had positive contributions to SOC in B_B and C_H when it was expected to be negative (section 2.1.1). Land holding size was the only variable with a negative influence in K_G. It implied that when land holding size increases, the SOC decreases. Almost significant was the chemical fertilizers input in K_G, implying the reduction in the use of fertlilizers according to the policy had a positive effect.

The highest R-square value was in B_B where the regression model can explain around 70% of variances in SOC. However, none of the other three taluks (C_H, K_G, and M_HK) had a R-square value higher than 50% which means there was more than 50% of the variance can not be explained by the model.

Table 46 Multiple regression model by backward method explaining the variance of soil organic carbon in 5 taluks; the significance values are in bold if they are below 0.05

SOC	B_B			C_H			K_G			M_HK			U_U		
	B	Beta	P.	B	Beta	P.	B	Beta	P.	B	Beta	P.	B	Beta	P.
Constant	3.39		0.06	0.36		0.00	0.30		0.00	0.58		0.00			
2009_P	0.33	0.24	**0.01**	-0.30	-1.01	**0.00**	0.19	0.49	**0.00**	0.47	0.65	**0.00**			
2009_N	0.54	<u>0.30</u>	**0.00**	-0.37	-0.64	**0.01**	0.13	0.28	**0.07**	0.28	0.28	**0.00**			
S_P															
S _K															
S_EC	2.18	0.68	**0.00**	0.30	1.03	**0.01**									
S_pH	-0.36	-0.17	0.10												
CI%															
LDI															
Irri %															
Ldhd							-0.03	-0.31	0.**03**						
CFrN							-0.00	-0.27	0.08						
OFrNP															
A_Crl															
A_Pls															
A_Olsd															
A_Rt															
A_Frt															
A_Veg															
A_Othr															
R-square	(p<0.05)		0.69	(p<0.05)		0.47	(p<0.05)		0.33	(p<0.05)		0.45			
Adj. R-sqr			0.66			0.22			0.25			0.43			
ANVA F			23.6			3.06			4.31			21.67			
ANVA sig.			0.00			0.04			0.00			0.00			

4.4.2 Water Electrical Conductivity

The dummy variable 2009_P used in the water_EC regression model taking 2009_N as benchmark data. Therefore, the purpose of dummy variable 2009_P is to see if the differences of W_EC were caused by policy implementation. Although R-square values were high in general, very few significant variables were found (Table 47). The only exception was observed in U_U where the dummy variable 2009_P and area_cereal had significantly positive relationship with W_EC. In addition, the degrees of effects were high for both variables according to their beta-values. Therefore, for U_U, it can be said that the policy had a positive correlation but negative effects on W_EC. Besides, the more area was under cereal production, the higher the W_EC value. The fact is that rice is the most prevalently cultivated cereal crop in U_U which influences the water quality quite much.

Table 47 Multiple regression model by enter method explaining the variance of water electrical conductivity in 5 taluks; the significance values are in bold if they are below 0.05

W_EC	B_B			C_H			K_G			M_HK			U_U		
	B	Beta	P.	B	Beta	P.	B	Beta	P.	B	Beta	P.	B	Beta	P.
Constant	4.5		0.25	1.75		0.14	0.26		0.00	1.18		0.31	0.03		0.36
2009_P	29.4	26.8	0.38	0.26	0.27	0.56	-0.00	-0.18	0.77	-0.03	-0.08	0.95	0.04	1.07	**0.01**
SOC	0.01	0.02	0.95	-1.48	-0.23	0.48	-0.05	-0.44	0.15	-0.52	-0.67	0.51			
CFrN	0.00	0.37	0.88	0.01	0.95	0.12	0.00	0.94	0.23	0.02	1.69	0.36			
OFrNP	-0.30	-26.4	0.36				0.00	0.15	0.73	0.01	1.50	0.39	0.00	-0.68	0.16
Irri %	0.00	0.27	0.58				0.00	0.12	0.78				0.00	-0.06	0.85
A_Crl	0.00	0.07	0.90	-0.01	-0.67	0.29							0.00	0.65	**0.04**
A_Pls	-0.00	-0.23	0.65							0.00	0.33	0.57			
A_Olsd							-0.00	-0.91	0.10	-0.00	-0.38	0.67	0.00	0.07	0.81
A_Rt				0.00	0.20	0.54	-0.00	-0.40	0.41						
A_Frt	0.00	0.32	0.51	-0.02	-0.95	0.15				-0.01	-0.74	0.24			
A_Veg	-0.02	-0.49	0.50				-0.00	-2.22	0.08						
A_Othr				0.04	0.94	0.13	0.00	1.30	0.17	-0.00	-0.40	0.44	0.00	0.07	0.80
R-square	(p<0.05)		0.49	(p<0.05)		0.89	(p<0.05)		0.77	(p<0.05)		0.82	(p<0.05)		0.63
Adj. R-sqr			-0.41			0.52			0.26			0.13			0.39
ANVA F			0.54			2.42			1.53			1.19			2.59
ANVA sig.			0.79			0.32			0.36			0.53			0.09

As for the SOC regression model, a drastic reduction of variables happened by using the backward method (Table 48). Also in this model, the dummy 2009_P only had a significant effect in U_U, which implied that the variances of W_EC, were not generally influenced by the policy implementation. Even more, W_EC was hardly influenced by other chosen explanatory variables. Particularly B_B and K_G demonstrated extremely low R-square values (0.27 and 0.30 for B_B and K_G respectively). However, the same trend of influences was observed for C_H and M_HK. For both taluks, chemical fertilizer N had positive relationship on W_EC. Instead, a negative relationship existed between areaf_fruit and W_EC with substantial degree of influences.

Last, the model for U_U was distinguished from other taluks. Besides the dummy variable 2009_P, the variables organic fertilizer N proportion and area_cereal also contributed significantly to the model either negatively or positively. The results indicated higher proportion of organic fertilizer application helped reducing the W_EC. On the other hands, more area was used for cereal cultivation, there will be higher W_EC.

Table 48 Multiple regression model by backward method explaining the variance of water electrical conductivity in 5 taluks; the significance values are in bold if they are below 0.05

W_EC	B_B			C_H			K_G			M_HK			U_U		
	B	Beta	P.	B	Beta	P.	B	Beta	Sig	B	Beta	Sig	B	Beta	Sig
Constant	0.74		0.00	1.02		0.00	0.24		0.00	1.67		0.00	0.03		0.00
2009_P	0.43	0.39	0.14										0.04	1.08	**0.00**
SOC															
CFrN				0.01	1.07	**0.01**	0.00	0.32	0.22	0.01	0.57	0.06			
OFrNP													0.00	-0.73	**0.01**
Irri %															
A_Crl													0.00	0.60	**0.01**
A_Pls															
A_Olsd															
A_Rt															
A_Frt	0.00	0.27	0.29	-0.02	-0.87	**0.05**				-0.01	-0.62	**0.03**			
A_Veg							-0.00	-0.47	0.08						
A_Othr				0.03	0.65	0.08				-0.00	-0.35	0.21			
R-square	(p<0.05)		0.27	(p<0.05)		0.67	(p<0.05)		0.30	(p<0.05)		0.61	(p<0.05)		0.62
Adj. R-sqr			0.15			0.50			0.18			0.44			0.52
ANOVA F			2.24			4.10			2.43			3.70			6.59
ANVA sig.			0.14			0.06			0.13			0.07			0.00

4.4.3 Planned Biota per hectare

The results of planned biota per ha regression model using enter method showed much variation among taluks (Table 49). A positive significant relationship between dummy variable 2009_N and planned biota per ha appeared in M_HK. Regarding to other variables, land holding size contributed significantly to the models of B_B, K_G and M_HK constantly with negative correlation. The phenomenon may come from the method of computation which leads to negative effect of land holding size data.

Table 49 Multiple regression model by enter method explaining the variance of planned biota per ha in 5 taluks; the significance values are in bold if they are below 0.05

Planned biota/ ha	B_B			C_H			K_G			M_HK			U_U		
	B	Beta	P.	B	Beta	P.	B	Beta	P.	B	Beta	P.	B	Beta	P.
Constant	4.98		0.02	6.25		0.19	3.27		0.11	3.94		0.19	9.62		0.80
2009_P	3.58	0.37	0.06	-5.61	-0.31	0.12	-0.56	-0.05	0.70	1.58	0.11	0.36	6.22	0.24	0.11
2009_N	2.05	0.16	0.21	-0.51	-0.01	0.93	1.21	0.09	0.66	8.52	0.43	**0.00**	-1.99	-0.05	0.62
Ldhd	-1.70	-0.55	**0.00**	-0.17	-0.08	0.73	-1.04	-0.34	**0.02**	-2.19	-0.36	**0.00**	-0.33	-0.02	0.87
CI%	0.01	0.19	0.11	1.91	0.28	0.11	1.1	0.15	0.28	0.97	0.46	**0.00**	7.67	0.29	**0.01**
CFrN	0.02	0.46	0.**00**	0.06	0.19	0.13	0.01	0.23	0.13	0.10	0.35	**0.03**	-0.00	-0.01	0.89
OFrNP	0.00	0.03	0.84	0.04	0.17	0.23	0.00	0.00	0.96	0.01	0.11	0.48	0.04	0.10	0.50
LDI	0.03	0.01	0.93	1.84	0.33	**0.00**	0.32	0.14	0.28	-0.13	-0.04	0.68	2.03	0.77	**0.00**
A_Crl	0.01	0.12	0.23										-0.19	-0.61	0.62
A_Pls	0.05	0.16	0.07	-0.06	-0.06	0.60	-0.05	-0.28	0.08	-0.02	-0.09	0.39			
A_Olsd	0.01	0.06	0.56	-0.07	-0.44	**0.00**	-0.00	-0.05	0.70	-0.00	-0.00	0.97	-0.06	-0.12	0.88
A_Rt	-0.34	-0.04	0.54	-0.03	-0.04	0.68	0.08	0.42	**0.00**						
A_Frt				-0.19	-0.22	0.08				0.01	0.03	0.73	-0.02	-0.00	0.96
A_Veg	-0.13	-0.25	**0.01**				-0.02	-0.05	0.90				-0.41	-0.69	0.32
A_Othr				-.071	-0.23	0.10	0.15	0.19	0.62	0.00	-0.00	0.98	-0.18	-0.33	0.65
R-square	(p<0.05)		0.90	(p<0.05)		0.63	(p<0.05)		0.61	(p<0.05)		0.64	(p<0.05)		0.69
Adj. R-sqr			0.81			0.52			0.44			0.55			0.59
ANVA F			11.9			5.70			3.50			7.00			7.02
ANVA sig.			0.00			0.00			0.00			0.00			0.00

Compared to previous two indicators, planned biota per ha had more significantly related variables that can explain its variances. Although the dummy variable 2009_P did not show a significant contribution in the enter models (see Table 49), it did in B_B, C_H and U_U in the backward models (Table 50), with a negative relationship in C_H.

The most common shared explanatory variable was cropping intensity (CI%) which had a positive relationship in B_B , C_H, M_HK, and U_U. The relationship between CI% and planned biota per ha does not seem very logical to other biodiversity studies in which it often shows the negative relationship between cropping intensity and biodiversity (Billeter, et al, 2008). The variables which contribute in three taluks were land holding size, chemical fertilizer N and area_other. Land holding size was negatively related to planned biota ration in B_B, K_G and M_HK with most substantial influence occurs in B_B (beta-value =- 0.54). As for the variable, chemical fertilizer N, it had positive relationship with planned biota ratio. The logical explanation will be the more fertilizer farmers applying on farm, the more crops either number of types or quantity are cultivated.

Table 50 Multiple regression model by backward method explaining the variance of planned biota per ha in 5 taluks; the significance values are in bold if they are below 0.05

Planned biota /ha	B_B			C_H			K_G			M_HK			U_U		
	B	Beta	P.	B	Beta	P.	B	Beta	P.	B	Beta	P.	B	Beta	P.
Constant	5.44		0.00	8.82		0.00	4.70		0.00	5.10		0.00	5.84		0.25
2009_P	3.43	0.35	**0.00**	-4.86	-0.27	**0.03**							7.46	0.29	**0.03**
2009_N										7.34	0.37	**0.00**			
Ldhd	-1.68	-0.54	**0.00**				-1.22	-0.39	**0.00**	-1.69	-0.28	**0.00**			
CI%	0.02	0.31	**0.00**	1.77	0.26	**0.03**				1.01	0.48	**0.00**	8.40	0.31	**0.00**
CFrN	0.01	0.41	**0.00**				0.01	0.23	0.06	0.08	0.27	**0.00**			
OFrNP															
LDI				2.00	0.36	**0.00**							2.07	0.78	**0.00**
A_Crl													-0.14	-0.46	**0.00**
A_Pls	0.04	0.15	**0.04**				-0.04	-0.23	**0.05**						
A_Olsd				-0.07	-0.47	**0.00**									
A_Rt							0.08	0.42	**0.00**						
A_Frt				-0.16	-0.19	0.06									
A_Veg	-0.11	-0.23	**0.00**										-0.36	-0.60	**0.00**
A_Othr				-0.05	-0.16	0.20	0.16	0.21	0.08				-0.13	-0.25	**0.04**
R-square	(p<0.05)		0.79	(p<0.05)		0.60	(p<0.05)		0.57	(p<0.05)		0.62	(p<0.05)		0.68
Adj. R-sqr			0.75			0.55			0.51			0.59			0.63
ANVA F			24.6			11.3			9.04			20.3			15.2
ANVA sig.			0.00			0.00			0.00			0.00			.000

4.4.4 Multiple Regression Models of Three Indicators: State-level Analysis

In this section, the regression models were constructed at state-level, in order to observe if the influential factors are different between taluk and state-level. Two regression methods, enter (Table 51) and backward (Table 52), were again applied.

For soil organic carbon, the results from enter method corresponded well to the ones at taluk-level: the dummy variable 2009_P, soil EC, cropping intensity, land holding size, area_oilseed and area_root were significantly influencing the model. Especially, soil_EC and land holding size had the same effects at taluk level (see Table 46). After integration to state-level, two cropping pattern variables: area_oilseed and area_root started to have negative effect to the model, indicating that a larger proportion of area used for oilseed cultivation and root crops, leads to lower SOC. Regarding to the backward method, variables: soil EC, cropping intensity, land holding size, area_oilseed and area_root still played important roles for the model. Organic fertilizer proportion displayed more significance in this model, showing a negative relationship with SOC. This is surprising as positive effects were expected.

The model for water electrical conductivity had a relative higher R-square value at state-level compared to taluk-level. There were 6 variables contributing significantly to the model at state-level. The dummy variable 2009_P had no significant influence showing the policy was not the main factor affecting the variances of W_EC. In addition, only chemical fertilizer N showed significant influence in both taluk and state-level, though it had opposite direction of influence at respective level. Besides, cropping patterns seemed affecting much that area for oilseed, fruit and others had significant positive relationship to W_EC. Last, rainfall data was only applied at state-level to see, however it had no significant influence in this case.

The main influential variables for planned biota per hectare were generally the same in both levels. For example, land holding size, cropping intensity, livestock density index showed the same trend of influences in both levels while livestock density index had the highest degree of influence. For the dummy variables 2009_P and 2009_N, the influences were more outstanding at taluk-level analysis suggesting that the policy did not change much the overall numbers of species on farm. Four cropping pattern variables are_oilseed, root, vegetable, and other had significant contribution to the model. Six out of 7 cropping patterns showed significant influences to planned biota per ha at taluk level but spreading in different taluks. It is difficult to compare the differences of cropping patterns between two levels.

Table 51 Multiple regression model by enter method explaining the variance of three agro-ecological indicators at state-level; the significance values are in bold if they are below 0.05

SOC	B	Beta	P.	W_EC	B	Beta	P.	Planned biota/ha	B	Beta	P.
Constant	0.87		0.05	Constant	0.64		0.23	Constant	2.92		0.01
2009_P	0.30	0.27	**0.00**	2009_P	-0.05	-0.04	0.80	2009_P	-1.16	-0.06	0.27
2009_N	-0.01	-0.00	0.94	Rfl	0.00	0.04	0.80	2009_N	-0.50	-0.02	0.74
Rfl	0.00	0.05	0.76	SOC	0.04	0.04	0.78	Ldhd	-0.99	-0.26	**0.00**
S_P	0.00	0.06	0.46	CFrN	-0.00	-0.45	**0.01**	CI%	0.02	0.19	**0.00**
S _K	0.00	0.12	0.22	OFrNP	-0.00	-0.07	0.66	CFrN	0.00	0.06	0.32
S_EC	0.39	0.33	**0.00**	Irri %	0.00	0.09	**0.54**	OFrNP	0.03	0.15	**0.02**
S_pH	-0.07	-0.19	0.13	A_Crl				LDI	1.25	0.45	**0.00**
CI%	0.00	0.54	**0.00**	A_Pls	0.00	0.13	**0.36**	A_Crl			
LDI	0.01	0.06	0.39	A_Olsd	0.00	0.36	**0.02**	A_Pls	-0.01	-0.03	0.60
Irri %	0.00	0.00	0.94	A_Rt	0.01	0.15	0.24	A_Olsd	0.03	0.16	**0.00**
Ldhd	-0.04	-0.18	**0.03**	A_Frt	0.01	0.24	**0.09**	A_Rt	0.08	0.12	**0.03**
CFrN	0.00	-0.03	0.69	A_Veg	-0.00	-0.17	0.19	A_Frt	-0.00	-0.02	0.73
OFrNP	-0.00	-.018	**0.06**	A_Othr	0.01	0.40	**0.01**	A_Veg	-0.06	-0.09	0.12
A_Crl								A_Othr	0.06	0.14	**0.02**
A_Pls	0.00	0.03	0.69								
A_Olsd	-0.00	-0.16	**0.04**								
A_Rt	-0.00	-0.14	**0.04**								
A_Frt	0.00	0.07	0.40								
A_Veg	-0.00	-0.02	0.73								
A_Othr	-0.00	-0.06	0.41								
R-square			0.45	R-square			0.75	R-square			0.65
Adj. R-sqr			0.37	Adj. R-sqr			0.57	Adj. R-sqr			0.42
ANVA F			5.91	ANOVA F			4.13	ANOVA F			10.81
ANVA sig.			0.00	ANVA sig.			0.00	ANVA sig.			0.00

Table 52 Multiple regression model by backward method explaining the variance of three agro-ecological indicators at state-level; the significance values are in bold if they are below 0.05

SOC	B	Beta	P.	W_EC	B	Beta	P.	Planned biota /ha	B	Beta	P.
Constant	0.90		0.00	Constant	0.76		0	Constant	3.12		0.00
2009_P	0.25	0.22	**0.00**	2009_P				2009_P			
2009_N				Rfl				2009_N			
Rfl				SOC				Ldhd	-1.04	-0.27	**0.00**
S_P				CFrN	-0.00	-0.46	**0.00**	CI%	0.02	0.18	**0.00**
S _K				OFrNP				CFrN			
S_EC	0.43	0.36	**0.00**	Irri %				OFrNP	0.02	0.11	**0.04**
S_pH	-0.06	-0.15	0.09	A_Crl				LDI	1.31	0.47	**0.00**
CI%	0.00	0.56	**0.00**	A_Pls	0.01	0.20	0.09	A_Crl			
LDI				A_Olsd	0.01	0.42	**0.00**	A_Pls			
Irri %				A_Rt				A_Olsd	0.03	0.17	**0.00**
Ldhd	-0.04	-0.20	**0.00**	A_Frt	0.01	0.28	**0.01**	A_Rt	0.08	0.13	**0.01**
CFrN				A_Veg				A_Frt			
OFrNP	-0.00	-.014	**0.04**	A_Othr	0.01	0.35	**0.00**	A_Veg	-0.07	-0.11	**0.05**
A_Crl								A_Othr	0.05	0.13	**0.02**
A_Pls											
A_Olsd	-.002	-0.14	**0.03**								
A_Rt	-.006	-0.16	**0.01**								
A_Frt											
A_Veg											
A_Othr											
R-square			0.65	R-square			0.72	R-square			0.65
Adj. R-sqr			0.42	Adj. R-sqr			0.5	Adj. R-sqr			0.42
ANVA F			13.8	ANOVA F			9.44	ANOVA F			17.45
ANVA sig.			0.00	ANVA sig.			0.00	ANVA sig.			0.00

5. <u>Discussion</u>

5.1 Profiles of Farming Households in 5 taluks

The policy, Karnataka State Policy of Organic Farming (KSPoOF) had been introduced to farmers in 2006 by Government of Karnataka State, aiming at helping farmers to reduce the external input and cost, meanwhile enhance the three dimensions of sustainability (United Nations, 1987) of the farms. The policy targeted especially to marginal and small farmers who have less ability to assess to external resources.

Before assessing the agro-ecological indicators, it is important to know whether the farms under the policy had the farming practices according to organic principles defined by KSPoOF. It is then possible to say the changes found in agro-ecological indicator assessment, if any, could be resulted from the policy implementation. Three facts were regarded as conversion in this research based on the priniciples of the policy and available data to be analyzed.

This chapter begins with the discussion of the profiles for each case study taluk, sequenced from the highest proportion of organic fertilizer application to the lowest.

5.1.1 Mysore_HD Kote (M_HK)

Compared to 2006 (village before the policy implemented), M_HK had significant larger land holding size in 2009_P (village in 2009, same as 2006 but the sampling farms received influences from the policy). Most farmers in 2006 and 2009_N (village in 2009, neighboring to 2009_P, the sampling farms received no influences from the policy) were marginal farms with an average land holding size of 0.8 ha, while most farmers belonged to small ones in 2009_P. The main reason for this observation is that the interviewees were not identical for all three situations which may be due to the farm surveys were conducted by different organizations in different years. However, this observation suggested that farmers with larger land were more prone to convert to organic farming in M_HK. It may be easier for farmers with larger land to convert because they possessed more resources such as number of livestock and cultivation land area.

The cultivation area for cereals and pulses increased in 2009: more cereals in 2009_P but more pulses in 2009_N. In 2009, farmers grew maize as one of the cereal crops, instead of rice for farmers in 2006. Although different interviewees can be the main reason for the differences, the Integrated Scheme for Oilseeds, Pulses, Oil Palm and Maize (ISOPOM) can contribute greatly to the increase of maize production. The ISOPOM scheme was held in all the districts of the state since 2004-2005, so that Karnataka State ranks first of maize production in India (Anonymous, 2009). Maize can be used as animal feed for on farm livestock in order to increase farm-derived manure which is very beneficial to the organic farmers. Although livestock density was the smallest in 2009_P, we can not conclude if there is negative linkage between maize production and livestock density due to the negative relationship between livestock density and land holding size. Cotton was grown under the same percentage of cultivation area in three situations, indicating that cotton stayed as a very important income generating crop in M_HK, also for the farmers in policy village. The steady cropping area for cotton in three situations showed the potential for organic cotton production in M_HK which is an important taluk for cotton production. The prosperous cultivation of fodder crops fits to the demand of the policy, but the cultivation of major cash crop keeps an important activity of farmers. It should be studied further the fertilization and pest management for organic cotton production, since the demand for organic cotton is rising rapidly (Anonymous, 2007a).

Farmers in M_HK showed high interest in using organic fertilizer which reflected on nearly 100% of organic fertilizer application proportion in 2006 and 100% in 2009_P. However, the total amounts of N-input were very low in both 2006 and 2009_P. It is indicated that the fertilizer input is traditionally low in rainfed agriculture. The level of fertilizer input gets even lower when farm yard manure (FYM) is mostly used (Rego, et al, 2003). The situation of low FYM input can be compensated by incorporation of green manure on farm. The major cereal crops in M_HK are pearl millet, sorghum and maize, in addition, major pulse crops are horsegram and cowpea. Application of sorghum residue with 5t/ha is demonstrated to be similar to FYM application of 10t/ha in terms of effects on maize cultivation in Karnataka state (Kumar et al, 2007). About the pulse crops, horsegram and cowpea are important crops grown for grain, fodder and green manure purpose (Venugopal, 1983) in Karnataka State. However, it is impossible to estimate the N-input from green manure and its management in this research since there is no related question listed on the questionnaire for farm surveys.

5.1.2 Bijapur_Bijpapur (B_B)

In B_B, farmers in 2006 possessed farms that were slightly larger than 2 ha. Average land holding sizes in situation 2009_P and situation 2009_N were significantly smaller than 2006 (<1 ha per farm). This finding is not common across the five taluks because B_B is the only taluk where land holding size in 2009_P is smaller than in 2006. Similar to M_HK, the main reason for this observation is that the interviewees were not identical for all three situations. The result suggests that more marginal farmers are motivated to convert to organic farming in B_B or at least they are more interested in talking about it. The second reason for the land size difference could be caused by the unequal sample sizes in three situations (N=31 in 2006, N=10 in 2009_P, N=5 in 2009_N) resulting in unrepresentative data.

The cropping pattern does not vary much in B_B where cereal crops have always been the dominant group. In 2009_N, cereals share the dominant position with oilseed crops, while in 2009_P the proportion of oilseed crops increased compared to 2006. In addition, vegetables group was grown only in both situations in 2009. Although the observations can be due to the different interviewees, the emerging vegetable crops corresponds to the sayings of 7 farmer representatives from Bijapur during the participatory impact assessment workshop in Bangalore (Purushothaman, et al, 2010): In a longer term, farmers prefer to shift to fruit and vegetables due to the higher demand for organic fruit and vegetables by consumers. Nevertheless, these changes of cropping pattern were not assumed by KSPoOF.

B_B is the other taluk besides M_HK, having purely organic fertilizer applied in 2009_P which meets one of the criteria for organic farming. Interestingly, there was zero organic fertilizer application in 2009_N which is not logical since mixed fertilization had been practiced in 2006. Total amount of N-input/ha was similar between 2009_P and 2009_N which is about half of the total amount in 2006. The cause of the phenomenon is possibly due to 20-30% bigger area used for oilseed crop cultivation including groundnut and sunflower in both situations in 2009. Within 6 different rotation system studied by Rego *et al*.(2003), sole groundnut rotation received the least attention for N-input (27 kg ha^{-1}) in two years rotation because groundnut is a leguminous oilseed crop. Therefore, the real N-input in 2009_P and 2009_N should be higher than estimated.

5.1.3 Udupi_Udupi (U_U)

In U_U, the land holding size was significantly larger in 2009_P compare to 2006, but all farmers in both situations still belonged to marginal ones. Although marginal farmers were prevalent in U_U, the least farmers' suicidal cases happened in U_U from 2003 to 2007 compared to other districts in Karnataka state (Assadi, 2003). The reason can be inherently better biophysical conditions such as higher soil organic matter contents due to much litter from forest and higher rainfall (Purushothaman, et al, 2010).

There was little change in terms of cropping pattern, although the cultivation of vegetables was only recorded in 2009_P. Udupi disctrict was mentioned as a net importer of vegetables (Anonymous, 2010b), hence vegetables seem to be a promising crop to grow,especially organically (Purushothaman, et al, 2010). Besides rice, the major cereal crop, other cash crops like arecas, coconuts and jasmines are the important crops of the district for exportation use. The status of cropping pattern showed the farmers were attracted to the profits from organic products market, however this benefit is not identical to the one expected by KSPoOF.

Organic fertilizer proportion was higher in 2009_P (89%) than the other two situations (both are 66%) which demonstrates the progress to reach one of the organic farming standards. Opposed to B_B and M_HK, the higher organic fertilizer proportion is associated with a higher average N-input/ha in 2009_P. But the livestock density index did not have significant difference among three situations, therefore, there could be another sources for animal manure. Other than cow dung, farmers in 2009_P kept more chicken on farm than 2006. The chicken dung can be a good source for organic fertilizer especially high in P contents. However, it was not included as organic fertilizer in this research because interviewed farmers only regarded cow dung as farm yard manure when answering the related questions during farm surveys.

5.1.4 Chitradurga_Hiriyur (C_H)

The land holding size in C_H was significantly larger in 2009_P, while none of the interviewed farmers in 2006 had land exceeding 2 ha. It is indicated that around 66% of all farming labors belong to marginal and small farmers in C_H (Anonymous, 2007b) which can explain the conspicuous small land holding sizes in 2006. Again, the same reason for the significantly differences in terms of land holding sizes in different situationis the different interviewees in three situations. It also showed that small to medium sized farmers were more prone to convert to organic faming in C_H. Although there was much larger average land holding size in 2009_N, the small sampling size (N=3) leading to a relatively high standard deviation and likely unrepresentative data for 2009_N.

Cereals and oilseeds were two major crops cultivated in both 2006 and 2009_P with similar share in cropping pattern. The differences of cropping pattern between 2006 and 2009_P are increasing fruit and tuber areas in 2009_P but decreasing areas for pulses and other crops group in 2009_P. The reason for the decline of pulses cultivation is not clear, as in organic farming these are useful to stay self-sufficient of animal feed. The increase of fruit cultivation area is possibly motivated by special scheme and fund that promotes horticulture area coverage (Anonymous, 2007b). Concluding from the situations in C_H and also in M_HK, another polical scheme can decide greatly the choices of farmers in terms of which crop to grow.

The organic fertilizer proportion in 2009_P was less than previous 3 taluks, only 74% of organic fertilizer and the other 26% chemical fertilizer were applied in 2009_P. In 2009_N and 2006, less than 50% of organic fertilizers were used by farmers which showed clearly the differences between villages with or without policy implemented. The quantity of total N-input was higher in 2009_P compared to 2006, nevertheless, the average amount of N-input was very low in 2006 which is not very common if the chemical fertilizers were used more. The large amount of average N-input in 2009_N will not be discussed further here because there were only 2 samples for this question. However, the changes can not be linked with livestock density because there was no significant difference observed between 2006 and 2009_p. Last point is that although higher proportion of organic fertilizer was used in 2009_P, several negative effects are observed later.

5.1.5 Kolar_Gowribdinur (K_G)

The land holding sizes were very similar among three situations. The samples were collected in the same village for all three situations but still, different farmers. The average farm sizes indicated that the farmers belonged to small scale ones, but the raw data showed that the samples were scattered over marginal to medium farms. Here we can not observe at which scale the farmers were more prone to convert to organic farming. In addition, different sizes of farms existed in the same village in K_G.

The percentage for oilseeds cultivation area stayed very close in three situations. Instead of groundnut which was cultivated as oilseeds crop in 2006, it was sunflowers grown in 2009. Substantial increasing of cropping area for cereal crops was observed in 2009_P and also 2009_N. Maize and pearl millet, were two new cereal crops grown in 2009. Maize can be a very good animal feed for the livestock on farm. However, ivestock density index showed no differences between 2006 and 2009_P.

K_G was the taluk with the least proportion of organic fertilizer application (27%) in the policy village (2009_P). Plus the observation that there was no difference among three situations in terms of livestock density, farmers in K_G did not seem to strive for meeting the organic farming standards. Average N-input was higher in both 2009_P and 2009_N, however it came mainly from chemical fertilizers. In general, the conditions in terms of land holding size, fertilizer application, and livestock density stayed similar for 2006 and 2009_P except for some changes in cropping pattern. In a matter of fact, K_G is the only taluk having no distress in our sampling taluks which may result in less incentive for farmers to follow the policy.

5.2 Agro-Ecological Impact Assessment

5.2.1 Soil Organic Carbon

The multiple regression models indicated a significantly positive influence of the variable 2009_P (village with the policy implemented) on soil organic carbon content, in 4 taluks: Bijapur_Bijapur (B_B), Chitradurga_Hiriyur (C_H), Mysore_HD Kote (M_HK) and Kolar_Gowribdinur (K_G), were analyzed. Only in B_B, the dummy variable 2009_N (village without the policy intervention) also had substantial influence on SOC. From the results of ANOVA analysis for SOC content, the SOC content was significantly higher in 2009_N then in 2006 in B_B, M_HK and K_G. But the regression models reflected these ANOVA results only in B_B ($SOC_{2009\_N} > SOC_{2006}$). It suggested that the influences of the policy override the temporal factor, when taking into account other variables.

Besides the dummy variables 2009_P and 2009_N, only 2 out of 17 explanatory variables had significant effects on the variance of SOC, which are soil electrical conductivity (Soil_EC) in B_B and C_H; land holding size in Kolar_Gowribidinur (K_G). The positive relationship between soil_EC and SOC is different from our expectation, since higher salinity is one of the main factors leading to soil degradation, and related to this, a lower SOC. According to World Reference Base (WRB), salinity is classified into 3 classes and the lowest one is with EC value lower than 4 dS/m. The values for soil_EC ranged from 0.1-0.3 dS/m in B_B and 0.4-1.4 dS/m for C_H, both below the lowest class. Therefore, the increases of soil EC may not have inverse effect on soil fertility yet. The previous study (Hartsock, et al, 2000) observed that drought is the reason for substantial lower soil EC value in 1999. The observation can be used for explaining for such low soil EC value in B_B and C_H which are located in northern dry zone and central dry zone of the state receiving the top two low rainfalls.

Soil Ca^{2+}, Mg^{2+}, and soil moisture can explain a large amount of variances in soil EC, indicated by Hartsock et al. (2000). This can be confirmed by another study doing a 21-year biodynamic-organic-conventional farming comparison trial showing that there were higher content of Ca^{2+} and Mg^{2+} in organic managed farms than conventional ones (Mader et al, 2002). Since in B_B, 100% of organic fertilizer was applied in the policy village; and in C_H, organic fertilizer proportion was much higher in 2009_P compared to 2006. The higher amount of Ca^{2+} and Mg^{2+} may present in the soil of policy village due to the higher proportion and amount of organic fertilizer input which consequently led to the results of higher S_EC. Besides, large variety of micronutrients may also present with increasing organic fertilizer. The recognition of the needs of micronutrients for crop production in India has been widely discussed (Rego et al, 2007; Sahrawat et al, 2010).

Although the results for dummy variable 2009_P reflecting that the policy did have an effect on SOC, all the explanatory variables included in the model did not have such impact as was expected. It could be that the changes of those variables were not sufficient enough to explain the variance of SOC, indicating that the farms under the policy did not change much compared to situation before the policy. Also, the variance of SOC can not be explained by only certain variables such as organic fertilizer use or livestock density. The policy embraces a range of measures, including technical advises from NGOs, which may have influenced better farm management in general.

Although much data has been collected for this study, the time period is still short to conclude on effects of conversion to organic farming. To have increasing SOC may take more time and to measure changes in long-term experiments are needed (Mader, et al, 2002; Poudel et al, 2001). In general, on the long-term increases are found (Stolze, et al, 2000), although there are also many studies (Van Diepeningen et al, 2006) that did not find effects of organic farming on SOC. Reviewing a range of studies, Leifeld and Führer (Leifeld, J. et al, 2010)conclude that the claim for beneficial effects of organic farming on SOC is premature and that reported advantages of organic farming for SOC are largely determined by higher and often disproportionate application of organic fertilizer compared to conventional farming. Nevertheless, it can be concluded that SOC increased in villages where the organic policy was introduced, probably caused by several complementary factors.

5.2.2 Water Electricity Conductivity

Regarding to the water quality assessment, water salinity and hardness are expected to be the main parameter affecting water quality (Anonymous, 2010a), and therefore water electrical conductivity (W_EC) was suitable being the measurable indicator. The examined water came from groundwater, the major irrigation sources for small holder farmers. Rainfall is an important factor for W_EC but it was not included in the regression model at taluk level because the comparison of W_EC can only be done to situation 2009_P and 2009_N, where rainfall was similar. But, to compare only the situations in 2009 leads to a difficulty to conclude the influences from temporal factors. For example, in year 2008 there was a deficit of pre-monsoon rainfall in the major part of Karnataka state (Anonymous, 2009). A rainfall deficit results in a faster evapotransporation rate and drainage which influence W_EC greatly (Maas, et al, 1977). Whether there was any effect of the drought in 2008 cannot be reflected on our results.

None of the variables had a significant effect on W_EC in enter regression model. Some potential causes are: (i) variances between 2009_P and 2009_N are small, (ii) there is high multicollinearity between the variables, for instance, the beta values of dummy variable 2009_P and OFrNP are extremely high suggesting that these values are unreasonable. In fact, the multicollinearity was indeed found indicating by the extremely high VIF values of these variables. However, the backward method showed some interesting results. For example, in U_U, the dummy variables 2009_P, area_cereal and organic fertilizer proportion contributed significantly to the model. This result was validated by ANOVA analysis showing U_U had significant higher W_EC value in 2009_P compared to 2009_N. It was unexpected to have area_cereals as the influential factor for W_EC since cereal cultivation in Karnataka state is mainly rainfed, and traditional cereal crops are mostly drought-tolerant. However, in U_U, rice is the dominant cereal crop which needs large amounts of water. According to farmers from Udupi (Purushothaman, et al, 2010), organic rice cultivation is mainly irrigated, not flooded. Looking into the data for irrigation percentage, 5 sampling farms in 2009_N had higher irrigation percentage than 2009_P. Hence, it is possible that the irrigation frequency and irrigation rate are more affective than the percentage per se. The results showed that converting to organic farming did have influence on W_EC but in a different direction as expected by the policy and the effects are specific to different cases.

Since rice is one of the most sensitive crops to salinity (Scardaci et al, 2002), caution needs to be taken when risk for salinity is existing. Presently, the W_EC value in U_U is still within the safe range for irrigation (W_EC = 0.05 – 0.07 dS/m), but there are some other factors need to be considered at the same time such as the drainage rate and the leaching rate (Ayers, et al, 1985).

The area_fruit had a significant negative effect on W_EC in both C_H and M_HK. The common fruit grown in C_H and M_HK is banana. This negative effect can be because the organic famers tend to do mulching surrounding their fruit trees, as observed by Dr. Pushpalatha when comparing ecological and traditional farming in south India (1992). Mulching can alleviate the evaportransporation rate of the crops and also protect the soil structure from destroying by wind or heavy rainfall, consequently enhancing the water infiltration. However, these factors can not be integrated to this research. Therefore it could be the reasons why the effects from the policy seem little.

5.2.3 Planned Biota per Hectare

Agrobiodiversity in this research is determined by the planned biota in agricultural landscape, defined by Edwards and Hilbeck (2001). The classification is somehow arbitrary and different from mostly used methods in research concerning biodiversity in agricultural landscapes. Ecologists often assess the impact of land use to certain species or groups of species such as vascular plants and arthropods (Billeter, et al, 2008). However, the planned biota concept suits well to this research since the focus of this research is especially placed on anthropogenic changes on farm land. Besides, the time frame of the whole project (year 2006 to 2009) is relatively short to get a promising observation of alterations of different functional groups existing in biodiversity networks.

Because the numbers for individual species groups were too small, four planned biota groups (field crops, trees, livestock and plantation crops) were summed up for analysis. Although the specific numbers were recorded, the records for specific types of trees and plantation crops were insufficient which limits further discussion. The planned biota ratio (species/ha) were significantly different among three situations in B_B, C_H, M_HK and U_U in various degree and direction, but not in K_G. This corresponds to the previous discussion saying that the farming conditions in K_G stayed mostly the same. The dummy variable 2009_P had an effect in the multiple regression models, positive in B_B and U_U; negative in C_H. Nevertheless, this implies that the policy had a generally positive influence on planned biota.

When dealing with indicators that are calculated scaled to area, the size of the farms can have a large influence. In U_U , the maximum planned biota per ha in 2006 was large with 72.5 species/ha, but actually the total species number for this particular farm (no. 21) was not big (species no.=9). However, the land holding size was very small (0.12 ha). Hence, after computing (total species no./land holding sizes), the planned biota per ha became very large. The consequence of the computation is reflected in the results of the bivariate correlation analysis, showing that land holding size had a significantly negative relationship with planned biota per ha in all taluks. This finding can explain well the negative relationship between the dummy 2009_P and planned biota per ha in C_H where land holding sizes in 2006 were much smaller than the ones in 2009. The negative influence of the land holding size does thus not necessarily reflect a lower agrobiodiversity. It may be that most farms had a similar amount of species, and that the size of the farm determines the ‘planned biota per ha’ in this research. If all small farms had the same type of species, agrobiodiversity did not increase with smaller farms. Only if the species are different from other farms, at village level agrobiodiversity based on planned biota, increases.

Cropping intensity and chemical fertilizer N, had a positive effect on planned biota per ha, which was significant in 4 and respectively 3 taluks. This result contrasts with other studies regarding biodiversity assessment. However, when more land was used for cultivation or more harvests occurred in one year, there is a high possibility that more crop species were grown on the farms. The same explanation can be applied to chemical fertilizer N application: the higher fertilizer input farmers applied on farm, more crops can be cultivated.

The last point is about area_vegetables which was significantly negative related with planned biota per ha in B_B and U_U. The results relate to the sayings of the farmers from B_B and U_U attending the workshop in 2010 (Purushothaman, et al, 2010), that farmers are prone to grow more vegetables and fruits organically due to higher demands on the market. However, when more arable land is used for vegetables cultivation, less is available for the traditional crops such as cereals and pulses. In addition, the major reason for the negative influence of area_vegetables on the planned biota ratio is that there was no clarification of each type of vegetables grown on farm from the farm survey data, but the word vegetable was used as sole representative for this crop group. As vegetables are often cultivated on smaller areas, it is likely that this crop group is more diverse than for example cereals. Caution should thus be taken interpreting the results.

5.2.4 State-Level Analysis

Because the impacts on the indicators were not the same and also very much dependent on the conditions in each taluk, also a state-level regression analysis was executed, that allows to examine the effects of the policy at a higher level. It helps with the development in the future since the State Level Organic Mission Empowered Committee has been constituted to plan and implement the organic farming promotion programs to the whole state (Anonymous, 2009).

The climate variable “rainfall” was included into analysis of soil organic carbon and water EC only at state-level. However, rainfall has no influence on either of them. The majority of water samples for water quality assessment were collected from the tube well on farm sourced from groundwater (Patil, S. 2010. pers. Comm. March). The salt contents of groundwater are determined by base exchange, transpiration, evaporation, and precipitation (Chhabra, 1996). Although climate is an important factor for water quality, evapotranspiration or dissolution are the general reasons for increases in salinity. The rainfall data came as average data from close-by weather monitoring station to the case study taluk. It happened also if the taluk is located in the middle of two weather monitoring stations, average data from the records of two stations were used for the all households in one taluk. It is possible that the generality of rainfall data is not capable to describe the variances of indicators among taluks.

The variable 2009_P standing for policy implementation in 2009, has a significant influence only in the SOC model, but not to the other two indicators. In fact, the dummy variable 2009_P in the W_EC regression model stands for the difference between 2009_P and 2009_N instead of comparing with 2006. Likely, the variance is smaller when temporal differences are not included. This explanation can be confirmed by ANOVA analysis and regression model of W_EC at taluk-level, where only U_U showed the significant difference. Actually, the accumulation of salts in groundwater takes a longer time to be observed, vice versa the salt content decline. It is logical that soil organic carbon content is the only indicator influenced significantly by variable 2009_P according to the results of ANOVA analysis of SOC in each taluk. However, since the term of research is rather short (3-4 years), the substantial changes in SOC seems unlikely. Several studies comparing organic farms and conventional farms for decades have been carried out in some European countries where the results showed that organically managed farms tend to have higher total soil organic carbon contents (Armstrong Brown et al, 1993; Stolze, et al, 2000). Besides, soils with lower organic matter content before conversion tend to have more promising increment in soil organic carbon content (Loes et al, 1997). The result could have been confirmed further by the ratio of soil microbial biomass to soil organic carbon (Stolze, et al, 2000). However, the sampling size of soil microbial biomass is insufficient to apply on taluk or state-level analysis.

5.2.5 Crop Yield

To increase crop yields is one of the goals of the Karnataka Agricultural policy. Better crop yields can also reflect the fertility of the soil or the management of the farms. There were few significant differences happening in crop yields among three situations through all five taluks. Few exceptions are: the yields of pearl millet in B_B; finger millet in K_G; and horsegram in M_HK. The similarity of these observations is that the crop yields in 2009_P were always the better one if there was any difference. If we compare the pearl millet yields in B_B to the average of the whole state (Figure 29), the yields in three situations (2006, 2009_P and 2009_N) are higher than state average, especially for situation 2009_P. It seems that the case study taluk already had good conditions in growing pearl millet and the capability was even enhanced in 2009_P. In fact, pearl millet can tolerate drought, high temperatures, and is able to grow under low nutrient conditions. Soil organic carbon was positively related to the yield of pearl millet (Section 4.3.4.1) which suggests some degree of improvement in SOC is able to increase the production.

Finger millet is a traditional food in Karnataka state and also the daily diet, especially for the rural population. Finger millet is also drought and high temperature tolerant. It is demonstrated in Figure 29 that Kolar_Gowribidnur (K_G) and Mysore_HD Kote (M_HK) had yields similar to the state average yield in 2006, but higher in 2009_P, especially for K_G. Nevertheless, the only relationship that can be observed from our data is the negative relationship between area_root and yield_finger millets ($r=-0.58$, $p<0.05$). There is no causality relationship between these two variables, because finger millet is often intercropped with mustard or niger, cow pea, red gram or other millet varieties (Millet Conservatinos in Southern India). The higher N-input in 2009_P in K_G may be a cause for the higher yield of finger millet, but no relationship was observed. The possible related feature in M_HK is the increment of area for pulses cultivation which may be used in intercropping with finger millet. Although there is no record for pulse cultivation in K_G in 2009, higher N-input in 2009_P was applied on farm which may have an influence on the higher yield of finger millet.

Sorghum is the crop that is grown in most of the taluks: B_B, K_G, M_HK, and U_U. In U_U, the only situation that had sorghum cultivated is 2009_P therefore it can not be compared here. Although the average yields of sorghum are much higher in 2009_P for all three taluks, just like pearl millet and finger millet, contrasting to the state average yield in 2006, our data seems to be too high to be realistic.

Groundnut is a very popular oilseed crop to grow in Karnataka state. From the record of state average yield, the production of groundnut seems not volatile. It was only a bit higher in 2005-2006 which is also reflected in the record of our case study taluks. The yields in B_B and M_HK were however very high, which seems unrealistic just like for sorghum yield described above. However, in a study of Rego et al. (2003), yields reached 1400 and 1100 (kg ha^{-1} yr^{-1}) in 1995 and 1996 respectively, which means the results here could be reasonable. The groundnut yield keeps high in B_B, where we can only find the negative relationships between cropping intensity and yield_groundnut. The bivariate correlation result also showed that there are negative relationships with organic fertilizer N proportion, and water pH value, however, the causality can not be found from this result.

Although the analysis of data is limited to find significant relationships, results suggest that organic farming can have a positive influence on crop yields.

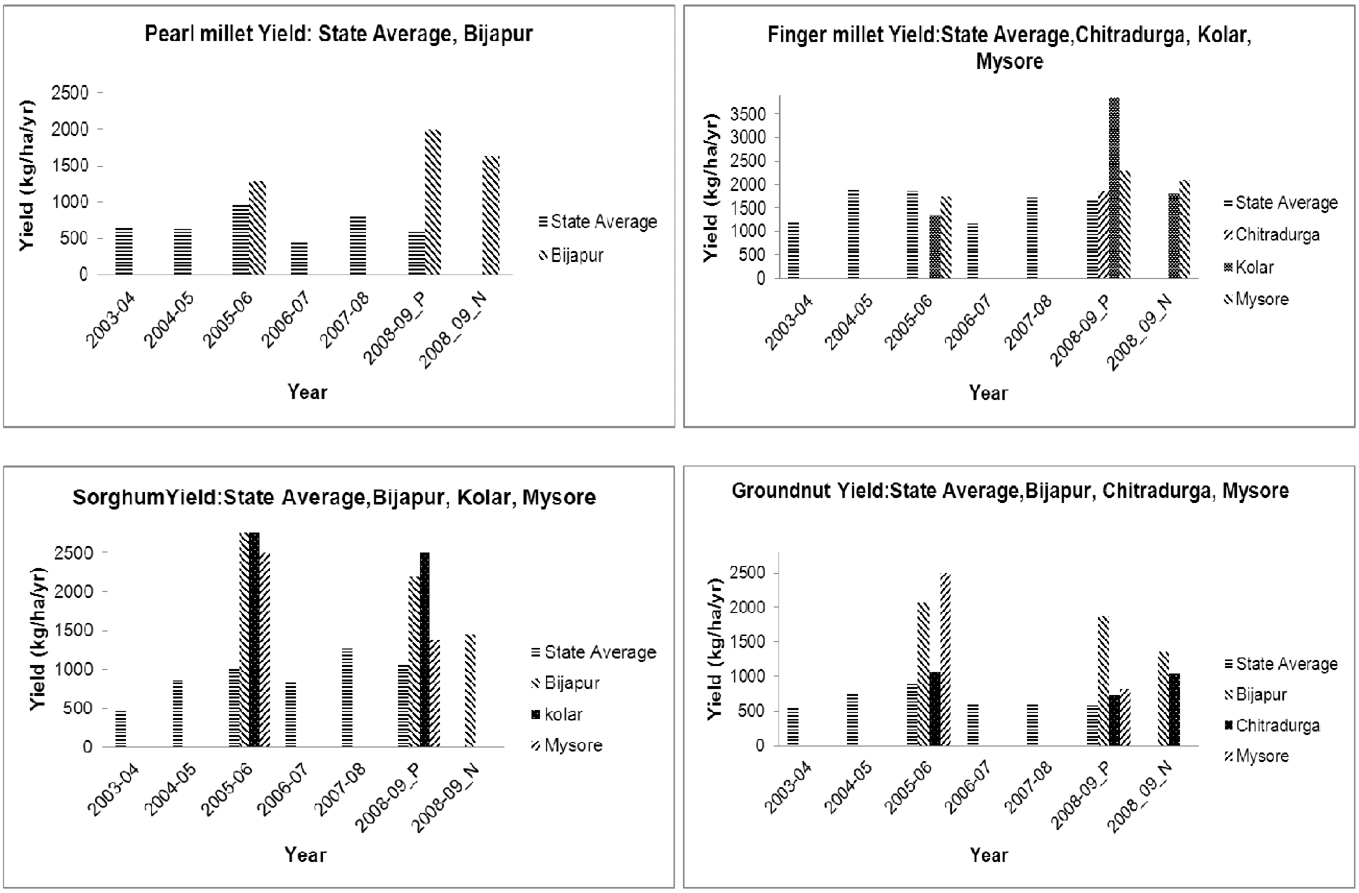

Figure 29. Comparison of Crop Yields between Average Yield of the State and the ones in Case Study Taluks from 2003 - 2009

5.2.6 Improvement and Recommendation

The Karnataka State Policy of Organic Farming (KSPoOF) has clearly declared the principles of organic farming in terms of crop production and animal husbandry. However, in the case study villages of this research, which were meant to be selected for conversion, chemical fertilizers were still used. Looking at this situation from state-level, although the organic farming policy was aimed to extend to the whole state, the consumption of fertilizer has still been raised in past four years (Table 53).

Table 53 Annual chemical fertilizer input from 2006 to 2010 in Karnataka State, India

	Fertilizer Input (in 100,000 t)			
Year	**N**	**P**	**K**	**Total (N+P+K)**
2006-2007	7.56	4.38	2.91	14.85
2007-2008	7.90	3.87	3.30	15.07
2008-2009	8.75	5.34	4.50	18.59
2009-2010	9.98	7.17	4.33	21.48

Source: (Anonymous, 2009)

The KSPoOF is just one of the many policies existing presently. There are policies providing subsidies for both farmers and manufacturers for purchasing and producing chemical fertilizers. There also is a policy promoting intensive farming with high yield variety seeds. Although it is emerging quickly (Ramesh et al, 2010), organic farming is still in the niche market in India. Besides chemical fertilizers, pesticide application is the other prohibited substance in organic farming that has been continuously used. However, the data about pesticide is not sufficient enough for analysis in this research. According to a farmers interview in Kolar (March 2010 pers. Comm.), they complained the biocides provided by the local NGO are not effective enough for plant protection, therefore, they were using synthetic pesticides as usual.

The government and the NGOs in charge are supposed to provide more effective assistance than what they provide currently. For example, the experiments of vermicompost production can be done in the research institutes or experimenting farms in advance and be able to meet instant needs for farm use. Of course, the farmers need to be educated of making their own vermicompost at the same time. Similar to the example before, natural or organic biocides need to be provided sufficiently and efficiently. However, it needs great investments on researches and experimenting. In fact, these issues are corresponding to one of the goal in KSPOoF as from lab to the farm.

Although the initiative for the policy is to help marginal and small farmers from getting into debt trap, the results of four taluks except for Bijpuar_Bijapur, showed that medium to small farmers are more prone to convert to organic farming than marginal ones. The given explanation is that larger land holders possess more resources in terms of livestock and cultivation area which make it easier to convert to organic farming. For example, the small-scaled farmers interviewed in Kolar (March 2010 pers. Comm.) mentioned that he was about to convert to organic farming, but his on-farm vermicompost is still experimenting on farm, not ready to use. Besides, he did not grow the fodders for animal feed by himself (reasons were not explained) which means he still needs to purchase the external input. There is not much increment in pulse area in 2009_P from our data either which shows the subsistent system has not been achieved yet. A feasible solution to achieve closed cycles in farming systems is to cooperate with the neighbors for exchanging resources. However, it also needs government or NGOs to make proper arrangement and educate the farmers.

The results of the analyses regarding to changes of agro-ecological indicators for 5 taluks, varied among taluks. One explanation is that the five case study sites are inherently different from each other in respect to climate, soil fertility, etc. The other explanation is that the samplings from farm survey were conducted by different NGOs in different years and individual locations, that the interpretation or intactness of data varied much. Moreover, the unequal and small sample sizes violate the assumption of statistical methods easily which brings the uncertainty of analysis. Since the same NGOs are not always there due to financial status or some other reasons, there should be some official organizations from the government to conduct similar farm surveys every year, or provide stable funding for local NGOs for this task in order to keep the most complete data set for future use.

6. Conclusion

This research aimed to quantitatively analyze the changes in farming practices between before (year 2006) and after (year 2009) the launching of a policy stimulating conversion to organic farming in Karnataka (KSPoOF), India, and to assess its ecological impacts. The analysis was performed along four research questions, for which conclusions are provided below.

- Were there changes in farming practices between year 2009, 3 years after the policy had been deployed and year 2006, before the policy, in terms of : types of fertilizer applied on farm; cropping pattern, livestock density?

In general, the conversion from conventional to organic farming has been observed in our study cases, with much variations of the pace and extent among 5 taluks. This conclusion is based on the proportion of organic fertilizer application. Bijapur_Bijapur and Mysore_HD Kote are the two most distinct taluks, as fertilizer application was 100% organically after the policy was introduced. However, low organic fertilizer applications in the farms in B_B and M_HK suggest that being self-sufficient in organic fertilizer is still a challenge for promoting organic farming. Udupi_Udupi and Chitradurga_Hiriyur still have mixed fertilization application in the policy village, but the proportion of organic fertilizers increased. In contrast, in Kolar_Gowribdinur, no changes of organic fertilizer proportion are observed in the policy farms in 2009. On the other hand, the influences of the policy regarding to cropping pattern are not much. Cropping patterns stay similar for most of the taluks in 2006 and in 2009. However, if comparing between villages with (2009_P) and without (2009_N) policy implementation, more subsistent crops were cultivated in 2009_P. Nevertheless, the conspicuous increment in oilseeds, vegetables, and maize production area has been affected mainly by market and other political schemes. The influences of the policy in livestock density are even limited. No taluks are observed to have significant differences in livestock density between before and after the policy.

- Are the agro-ecological conditions on farm better in policy village in year 2009 (2009_P) than in year 2006, in terms of: soil quality, agrobiodiveristy, water quality and crop yield?

Soil organic carbon is the most influenced indicator by the policy. It has been significantly increasing from 2006 to 2009_P in 3 out of 4 taluks that have been analyzed. Chitradurga_Hiriyur is the only taluk that shows a decline in average SOC content. Although the changes of planned biota per ha are significant in 3 out of 5 taluks, it is strongly correlated with land holding size which makes it impossible to conclude the influence of the policy. This indicates a better assessment method should be applied in the future. Water electrical conductivity is only significantly different in Udupi_Udupi (U_U) between two situations. Concerning to the paddy prevalent cropping pattern in U_U, a water saving farming practices or irrigation water monitoring system should be developed in the future.

- Which are the major factors influencing the changes of agro-ecological conditions on farms? Are the influencing factors related to the policy implementation?

The policy itself had significant influences on some of the changes, but the effect was difficult to disentangle in f.e. organic fertilizer application, livestock density. The effect can be partly explained by a large influence of the presence of an NGO itself, giving training and other opportunities. The most significant factors that influence the agro-ecological indicators in this research are soil electrical conductivity, land holding size and cropping patterns. The influences may come from higher micronutrient levels in the farm yard manure application, how much resources farmers possess, and the physiological traits of different crops.

- Do the changes observed show any differences between different districts and villages, and at different levels (village/state)?

There is a difference in uptake of practices and impacts in different taluks. Therefore, and because of the short time period causing sometimes unexpected changes, at state level effects of explaining variables appear less influential because the integrated data sets come from different taluks with various variation and different direction in terms of influencing the variances of the indicators. Different directions of the influence of each data set may compensate each other's effect and also the differences of sampling method by individual NGO can result in different distribution of each data set. This indicates the need to perform assessments at local levels and constantly keep statistic records in the local offices in charge.

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<u>Appendix I</u> Catalogue of Crops Classified into Six Crop Groups in Karnataka state

Crop group	Name in English	Latin name	Name in Kannada
Cereals and millets	Finger millet	*Eleusine coracana*	Ragi
	Maize	*Zea mays*	Musikinu
	Pearl millet (Bajra)	*Pennisetum typhoideum*	Sajje
	Rice	*Oryza sativa*	Akki
	Sorghum	*Sorghum vulgare*	Jowar
	Wheat	*Triticum aestivum*	Godhi
Pulses and legumes	Chickpeas (Bengal gram)	*Cicer arietinum*	Kadale
	Cow peas	*Vigna catjang*	Alasande
	Green gram	*Phaseolus aureus*	Hesare Kalu
	Horse gram	*Dolichos biflorus*	Hurule
	Pigeon Pea	*Cajanus cajan*	Tur
Roots and tubers	Onion	*Allium cepa*	Eerulli
	Potato	*Solanum tubersum*	Alu
Nuts and oilseeds	Cashew nut	*Anacardium occidentale*	Geru beeja
	Coconut	*Cocos nucifera*	Thengini kai
	Groundnut	*Arachis hypogea*	Kadala kayi
Fruit	Mango	*Mangifera indica*	Mavinaka
	Papaya	*Carica papaya*	Parangi
	Banana	*Musa spp.*	
	Watermelon	*Citrullus lanatus*	
Others	Areca nut	*Areca catechu*	Adikke
	Cotton	*Gossypium spp.*	Hathi
	Mulberry	*Morus sp.*	Hippa Nerele
	Jasmine	*Oleaceae sp.*	
	Tobacco	*Nicotiana sp.*	

Crops' Names Are Written in English, Latin and Kannada

Appendix II Crops Cultivated in Five Case Study Taluks in 2006 and 2009

District-Taluk		Cereal/Millet	Pulse/Legume	Oilseed/Nut	Root/Tuber	Fruit	Vegetable	Other
Bijapur_Bijapur	**2006**	Wheat, Sorghum Maize, Pearl millet	Chickpea, pigeon pea, Greengram	Sunflower, groundnut	Onion, Potato	Bari, Grape		
	2009	Wheat, Sorghum, Maize, Pearl millet, Finger millet	Pulse (not specified)	Sunflower, Groundnut		Grape	Vegetable (not specified)	
Chitradurga_Hiriyur	**2006**	Rice, Finger millet	Pigeon pea, Horsegram	Sunflower, Groundnut	Onion			Mulberry, Areca
	2009	Rice, Finger millet		Sunflower, Groundnut, Coconut	Onion	Banana, Papaya		Mulberry, Areca, Tobacco
Kolar_Gowribdibnur	**2006**	Sorghum, Rice, Finger millet	Pulse (not specified)	Groundnut, Coconut	Onion, Potato			
	2009	Sorghum, Maize, Pearl millet, Rice, Finger millet		Sunflower	Potato		Tomato	Marigold
Mysore_HD Kote	**2006**	Sorghum, Rice, Finger millet	Horsegram, Cow pea	Groundnut		Banana, Watermelon		Cotton
	2009	Sorghum, Maize, Finger millet	Horsegram	Groundnut		Banana, Watermelon		Cotton
Udupi_Udupi	**2006**	Rice		Coconut, Cashewnut		Banana		Areca,
	2009	Rice, Sorghum		Coconut			Vegetables (not specified)	Areca, Jasmine

Appendix III Overview of the amount of fertilizer application in three situations though five taluks

	Bijapur_Bijapur			Chitradurga_Hiriyur			Kolar_Gowribdinur			Mysore_HD Kote			Udupi_Udupi		
Chemical fertilizer	**2006**	**2009_P**	**2009_N**	**2006**	**2009_P**	**2009_N**	**2006**	**2009_P**	**2009_N**	**2006**	**2009_P**	**2009_N**	**2006**	**2009_P**	**2009_N**
N (kg/ha/yr)															
Range	0-450	0	45-88.6	0-114	0-71.5	11-81	8-337	0-146	90-226	0-112	0	3.7-37	0-225	0-75.8	8.7-112
Mean	91.2	0	68	11	18	46	50.6	69.4	135	6	0	17	19	11.5	38.7
Std Deviation	92.8	0	17.3	17.4	26.6	49.5	73	50	53.7	19	0	12	35	23	49
P (kg/ha/yr)															
Range	0-506	0	50.6-99	0-128	0-80.5	12-91	9-379	0-164	101-255	0-126	0	4.2-42	0-253	0-85.2	9-126
Mean	102.5	0	76.5	12.5	20.5	51.7	56.9	78	152	6.8	0	19.4	20.4	12.9	43.5
Std Deviation	104	0	19.5	19.6	29.9	55.6	82.5	56.4	60	21.6	0	13.8	39.7	26.6	55

	Bijapur_Bijapur			Chitradurga_Hiriyur			Kolar_Gowribdinur			Mysore_HD Kote			Udupi_Udupi		
Organic fertilizer	**2006**	**2009_P**	**2009_N**	**2006**	**2009_P**	**2009_N**	**2006**	**2009_P**	**2009_N**	**2006**	**2009_P**	**2009_N**	**2006**	**2009_P**	**2009_N**
N (kg/ha/yr)															
Range	0-162	33.7-101	0-4	0-22.9	13-79.7	1-124	0-148	0-43	0	0-131	9-33.7	13-37.8	0-194	15-152	22-75
Mean	24.7	61.7	0.8	9.3	36.7	42.5	19.7	19.5	0	19.6	17.7	20	27.7	56.9	45
Std Deviation	32.5	17.9	1.8	6	19.5	70.5	31	14.5	0	3.2	4.4	2.8	32	36	23.9
P (kg/ha/yr).2															
Range	0-35	7-22.2	0-0.9	0-5.4	2.9-17	0-27	0-32	0-9.5	0	0-28	2-7.4	2.9-8.3	0-42	3-33	4.9-16
Mean	5.4	13.5	0.18	2	8	9.3	4.3	4.3	0	4.3	3.9	4.4	6	12.5	9.9
Std Deviation	7.16	3.9	0.4	1.3	4.2	15.5	6.8	3.2	0	5	2	2.2	7	7.9	5.2
K (kg/ha/yr)															
Range	0-134	28-84	0-3.4	0-19	10-66	1-102	0-123	0-35.8	0	0-108	7-28	11-31	0-161	12.8-126	18.5-62
Mean	20.5	51.2	0.68	7.7	30.5	35.3	16.4	16	0	16.3	14.7	16.6	23	37.3	47
Std Deviation	27	14.9	1.5	5.2	16	58.5	25.8	12	0	19	7.4	8	26	30	19.8

Appendix IV Analysis of Soil Organic Carbon

One-way ANOVA analysis and pair-wise comparion (Games-Howell) for Soil Organic Carbon in Four Taluks

(a) Bijapur_Bijapur

Situation	Descriptive Statistics					ANOVA	
	N	Min.	Max.	Mean	Std. Deviation	F	P.
2006	31	0.4	2.5	0.83[a]	0.41	3.07	0.05
2009_P	10	0.6	3.6	1.3[ab]	0.9		
2009_N	5	1	1.2	1.1[b]	0.1		
Total	46						

(b)Chitradurga_Hiriyur

Situation	Descriptive Statistics					ANOVA	
	N	Min.	Max.	Mean	Std. Deviation	F	P.
2006	26	0.18	0.79	0.49[a]	0.16	0.6	0.5
2009_P	10	0.33	0.56	0.43[a]	0.07		
2009_N	3	0.4	0.48	0.45[a]	0.04		
Total	39						

(c)Kolar_Gowribdinur

Situation	Descriptive Statistics					ANOVA	
	N	Min.	Max.	Mean	Std. Deviation	F	P.
2006	25	0.04	0.38	0.19[a]	0.1	4.7	0.0
2009_P	9	0.2	0.38	0.37[ab]	0.07		
2009_N	5	0.08	0.92	0.3[b]	0.26		
Total	39						

(d) Mysore_HD Kote

	Descriptive Statistics					ANOVA	
Situation	N	Min.	Max.	Mean	Std. Deviation	F	P.
2006	49	0.24	0.87	0.58[a]	0.2	25.9	0.0
2009_N	5	0.73	0.96	0.87[b]	0.1		
2009_P	10	0.63	1.26	1.06[b]	0.26		
Total	64						

<u>Appendix V</u> Spearsman's Rho Correlation Matrix

(a) Bijapur_Bijapur

	1	2	3	4a	4b	4c	4d	4d	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1.SOC		.272	-.130	.074	-.081	**.478***	.119	.168	.052	-.008	-.212	.187	.160	.218	-.234	-.323	-.282	.051	**.415****	.171	-.476	a	a	a	a	-.512	.148
2.PlBio	46		-.257	.124	.144	.413	-.217	-.030	.263	**.310***	-.192	**.502****	**.350***	**.514****	**-.718****	**-.882****	.088	-.172	.172	-.124	**-.584***	a	a	a	a	-.347	.369
3.W_EC	15	15		.000	.500	-.060	-.107	-.866	.408	**.525***	-.494	.092	.124	**-.577***	-.149	.498	.352	.079	-.148	.164	.340	a	a	a	a	**.606***	**-.88****
4a.Ywht	27	27	5		**.487***	**.619***	.205	.327	.347	**.564****	.298	**.536****	**.451***	-.110	-.279	-.159	-.070	-.097	.344	-.060	-.308	a	a	a	a	.000	.300
4b.Ysgm	28	28	3	21		-.201	-.500	.034	.190	**.580****	**.466***	**.413***	**.410***	-.016	-.203	-.086	.021	.098	.041	-.238	-.866	a	a	a	a	**1.00****	-.500
4c.Ypmt	21	21	8	13	12		-.866	.118	.362	.411	-.242	**.439***	**.479***	.011	-.394	-.337	.116	-.264	-.053	-.159	-.161	a	a	a	a	.193	.410
4d.Ygnt	9	9	7	5	3	3		a	.311	.451	.034	-.133	.050	**-.695***	-.067	.313	-.553	.445	-.117	.301	-.746	a	a	a	a	-.714	.286
4e.Ygrp	24	24	3	14	16	7	a		.088	.059	.304	-.039	-.154	.312	.184	-.059	**-.568****	.229	.391	**.536****	**-1.00****	a	a	a	a	-.866	.866
5.OFrNP	46	46	15	27	28	21	9	24		**.781****	**-.515****	**.293***	**.326***	-.056	**-.303***	-.211	-.218	-.205	.090	.207	.028	a	a	a	a	.464	-.164
6.OFrN	46	46	15	27	28	21	9	24	46		-.061	**.490****	**.539****	-.231	**-.414****	-.232	-.092	-.137	.171	.081	-.268	a	a	a	a	.330	-.372
7.CFrN	46	46	15	27	28	21	9	24	46	46		.025	-.036	-.221	.147	.249	.025	.159	.092	-.090	-.147	a	a	a	a	-.492	.226
8.LDI	46	46	15	27	28	21	9	24	46	46	46		**.579****	.011	**-.664**	**-.527****	.150	**-.305***	**.329***	-.152	-.386	a	a	a	a	-.235	-.069
9.Irr%	46	46	15	27	28	21	9	24	46	46	46	46		-.001	**-.624****	**-.550****	.145	**-.403****	.252	-.119	-.063	a	a	a	a	-.062	-.062
10.CI%	46	46	15	27	28	21	9	24	46	46	46	46	46		-.061	**-.569****	-.006	-.127	.061	-.090	.372	a	a	a	a	-.226	.327
11.LdCul	46	46	15	27	28	21	9	24	46	46	46	46	46	46		**.819****	-.133	.255	-.200	.100	**.716****	a	a	a	a	.215	-.006
12.Ldhd	46	46	15	27	28	21	9	24	46	46	46	46	46	46	46		-.128	.245	-.205	.127	.357	a	a	a	a	**.541***	-.501
13.SpH	46	46	15	27	28	21	9	24	46	46	46	46	46	46	46	46		-.049	-.186	**-.748****	.046	a	a	a	a	.182	-.511
14.S_P	46	46	15	27	28	21	9	24	46	46	46	46	46	46	46	46	46		-.189	-.032	-.222	a	a	a	a	.160	-.131
15.S_K	46	46	15	27	28	21	9	24	46	46	46	46	46	46	46	46	46	46		.171	-.365	a	a	a	a	-.220	-.041
16.S_EC	46	46	15	27	28	21	9	24	46	46	46	46	46	46	46	46	46	46	46		.339	a	a	a	a	.069	.039
17.W_pH	15	15	15	5	3	8	7	3	15	15	15	15	15	15	15	15	15	15	15	15		a	a	a	a	.505	-.351
18.W_Na	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	.	a	a	a	a	.
19.W_Ca	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	.	a	a	a	a
20.W_BiC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	.	a	a	a
21.W_Cl	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		a	a
22.W_SR	15	15	15	5	3	8	7	3	15	15	15	15	15	15	15	15	15	15	15	15	15	0	0	0	0		-.462
23.W_RC	15	15	15	5	3	8	7	3	15	15	15	15	15	15	15	15	15	15	15	15	15	0	0	0	0	15	

** Correlation is significant at the 0.01 level (2-tailed)
* Correlation is significant at the 0.05 level (2-tailed)
Left side of the matrix is labeled with sample numbers (N)

Appendix V_Spearsmans' Rho Correlation Matrix

(b) Chitradurga_Hiriyur

	1	2	3	4a	4b	4c	4d	4e	4f	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1.SOC		.20	.13	-.146	.08	-.090	.61		-.12	-.08	.018	.166	.146	-.028	.090	-.391*	-.321*	.113	.149	.139	.11	-.212	.382*	.358*	.228	.222	.321	.085
2.PlBio	39		-.36	.245	.646	.119	.60	-.94	-.51	-.03	-.118	.065	.41**	-.065	.616**	-.691**	-.838**	-.01	.499**	.212	-.600*	-.073	-.040	-.042	-.121	-.251	-.002	-.188
3.W_EC	11	11		.527	-.42	.235	.50	.	.50	-.31	-.155	.393	-.155	.	-.353	.263	.469	-.29	.083	.142	-.05	.025	1.00**	1.00**	1.00**	1.00**	1.00**	1.00**
4a.Yrc	22	30	8		.09	.631*	a	1.00	-.31	-.03	.035	.247	.006	-.010	.060	-.303	-.227	.21	.192	-.014	-.266	-.240	.156	.175	.098	-.093	.202	.096
4b.Yfmt	11	14	7	11		.114	a	.	-.05	-.64	-.721**	.361	.78**	-.604*	.524	-.387	-.655*	.10	.580*	.497	-.370	.012	-.572	-.657*	-.572	-.731*	-.339	-.425
4c.Ygnt	23	31	8	13	8		a	1.00	-.68	-.36	-.189	.287	-.174	-.097	-.052	-.188	-.241	-.00	-.059	-.232	-.142	-.451*	.232	.246	.075	.228	.314	.206
4d.Ysfl	5	5	3	a	a	a		.		.00	.300	-.100	.900*	a	.100	-.900*	-.600	-.30	.975**	-.400	-.100	.800	.600	.800	.600	.000	.600	-.400
4e.Yarc	a	4	a	2	a	2	a			.00	.949	.272	-.949	.389	-.949	.949	.949		-.816	-.816	.	.632	.105	.105	.105	.105	.105	.632
4f.Ymlry	16	19	3	17	7	7	a	.		.51	.265	-.486*	-.476*	.179	-.293	.305	.361	-.28	-.183	.084	.135	.317	.181	.179	.371	.191	-.049	.004
5.OFrNP	38	53	11	30	14	30	5	:	1		.661**	-.39**	.130	.284*	-.178	.007	.083	.375	-.048	.209	.239	.316*	-.079	-.069	-.053	-.015	-.115	.043
6.OFrN	37	53	11	29	14	30	5	4	18	51		.249	.043	.598**	-.537**	.020	.217	.579*	-.336*	.075	.519*	.042	.055	.077	.072	.184	.078	.216
7.CFrN	38	54	10	29	14	30	5	4	19	52	52		.004	.195	-.188	-.206	-.113	.30	-.172	-.013	.08	-.324*	.123	.113	-.104	-.072	-.014	-.031
8.LDI	38	54	11	29	14	31	5	4	18	52	52	53		-.082	.062	-.312*	-.208	-.09	.299*	-.018	-.22	.121	-.213	-.207	.024	-.186	-.094	-.134
9.Irr%	39	55	a	30	14	31	a	4	19	53	53	54	54		-.355**	.180	.249	.647*	-.310*	.287*	.581*	.232	-.015	-.052	.081	.178	.155	.433**
10.CI%	39	55	11	30	14	31	5	4	19	53	53	54	54	55		-.320*	-.629**	-.25	.305*	.075	-.725*	-.002	-.101	-.093	-.381*	-.528**	-.298	-.452**
11.LdCul	39	55	11	30	14	31	5	4	19	53	53	54	54	55	55		.877**	.021	-.423*	-.167	.522*	.297	-.184	-.210	.027	.178	.004	.355*
12.Ldhd	39	55	11	30	14	31	5	4	19	53	53	54	54	55	55	55		.054	-.439*	-.190	.671*	.235	-.126	-.154	.132	.271	.075	.373*
13.SpH	39	39	11	22	11	23	5	a	16	38	37	38	38	39	39	39	39		-.340	.638**	.479*	.215	.172	.097	-.048	.110	.102	.310
14.S_P	39	55	11	30	14	31	5	4	19	53	53	54	54	55	55	55	55	39		.529**	-.313	-.054	.096	.080	.202	.067	.160	-.054
15.S_K	39	55	11	30	14	31	5	4	19	53	53	54	54	55	55	55	55	39	55		.327*	.150	.178	.117	-.020	.022	.039	.149
16.S_EC	38	38	11	22	11	22	5	a	16	37	37	37	37	38	38	38	38	38	38	38		-.004	.271	.217	.421*	.652**	.485**	.680**
17.W_pH	31	42	11	24	10	24	4	4	17	40	40	41	41	42	42	42	42	31	42	42	30		-.393*	-.483**	-.160	-.214	-.169	.267
18.W_Na	31	42	11	24	10	24	4	4	17	40	40	41	41	42	42	42	42	31	42	42	30	42		.976**	.591**	.680**	.691**	.319*
19.W_Ca	31	42	11	24	10	24	4	4	17	40	40	41	41	42	42	42	42	31	42	42	30	42	42		.616**	.661**	.635**	.220
20.W_BiC	29	39	11	21	10	24	4	4	14	37	37	38	38	39	39	39	39	29	39	39	28	39	39	39		.831**	.798**	.530**
21.W_Cl	31	42	11	24	10	24	4	4	17	40	40	41	41	42	42	42	42	31	42	42	30	42	42	42	39		.900**	.696**
22.W_SR	31	42	11	24	10	24	4	4	17	40	40	41	41	42	42	42	42	31	42	42	30	42	42	42	39	42		.716**
23.W_RC	31	42	11	24	10	24	4	4	17	40	40	41	41	42	42	42	42	31	42	42	30	42	42	42	39	42	42	

** Correlation is significant at the 0.01 level (2-tailed)

* Correlation is significant at the 0.05 level (2-tailed)

Left side of the matrix is labeled with sample numbers (N)

Appendix V Spearsmans' Rho Correlation Matrix

(c) Kolar_Gowribdinur

	1	2	3	4a	4b	4c	4d	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1.SOC		.312	-.09	.271	.252	.030	.373	-.081	-.082	.033	.231	-.227	-.042	-.186	-.213	-.184	.300	**.344***	.156	-.032	-.146	-.215	-.160	-.024	-.194	-.218
2.PlBio	39		.034	-.129	.620	-.030	-.520	-.076	.021	.242	**.46****	-.193	.272	**-.442****	**-.676****	-.148	.314	.200	.100	**.621***	.159	.154	.295	.202	.263	.135
3.W_EC	14	14		-.592	.189	-.290	-1.00	-.263	-.147	.201	.233	.298	-.103	-.363	-.212	.508	a	.023	.211	.523	**.902****	**.879****	**.841****	**.831****	**.765****	**.637***
4a.Yfmt	17	17	5		-.316	a	1.000	-.024	.229	.184	.144	-.142	-.255	-.095	.251	-.426	.158	.431	-.148	-.616	-.676	-.459	-.667	-.667	-.553	-.872
4b.Ymiz	10	10	10	4		-.316	a	.285	.601	.043	-.018	-.415	.172	-.314	-.571	.150	a	.414	-.365	.508	.081	-.006	-.025	.093	.094	-.006
4c.Ysfl	6	6	6	a	4		a	-.277	**-.83***	-.030	.334	-.097	-.154	-.213	-.188	-.516	a	-.152	-.334	-.625	.185	.152	.213	.216	.216	-.152
4d.Yptt	9	9	2	2	a	a		-.162	-.487	-.354	-.403	.039	-.363	-.036	.367	-.453	-.295	-.259	-.452	a	-1.000	-1.00	-1.00	-1.00	1.00	1.00
5.OFrNP	39	39	14	17	10	6	9		**.83****	**-.51****	-.226	-.059	-.018	-.097	-.039	-.101	-.284	-.211	-.187	-.166	-.470	-.423	**-.544***	-.390	-.408	-.440
6.OFrN	39	39	14	17	10	6	9	39		-.068	-.206	.066	-.017	-.115	-.068	.038	-.074	-.054	-.092	.072	-.314	-.323	-.409	-.269	-.251	-.221
7.CFrN	39	39	14	17	10	6	9	39	39		.248	.115	-.022	-.064	-.072	.060	**.435****	.318*	.149	.156	.367	.356	.465	.389	.510	**.581***
8.LDI	39	39	14	17	10	6	9	39	39	39		-.196	-.216	-.163	-.048	.021	**.340***	.299	**.335***	.427	.227	.265	.399	.319	.440	.480
9.Irr%	39	39	14	17	10	6	9	39	39	39	39		.185	**.400***	**.351***	**.406***	.208	-.131	.211	-.008	.321	.210	.186	.186	.130	.331
10.CI%	39	39	14	17	10	6	9	39	39	39	39	39		**.422****	-.257	-.033	.151	**-.330***	-.237	.072	-.106	-.052	-.040	.020	-.081	-.184
11.LdCul	39	39	14	17	10	6	9	39	39	39	39	39	39		**.719****	.180	.098	**-.337***	-.144	-.387	-.477	-.475	**-.548***	-.422	-.529	-.327
12.Ldhd	39	39	14	17	10	6	9	39	39	39	39	39	39	39		.162	.006	-.127	-.019	-.520	-.347	-.363	-.471	-.369	-.423	-.135
13.SpH	39	39	14	17	10	6	9	39	39	39	39	39	39	39	39		.023	.012	**.619****	.291	.416	.240	.217	.243	.222	.291
14.S_P	39	39	a	17	a	a	9	39	39	39	39	39	39	39	39	39		**.42****	-.034	a	a	a	a	a	a	a
15.S_K	39	39	14	17	10	6	9	39	39	39	39	39	39	39	39	39	39		.242	.330	.161	.045	.069	-.129	.040	.084
16.S_EC	39	39	14	17	10	6	9	39	39	39	39	39	39	39	39	39	39	39		.152	.160	.025	.080	.104	.089	.376
17.W_pH	14	14	14	5	10	6	a	14	14	14	14	14	14	14	14	14	a	14	14		.426	.357	.479	.340	.389	.359
18.W_Na	14	14	14	5	10	6	2	14	14	14	14	14	14	14	14	14	a	14	14	14		**.968****	**.948****	**.893****	**.879****	**.717****
19.W_Ca	14	14	14	5	10	6	2	14	14	14	14	14	14	14	14	14	a	14	14	14	14		**.96****	**.928****	**.913****	**.741****
20.W_BiC	14	14	14	5	10	6	2	14	14	14	14	14	14	14	14	14	a	14	14	14	14	14		**.934****	**.946****	**.777****
21.W_Cl	14	14	14	5	10	6	2	14	14	14	14	14	14	14	14	14	a	14	14	14	14	14	14		**.948****	**.827****
22.W_SR	14	14	14	5	10	6	2	14	14	14	14	14	14	14	14	14	a	14	14	14	14	14	14	14		**.870****
23.W_RC	14	14	14	5	10	6	2	14	14	14	14	14	14	14	14	14	a	14	14	14	14	14	14	14	14	

** Correlation is significant at the 0.01 level (2-tailed)
* Correlation is significant at the 0.05 level (2-tailed)
Left side of the matrix is labeled with sample numbers (N)

Appendix V Spearsmans' Rho Correlation Matrix

(d) Mysore_HD Kote

	1	2	3	4a	4b	4c	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1.SOC		.072	-.293	-.157	-.294	**-.789****	-.063	-.041	.103	**-.257***	a	-.046	.141	.164	-.133	**.355****	-.035	.085	.085	-.397	-.031	.072	-.046	-.167	-1.00
2.PlBio	64		.318	.092	**.676****	.081	**-.348****	-.042	**.374****	-.093	a	**.640****	.030	**-.690****	.069	.100	.211	-.089	-.198	.098	.033	-.247	.009	.268	-1.00
3.W_EC	11	11		-.348	.375	.529	-.421	**.667***	.387	.087	a	.057	-.356	-.321	-.478	.582	.463	-.519	**-.767****	.504	.346	-.220	-.168	.479	1.00
4a.Yfmt	59	59	11		-.207	.268	-.005	.045	-.007	-.068	a	-.112	-.016	.126	.122	-.137	-.059	-.065	.410	-.483	-.143	.140	.194	-.109	-1.00
4b.Yhsg	16	16	6	15		.311	**-.651****	.205	**.647****	.473	a	.102	**-.652****	**-.787****	**-.560***	.340	**.525***	-.402	-.500	.045	-.281	-.582	-.582	-.045	1.00
4c.Yctn	36	36	10	33	13		.046	.013	-.095	.120	a	.273	-.095	**-.358***	**.522****	**-.783****	.134	-.149	**-.654***	.192	.019	-.539	-.361	.272	a
5.OFrNP	56	56	11	53	15	34		**.464****	**-.997****	-.133	a	.107	**.433****	.245	.155	-.152	**-.353****	.136	.013	-.083	-.094	.038	-.225	-.250	a
6.OFrN	64	64	11	59	16	36	56		**-.320****	.109	a	-.124	-.025	.033	-.084	.074	-.244	-.071	-.467	.522	**.779****	.203	.305	**.826****	1.00
7.CFrN	64	64	11	59	16	36	56	64		.121	a	-.056	**-.355****	-.242	-.147	.169	**.311***	-.103	.003	.084	.161	-.015	.262	.305	a
8.LDI	61	61	11	56	16	36	54	61	61		a	**-.392****	**-.549****	-.173	-.181	.040	-.080	-.090	-.348	.130	-.136	-.540	-.396	.005	-1.00
9.Irr%	a	a	a	a	a	a	a	a	a	a		a	a	a	a	a	a	a	a	a	a	a	a	a	a
10.CI%	64	64	11	59	16	36	56	64	64	61	a		**.507****	**-.556****	**.302***	-.099	.195	.057	.084	.348	.357	.226	.396	.336	1.00
11.LdCul	64	64	11	59	16	36	56	64	64	61	a	64		**.347****	.156	.095	.037	**.294***	.247	-.330	-.281	.086	-.199	-.505	-1.00
12.Ldhd	64	64	11	59	16	36	56	64	64	61	a	64	64		-.114	.175	-.049	.216	.242	-.534	-.431	-.058	-.316	**-.612***	-1.00
13.SpH	64	64	11	59	16	36	56	64	64	61	a	64	64	64		**-.546****	.037	.133	.061	.023	-.135	-.109	-.144	-.103	1.00
14.S_P	64	64	11	59	16	36	56	64	64	61	a	64	64	64	64		.017	.187	-.152	.216	.187	-.005	.211	.361	.
15.S_K	64	64	11	59	16	36	56	64	64	61	a	64	64	64	64	64		.008	-.037	.495	.329	.116	.362	.453	1.000
16.S_EC	64	64	11	59	16	36	56	64	64	61	a	64	64	64	64	64	64		.211	-.580	-.308	-.197	-.216	-.412	.
17.W_pH	11	11	11	11	6	10	11	11	11	11	a	11	11	11	11	11	11	11		-.404	-.105	.601	**.604***	-.305	-1.000
18.W_Na	11	11	11	11	6	10	11	11	11	11	a	11	11	11	11	11	11	11	11		.421	.206	.164	.555	1.000
19.W_Ca	11	11	11	11	6	10	11	11	11	11	a	11	11	11	11	11	11	11	11	11		.555	**.667***	**.921****	1.000
20.W_BiC	11	11	11	11	6	10	11	11	11	11	a	11	11	11	11	11	11	11	11	11	11		**.875****	.343	1.000
21.W_Cl	11	11	11	11	6	10	11	11	11	11	a	11	11	11	11	11	11	11	11	11	11	11		.543	1.000
22.W_SR	11	11	11	11	6	10	11	11	11	11	a	11	11	11	11	11	11	11	11	11	11	11	11		1.000
23.W_RC	2	2	2	2	2	a	a	2	a	2	a	2	2	2	2	a	2	a	2	2	2	2	2	2	

** Correlation is significant at the 0.01 level (2-tailed)

* Correlation is significant at the 0.05 level (2-tailed)

Left side of the matrix is labeled with sample numbers (N)

<u>Appendix V</u> Spearsmans' Rho Correlation Matrix

(e) Udupi_Udupi

	1	2	3	4a	4b	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1.SOC		.008	a	.100	-.356	-.243	-.139	.054	-.133	**.376***	-.014	-.066	-.073	.147	**.521****	.015	.140	a	a	a	a	a	a	a
2.PlBio	35		**.519***	-.158	-.038	.086	-.219	-.104	**.312***	**-.369**	.232	-.103	**-.311***	-.197	.090	.097	-.194	.434	**.648****	.215	.091	.390	**.550***	-.095
3.W_EC	a	16		-.165	.224	.007	.216	.213	-.224	-.303	.162	.158	-.065	.165	.242	-.402	-.229	.024	**.866****	.374	.275	.411	**.669****	-.030
4a.Yrc	30	45	15		-.169	-.214	-.160	.272	**.345***	-.015	**-.436**	**-.460****	**-.317***	.231	-.099	-.201	.199	.075	-.172	-.011	.047	-.121	-.057	.261
4b.Yarc	15	23	8	19		-.266	**.561****	.413	-.108	.229	-.087	.311	**.451***	**-.517***	**.416***	.337	**-.816****	.151	.102	-.552	.521	-.084	.443	.635
5.OFrNP	35	51	16	45	23		.191	**-.835****	-.086	**-.324***	.238	.042	-.113	**-.279***	.087	**.416****	-.159	.424	.167	.034	.077	-.204	.110	.325
6.OFrN	35	51	16	45	23	51		.179	-.057	.009	-.132	.170	**.385****	**-.305***	**.358****	**.336***	**-.521****	.225	.123	.186	.231	-.037	.025	.172
7.CFrN	35	50	15	44	22	50	50		.200	.269	-.279	-.097	.090	.186	-.021	**-.427****	-.021	-.484	-.019	.141	-.234	.495	-.039	**-.528***
8.LDI	35	51	16	45	23	51	51	50		-.074	**-.358***	**-.560****	**-.305***	-.127	-.037	-.008	-.019	-.019	-.287	-.077	-.128	-.164	-.382	.106
9.Irr%	35	51	16	45	23	51	51	50	51		.009	.092	.205	.176	**.287***	-.023	.070	-.351	**-.514***	-.260	-.017	.110	-.274	-.045
10.CI%	35	51	16	45	23	51	51	50	51	51		**.706****	.113	.060	.192	-.078	-.094	.065	.246	-.043	-.319	**.615***	.450	-.424
11.LdCul	35	51	16	45	23	51	51	50	51	51	51		**.682****	-.153	**.330***	.020	**-.345***	-.022	.272	.082	-.130	.377	.419	-.375
12.Ldhd	35	51	16	45	23	51	51	50	51	51	51	51		-.215	**.306***	.133	**-.390****	.003	.025	.067	.220	-.330	.016	.091
13.SpH	35	51	16	45	23	51	51	50	51	51	51	51	51		**-.444****	**-.539****	**.706****	-.328	-.029	.395	.213	.209	-.003	-.007
14.S_P	35	51	16	45	23	51	51	50	51	51	51	51	51	51		**.433****	**-.610****	-.016	.237	.220	.014	**.587***	.406	-.249
15.S_K	35	51	16	45	23	51	51	50	51	51	51	51	51	51	51		**-.415****	.190	-.451	-.245	.234	-.340	**-.547***	.445
16.S_EC	35	51	16	45	23	51	51	50	51	51	51	51	51	51	51	51		-.051	-.360	-.246	-.098	.134	-.183	-.067
17.W_pH	a	16	16	15	8	16	16	15	16	16	16	16	16	16	16	16	16		.368	-.004	.172	-.124	.352	.221
18.W_Na	a	16	16	15	8	16	16	15	16	16	16	16	16	16	16	16	16	16		.356	.285	.286	**.834****	.013
19.W_Ca	a	16	16	15	8	16	16	15	16	16	16	16	16	16	16	16	16	16	16		.060	.102	.051	-.210
20.W_BiC	a	16	16	15	8	16	16	15	16	16	16	16	16	16	16	16	16	16	16	16		-.389	.177	**.829****
21.W_Cl	a	16	16	15	8	16	16	15	16	16	16	16	16	16	16	16	16	16	16	16	16		.439	**-.657****
22.W_SR	a	16	16	15	8	16	16	15	16	16	16	16	16	16	16	16	16	16	16	16	16	16		-.022
23.W_RC	a	16	16	15	8	16	16	15	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	

** Correlation is significant at the 0.01 level (2-tailed)
* Correlation is significant at the 0.05 level (2-tailed)
Left side of the matrix is labeled with sample numbers (N)

Appendix VI Internship Report

1. Introduction

I started to join the LUPIS project to work on the Indian case study in September 2009. My plan was to spend three months in India for my thesis field work as well as my internship. Both the thesis and the internship were under the supervision of the chair group Plant Production Systems. On 30 December 2009, I arrived in Bangalore city, India, and an Indian non-governmental organization (NGO), Ashoka Trust for Research in Ecology and the Environment (ATREE), became my working station until 25 March 2010. ATREE is a partner of the chairgroup Plant Production Systems in the LUPIS project. It is an Indian NGO where research regarding conservation and sustainability of the environment takes place. Dr. Seema Purushothaman, the faculty of ATREE, was my co-supervisor in this project.

Most of the results from the field work have been presented explicitly in my thesis report. However, the thesis report has been written down based on the goal of the thesis, which was to quantitatively analyze impacts of the policy stimulating organic farming on agro-ecological indicators. The LUPIS project and the details of the thesis research such as the sampling method, introduction of the sampling sites can be found in thesis report. For the internship report, more is described about activities I have been doing during the three months stay. My major tasks during the internship were collecting the data for the thesis work, processing the raw data and analyzing it partially. Also the preparation before the main analysis is described in further detail. Therefore, the contents of this internship report comprise (i) the activities including literature reviews, collecting data, data management, data analysis done in ATREE, (ii) the interaction with (co) supervisors, (iii) self evaluation and (iv) conclusion. The data collection was done by researchers who spoke the regional language, and the plan for me was to mainly deal with these secondary data sets. Visiting the farms was not a necessity, but to get a feeling and understanding of the region, I managed to get a field trip organized.

2. Activities

2.1. Literature review

This internship began with an intensive literature review. During the period of proposal writing, I firstly realized what I would do is to compare the differences between organic and conventional farms. I focused much on how this kind of research had been done before and what were the conclusions. However, most of the studies, especially long term experiments, were done in Europe (Holland, 2004; Leifeld, Jens et al, 2009; Stolze, et al, 2000). I found a very useful book by Dr. Pushpalatha (1992) that described the methods and results of a study comparing ecological and conventional farms in south India. The period of the research by Dr. Pushpalatha was short with only one year, but it gave some good insight. As the incentive of this research was to find mitigation strategies for the prevalent farmers’ suicide incidences in India, especially in the state of Karnataka, I also wanted to learn more about this topic. Plenty of Indian newspaper reports were reviewed, as well as a book about a study on farmers' suicides in Andhra Pradesh and Karnataka (Sunianchandra, et al, 2007). Furthermore, literature on ecological indicators was reviewed. Articles about soil quality (Andrews et al, 2001; Doran, et al, 1994; Rezaei et al, 2006), water quality (Johnes, 1996; Shrestha et al, 2007; Vinten et al, 2001; Wolf et al, 2005), and biodiversity (Billeter, et al, 2008; Herzog et al, 2006; Kleijn et al, 2006) assessment were studied in order to understand the criteria for choosing the indicators of three aspects in environmental impact assessment. Most of the methods about modeling and statistical analysis came from other literature and an intensively used book, Discovering Statistics Using SPSS (Field, 2009).

2.2 Collecting Data

2.2.1 Secondary data

The policy, Karnataka State Policy of Organic Farming (KSPoOF, under the direction of the government department of Agriculture), was launched in 2004. However, it was in year 2006, when the first villages were selected to convert. Therefore, the data sets which were collected by different NGOs that were locally present and active in the field of agriculture in 2006, can act as benchmark data for this research. The data was collected from 14 taluks in five districts. All the results from the farm survey were recorded on paper in Kannada. Thanks to ATREE's staff, not only the questionnaire was translated into English, but also all the hard copy records were digitalized into Excel sheets. Besides the personal profile of the farmers, the contents of the questionnaire contained 24 main questions regarding to different aspects of farming households. These included economic and social status, and ecological conditions, either quantitatively or qualitatively. I used only the ones which were relevant for the impact assessment of agro-ecological indicators as listed below (**Table 54**a-h). Not all the sub-questions were necessary for this research, only the ones in bold which were used in further analysis (**Table 54** a-h).

Table 54Questions listed on the questionnaire designed for farm suvey in 2006

(a)

Crop information	Sub-questions
Cropping area	Pre monsoon/ post monsoon/ summer / **Total**
Productivity	Pre monsoon/ post monsoon/ summer/ T**otal**
Fertilizer used	**Organic/ Chemical total amount**

(b)

Soil Information	Sub-Questions
Soil Texture	Sandy/ Mixed loam/Loamy/Clay
Soil Type	Black/ Red/ Solid
Soil Fertility	**pH, E.C, Organic Carbon, Phosphorous, Potassium**, Trace lements (Zinc, Iron, Boron, Molybdenum, Copper)

(c)

Land Use /Irrigation	Sub-Questions
Landholding Details	Dry/ Irrigated/ Barren/ **Total**
Irrigated Area by Different Water Source	Well /Bore well /Tank /Canal /**Total**

(d)

Irrigation Water Information		f.	**Bicarbonates**
a.	**pH**.	g	**Chlorides**
b.	Soluble minerals	h	**Sulphates**
c.	**Sodium**	i.	Boron
d.	**Calcium and Magnesium**	J.	**S.A.R**
e.	**Carbonates**	k.	**Residual Sodium Carbonate (RSC)**

(e)

Livestock	Sub-Questions
Cows and buffalos	Local variety/ Improved ariety/ Product (annual)/ **Total number**
Buffalos	Same as above
Sheep	Same as above
Goats	Same as above
Pig	Same as above
Chicken	Same as above

(f)

Cropping pattern	Sub-Questions
Mono crop	Year-season/ Monocrop detail/ A**rea**
Mixed crop	Year-season/Mix crop detail / Ratio/ A**rea**

(g)

Plant and trees	Sub-Questions
Agricultural land	Number of plant and tree / T**otal**
Other land	Total

(h)

Plantation Crop	Sub-Questions
Mango	Productivity/ **Area**
Sapota	Same as above
Banana	Same as above
Coconut	Same as above
Vegetable	Same as above
Medicinal crop	Same as above
Other crop	Same as above

In 2009, all data were collected by ATREE, both in the villages with policy and in neighboring villages without policy intervention. Almost all the questions to be asked were the same as in 2006, although the format of questionnaire was different. Therefore, the data of both years was comparable.

The electronic data of 14 taluks for 2006 were provided by ATREE as raw data, organized in Excel files. For instance, the Excel file named: **Soil test_Bijapur_2006** (Table 55) contains soil data for each farm in the taluks Bijapur, Indi and Sindgi in Bijapur district in 2006.

Table 55 Example of Excel sheet containing soil data for each taluk in 2006

Data	Soil pH	Soil EC	Soil Organic Carbon	Soil N	Soil P	Soil K
Unit		dS/mm	%	kg/ha	kg/ha	kg/ha

Another example is the file named: **Crop_irrigation_ Bijapur_2006** which contains information on irrigation and other farm management variables (Table 56) in the taluks Bijapur, Indi and Sindgi in Bijapur district in 2006.

Table 56 Example of format of Excel sheet containing irrigation and farm management data for each taluk in 2006

Data	Total land	Total Cropping land	Total irrigated land	Chemical fertilizer	Organic fertilizer	Area_crop	Production on crop
Unit	acre	acre	acre	kg/year	kg/year	acre	kg

For some of the variables, titles were constructed for all taluks together, as for: **Biodiversity_2006 (**Table 57**)**, and for **livestock_2006** (Table 58):

Table 57

Data	Field crop species	Tree species	Animal species	Plantation crop species
Unit	Number	Number	Number	Number

Table 58

Species	Cows Ox	Buffalos	Sheep	Goats	Pig	Chicken	Other
unit	Number	Number	Number	Number	Number	Number	Number

The same data for 2009 came with only two Excel files. One was for villages with policy implemention, named **2009_organic village data**; and the other one was for villages without policy intervention named **2009_Inorganic village data**. The contents of the 2009 data sets were the same as 2006 only all the information was integrated into one Excel sheet with 14 separate tabs for different taluks. Besides the data mentioned above, other data also came as electronic files from ATREE: annual rainfall in 2006, soil microbial biomass C/N in 2009.

After having all the data and digesting all the information within, my next step was to select the valid samples and processing the raw data which will be described in Section 3. However, before that, some places were visited to complete the data collection.

2.2.2 Ground water and soil information

On February 2010, I visited two offices in Bangalore with Sheetal Patil, a colleague from ATREE: the department of Mines and Geology (http://mines.kar.nic.in/) and the National Bureau of Soil Survey and Land Use Planning (NBSS&LUP). The first department belongs to the Government of Karnataka (GOK) and this department collects and stores data on groundwater tests for different parts of the state where they carried out their studies. The purpose of our visit was to collect the nitrate contents and groundwater tables for all the case study sites. However, there was nearly zero water quality data available for 2006, which we needed to fill in the largely missing data for water. The most related data we could find was a report recording excess parameters in groundwater as drinking sources for 2006. Because the health risk was the main concern of that report, groundwater measurements for excess nitrate, fluoride, iron and hardness were recorded in the report for all taluks in Karnataka state. However, the data was not really relevant to our research, since we were interested in the water parameters for irrigation water. Besides, we could not find the water table and excess nitrate data for 2009 either.

The second visited office was the NBSS&LUP (http://nbsslup.nic.in/RTI_Bang.html). Our purpose was to collect the classification of soil for all our study taluks. In addition, we were lacking soil nitrogen and complete microbial biomass data. However, we could not find the soil nitrogen and microbial biomass data from the office either. We only retrieved the soil texture category for our 14 study taluks from a soil map. Problem was that the map was at district level, and although we could read the name of our study taluks on the map, we could not locate them precisely. Nevertheless, we had the chances to talk to a researcher in the office, Dr. Ramesh Kumar, who kindly provided an article studying the changes of the soil quality in the watershed of Bangalore rural area in 22 years. Later on, some of the contents of this article were cited in my thesis report.

All the data collected from these two visits were digitalized and saved in an Excel file named **Ground water parameters–soil texture (24 Feb)**. In general, the visits went efficiently, however, not very effectively in terms of the information retrieved. In fact, there were many data stored in the department of Mines and Geology, as we could see from the bookshelves in the office. Unfortunately, the booklist of the collections in that department was not comprehensive enough, without proper updating and sequences. In addition, not all the data were available for public review. For the other case, the researchers in the soil center were very nice allowing us visiting their library to search the information. However, not much specific information that we searched for was found. Again, as for the department of Mines and Geology, all the measurements of soil parameters were in fact collected and stored, however, but they are not for public review unless there are some cooperative projects between ATREE and the soil center (Ramesh Kumar, Feb 2010, pers. commun.).

2.2.3 Farm visit

The farm trip took place in March 2010, and the destination was Kolar, taluk Chintamani. I did some preparation before the trip, such as listing out the questions I would like to ask and read a introduction on Kolar on internet. In addition, Dr. Seema provided me a valuable report with the records of the meeting with farmers and a local NGO, in a Word file named **FGD Nandiganahalli Chintamani**. The meeting was held on 16 January 2010 and the opinions of farmers towards KSPoOF and related questions were written in the report.

The main purpose for this trip was to complete the FGDs by Iswaragouda Patil, who was in charge of conducting the FGDs and also to meet the local agriculture officials for interviews. The first farm we visited was a farm that had not converted to organic farming yet but was about to. The farmers were two brothers in their 40s to 50s (by personal observation). During the time of visiting, lands on the farm were under fallow. The soil seemed dry and clogged into medium to big blocks, because it was not the monsoon season and farmers did not use irrigation either. The major interview was carried out by Iswar, in Kannada. I did not understand the content, and did not ask right away, because I thought it was not appropriate to do so. It was good that Iswar and Seema helped to translate into English for me sometimes. From that I knew that farmers claimed that organic farming seems promising. They observed this from their organic farming neighbors, and therefore they would like to try out as well. Afterwards, they showed us the experiements with a manure vermicompost pit on farm. The storage tank was made by cement with a cement floor in the bottom. The local NGO was guiding them the methods and also helped with distributing the worms and biocides. However, the farmers claimed that the biocides provided by the NGO were not so effective and therefore they continue using chemical pesticides. It was difficult to ask questions and they did not reply to them all. One of the questions that was answered was whether all manure was farm derived. Their response was that they also bought organic manure from outside.

The second farm we visited was a converted farm. It was a pity that the farmer was not there. However, the scene on this farm was totally different from the previous farm. There was a whole piece of land (the precise area is not certain) where carrot was cultivated. This was possible because this farmer had an irrigation system to support the cultivation during the non monsoon seasons. Besides, we saw two water tanks in which azolla was cultivated for green manure and cattle feed. There were covers on top of the azolla ponds. In addition, all the azolla ponds were under a roof, similar to the cowshed. According to Iswar, these facilities were suggested by the NGOs to farmers, and they were meant to prevent evaporation caused by exposure to direct sun shine. In addition, there was a hole dug in the ground near by the farm land, which will be used to build a bio-reactor in the future. Although the farmer was not there to give some information, the distinct scene from the previous farm explained that the conversion seems quite promising with all kinds of infrastructure building in place. However, the resources possessed by the organic farmer were way better than the previous farmer which may allow him to convert much easier. The discrepancies existing between farmers will also depend a lot on their willingness to convert and the effect after conversion.

Although not many farms were visited during the trip, I felt quite happy about the trip. It is always good to see the farms with our own eyes. The pictures told much more than only the numbers on Excel sheets. However, main constraints were the languages and the distance from Bangalore to every other rural area. The traffic is not easy either, according to Iswar, he often needed to take the bus to a bigger location and then reach the farms by walking large distances.

2.2.4 Websites surfing

I have surfed to quite some websites to fill in the missing data or to understand more the general situation in the state / taluk in order to compare to our case study sites. Below are the lists of the websites and the information available.

Karnataka State Natural Disaster Monitoring Center (http://dmc.kar.nic.in/) is the site where I collect the average rainfall for every taluk in 2009.

Directorate of Economics and Statistics (http://des.kar.nic.in/index.html) is a very useful website where we can get the average sowing area and crop yields for every crop in different seasons. Besides, the documents called "Fully revised estimates of principal crops in Karnataka for the year 2005-2006" (or 2006-2007, 2007-2008, etc.) provided the statistics of different crop yields, fertilizer consumption and also information about what political scheme may influence the farming practices.

National Information Center (http://www.kar.nic.in/) is the portal website displaying all the links to different sectors of India. This was the entrance for me to get into the websites of every district in India (http://districts.nic.in/). I used them when I wanted to know more about the five districts of my research.

Karnataka State Department of Agriculture (http://raitamitra.kar.nic.in/) is the official website of KSDA. It supposed to be a very useful website for research However, the main page was written fully in Kannada which is not user-friendly for foreigner researchers.

3. Data Management

At first, when I received loads of data files, I was confused about what should I do with all those data. Besides, there were data for all 14 taluks which made the process even difficult for me. At the first glance at all data sets, I found few confusing points: (i) the sample sizes in 2006 are much bigger than in 2009 and varied in different taluks, and also in different villages, (ii) there were many samples having incomplete or discrepant information from the hard copy. Therefore, I made an Excel file called **Data collection (**Table 59**)** in order to organize exactly which parameter was available for which taluk, and the correct units were labeled in the file. Two districts are presented as examples here (Table 59). There are three signs within one cell in the table, which refer to the availability of data for situations 2006/2009_P/2009_N respectively. Looking at the water parameters for instance, it can be observed that for Bijapur_Bijapur, we have water pH data for all three villages, however, all villages have 2006 data missing (labeled in grey in Table 59).

Table 59 The table organizing available/unavailable data sets

	DISTRICT	Bijapur			Chitradurga		
	TALUK	Bijapur	Indi	Sindgi	Holalkere	Hiriyur	Molkalmuru
Data set							
SOIL	Data amount	32	53	53	32	42	23
	Soil Taxonomy	+ + +	+ + +	+ + +	+ + +	+ + +	+ + +
	Soil type				+	+	
	pH	+ + +	+ + +	+ + +	+ + +	+ + +	+ + +
	E.C (ds/mm)	+ + +	+ + +	+ + +	+ + +	+ + +	+ + +
	Org. C (%)	+ + +	+ + +	+ + +	+ + +	+ + +	+ + +
	Phosphorus (kg/ha)	+ + +	+ + +	+ + +	+ + +	+ + +	+ + +
	Potash (kg/ha)	+ + +	+ + +	+ + +	+ + +	+ + +	+ + +
	Microbial Biomass	- + +	- + +	- + +	- - -	- - -	- - -
WATER	pH	- + +	- + +	- + +	- + +	+ + +	- + +
	E.C (ds/m)	- + +	- + +	- + +	- + +	- + +	- + +
	Na (me/l)				- + +	+ + +	- + +
	Ca (Ca/Mg)				- + +	++ +	- + +
	Bicarbonate (me/l)				- + +	- + +	- + +
	Chloride (me/l)				- + +	+ + +	- + +
	SAR	- + +	- + +	- + +	- + +	+ + +	- + +
	RSC	- + +	- + +	- + +	- + +	+ + +	- + +
AGROBIO	Field crop	+ + +	+ + +	+ + +	+ + +	+ + +	+ + +
	Tree	+ + +	+ + +	+ + +	+ + +	+ + +	+ + +
	Animal	+ + +	+ + +	+ + +	+ + +	+ + +	+ + +
	plantation crop	+ + +	+ + +	+ + +	+ + +	+ + +	+ + +
CROP-IRR	data amount	32	53	52	32	42	24
	total land (acre)	+ + +	+ + +	+ + +	+ + +	+ + +	+ + +
	total irr-land (acre)	+ + +	+ + +	+ + +	+ + +	+ + +	+ + +
	Chemi, fertilizer (kg)	+ + +	+ + +	+ + +	+ + +	+ + +	+ + +
	DISTRICT	Bijapur			Chitradurga		
	TALUK	Bijapur	Indi	Sindgi	Holalkere	Hiriyur	Molkalmuru
	Org fertilizer (kg)	+ + +	+ + +	+ + +	+ + +	+ + +	+ + +
	Land under crop (ha)	+ + +	+ + +	+ + +	+ + +	+ + +	+ + +
	production(kg) (quintal)	+ + +	+ + +	+ + +	+ + +	+ + +	+ + +

Afterwards, the processing of the raw data was carried out for all 14 taluks. The process includes (i) unit conversion, and (ii) data categorization/ratio calculation.

3.1 Unit Conversion

A massive conversion was done for the unit of area, because all the area parameters in data sets (f.e cropping area, total land, area for certain crop) were in acre. Because most of the literature I reviewed were using hectare as the unit for area, in order to make the data more reader friendly for thesis readers and also for myself, I converted all the units “acre” to “hectare”. Besides, the units for weight in our original data sets were in tons or quintals (a quintal = 100 kg) and I changed them both to kilogram. In this sense, the unit for amount of organic fertilizer input, for example, is shown as kg ha^{-1} yr^{-1} through all the thesis report.

3.2 Data Categorization/Ratio Calculation

Data categorization and ratio calculation were the most important parts in data processing. I did these two processings at the same time. Hence they are described simultaneously here. I adopted some calculations used by Dr. Pushpalatha such as cropping intensity (%), cropping pattern (%), and irrigation percentage (%). All the units were scaled to utilized area (cropped area) if needed. However, before the calculation for cropping pattern, it was necessary to categorize all different crops into few major crop groups. Here I also adopted the classification by Dr. Pushpalatha since his study was done in Karnataka and Tamil Nadu, and we are dealing with almost the same crops. Later through the discussion with Dr. Seema, she suggested to further categorize them into two catalogues, which are subsistent and cash crops. However, the two-type classification did not integrate into any analysis later, because there was a direct relationship between the subsistent crop group and cereal crop group or cash crop group with oilseed crop group.

Regarding to other parameters, such as livestock density index, the N, P, K contents of chemical and organic fertilizers, conversion rate were conducted based on literature reviews, logical assumptions and discussion with Dr. Pytrik.

This part of activities was actually the most time consuming part. Not only because I was dealing with big data sets in 14 taluks, but also lots of time was spend on excluding invalid data sets from our files. It happened that I went back to hard copies for the data in 2006 and went through the farmers one by one to exam the correctness of the data sets. The reasons are that sometimes it happened that some farms had records for groundnut cultivation but no yields, or some farms had extreme usage of organic fertilizer, while they only had 1 or 2 cows on farm. A reason for problematic data sets is that different NGOs were involved, and the farm surveys were conducted by various farm interviewers while most of them quit the job afterwards and were discontinued. The definitions for each question varied from interviewer to interviewer, and also the hand writing on paper was hard to recognize sometimes.

4. Data Analysis in ATREE

During my stay in ATREE, only partial analyses were done. The first analysis was a bivariate correlation analysis for all parameters we had on hand. I included the slope (%), rainfall (mm/yr), the yields for every crop (kg/yr) and also the cropping area for every crop group (%). Quite some time was spent on sorting out the tables for each variable, and analyzing the variables significantly related with each other, such as Table 60.

Table 60 Demonstration of sorting out the variables correlated to each other

% Roots_Tuber Area		SOC (%)	Irrigated Land (%)	Cereal_ Millet Area (%)	Pulse_Legume Area (%)	Yld_Pulse_Legume (kg/yr)	Yld_Root_ Tuber (kg/yr)
Pearson correlation		-0.21*	0.13*	-0.10*	0.10*	0.13*	0.48**
	Sig. (2-tailed)	0	0.018	0.044	0.036	0.02	0
	N	279	320	369	375	326	326

The analyses done at ATREE were meant to help to understand the data. Later, the correlation analysis was conducted again because some parameters should be left out from the analysis such as crop yields, slope and also the area for subsistent/cash crop groups.

5. Communication with (co) supervisor

During my stay in ATREE, I had a requent communication with my supervisor Dr. Pytrik Reidsma in Wageningen via emails. In the very beginning, I finished the preliminary literature review and handed it in at the beginning of January 2010. Afterwards, I mainly reported back my progress in ATREE including the overview of data collection, and the problems I encountered when doing data management. I often requested for Pytrik’s advices regarding to the methods of data computation and statistic analysis. In addition, I reported back the records of meeting that had taken place in ATREE. Quite often, Pytrik also provided me some related literatures to read and understand more about the research.

As for the communication with my co-supervisor, Dr. Seema Purushothaman, it went also smoothly and quite constantly. We had meetings every one or two weeks together with Sheetal. The contents of the meetings were about what I did for the past week and to set the plans and deadlines for following activities such as visiting other departments, the farm trip or completing certain data analysis. Right after the meetings, I made the meeting records and send it to Dr. Seema, Sheetal and Dr. Pytrik. The purpose was to make sure I received the messages clearly and confirm once again the date of finishing.

The communication between me and Dr. Seema was not only about the thesis work, but she sent me the notifications of talks and speeches happening in ATREE from time to time. In fact, there was a meeting planned between Seema, me and Dr. Reyes Tirado who works for Greepeace organization in Bangalore, arranged by Dr. Seema. Dr. Reyes came to ATREE and gave a talk about “Greenhouse gas emissions and mitigation potential from fertilizer manufacture and application in India”. She, in fact, was promoting organic farming in India in order to mitigate the use of synthetic fertilizer. However, Dr. Reyes was occupied during that time and neither did I finish all the correlation analysis for discussion, so we did not meet in the end. There were also article readings from time to time in our office, and those were also moments where I obtained advises and comments from Dr. Seema. Although I am not an environmental economist, I think I obtained some knowledge from these events.

6. Self-evaluation

It has been six months since I came back from India. Besides that fragments of my Indian life passed through my head from time to time, I kept thinking what I should have done to make my field work and internship more fulfilling. The reason why I kept thinking about this, is because I somehow felt I did not use my time of stay very efficiently.

I did work hard, especially when I realized how much data I need to handle within three months. I stayed in the ATREE office for almost 10 hours a day. I went quite often on the weekends as well. In the beginning, I asked Dr. Seema for some time for me to do the literature review only and wrote a report about it. It did help me to understand more about the differences between organic farming and conventional ones. However, it was a pity that the reviews I did in ATREE were not cited much in my final thesis. It means after I came back to Wageningen, the loading of literature reviews was still heavy while writing the thesis. An essential issue is that I just kept on reading whatever I though would be relevant and important to this research, but I forgot to set a very clear scope of my search, in other words, my research. I was too focused on all the models and indicators set up by other researchers. For example, I still kept on proposing new variables for certain ecological indicators like microbial biomass for soil quality, and earth worm numbers and species for biodiversity. In the end, it was not feasible and not necessary for me to discuss more variables. Instead I just needed to analyze what could I do with the resources I had as time for this research was limited.

The second point was that there are only 5 taluks as analyzed in the final thesis report, not 14 as we designed in the beginning. As I can remember the data sets in Udupi_Karkala and Mysore_Mysore were very tough to handle because there were too many missing data, and unreasonable records. A substantial amount of time was spent on selecting the valid data sets, and excluding useless ones. However, concerning the time and man power I have (me only), it would be quite difficult to handle all 14 taluks at the same time. Besides, the results, conclusion and discussion of my thesis will enlarge tremendously. It was until few months after I came back to Wageningen that I decided with Dr. Pytrik that I would deal with only 5 taluks. I should have considered this way earlier.

For me, there may not be a second chance to join a project like LUPIS. Also there will not be a second opportunity for me to live in India as "researcher" instead of a tourist. I think I really should have planned even more contacts with people. Although I established very good relationships with staff and, PhD students in ATREE, and I even went to farmers one time, it was not enough in my point of view presently. There are some well-known agricultural universities in Bangalore and also quite some governmental research institutes. I should have made some contacts with the experts and had interviews with them. Of course if they were willing to. I could have talked about the organic agriculture development in the future in India. During that time, genetic modified brinja (egg plant) was trying to be imported to India which raised mass arguments. Those are topics concerning the organic agriculture sector.

I also would have liked to do more field trip. As I know, there are some organic farms in Mysore rural area. I was having a contact who said he could introduce me to visit the farm. However, it did not work in the end. I have to say I constrained myself a bit due to the cautions of security. I did not understand India so well (or say, very little) before I went, I felt quite released sometime after I arrived. Therefore, I believed if I managed well, I could have been to more places instead of staying in the office most of the time.

In fact, ATREE itself is a really international and prominent organization in India, which brought me many opportunities to contact with researchers from all over the world. There were around 6-7 times speeches or workshops that I attended. The topics were more related to the biodiversity and environmental conservations. There was one film appreciation and discussion talking about the Kaveri river which is located 100 km away as the water source for Bangalore city. I really enjoyed all the talks I attended and learned much from it. In this way, I also saw the openness and inspiring atmosphere of academic environment in Indian society.

7. Conclusion

The purpose of the internship is to make students acquaintant with the working environment where the work content could be relevant to their career in the future. I think I reached the purpose regarding to several activities I have done during my internship in ATREE. Being a researcher for my internship, I collected the data, and for this I went through literature, visited experts, and also went to the study site to visit the farmers. Besides, I organized all data sets, mainly the secondary ones collected by Indian NGOs. Afterwards, I analyzed the data following the methods of previous studies. The work loading was different for each activity. Since the main task of my internship was to collect the data for my thesis study, most of my time of internship was spent on organizing the secondary data sets. This could be more different from most researchers who need to collect the primary data by themselves. However, through the process of dealing with secondary data, I received much support from my collegues in ATREE and that was a good chance to enhance my ability to do team work.

I am not doing research for my first time, but it was my very first time that I had to fly to another country and work with other researchers. Although academic learning was very important, there were many other things that I had to cope with, including settling myself and encountering with the different culture. For the academic part, my breakthrough was to gain much knowledge towards a previously unfamiliar research topic, and gradually, I managed to finish my analysis. For other aspects, the gain was more emotional and personal experiences, but mostly wonderful. After this internship, I think I did obtain a certain ability to conduct either my own research or practical work in the future.