ENVIRONMENTAL POLLUTION EXPERIENCED BY AGRICULTURAL SYSTEMS: A STAKEHOLDER PERSPECTIVE

By

LAKSHMI MURALIKRISHNA

(2018-11-063)

THESIS

Submitted in partial fulfilment of the

requirement for the degree of

Master of Science in Agriculture

Faculty of Agriculture

Kerala Agricultural University, Thrissur

DEPARTMENT OF AGRICULTURAL EXTENSION

COLLEGE OF HORTICULTURE

VELLANIKKARA, THRISSUR – 680656

KERALA, INDIA

2020

DECLARATION

I, hereby declare that the thesis entitled "Environmental pollution experienced by agricultural systems: A stakeholder perspective" is a bonafide record of i csearch done by me during the course of research and that it has not previously tormed the basis for the award to me of any degree, diploma, fellowship or other similar title, of any other University or Society.

Vellaiaikkara

I 9/09/2020

Lakshmi Muralikrish na

2018-11-063

CERTIFICATE

Certified that this thesis entitled "Environmental pollution experienced by agricultural systems: A stakeholder perspective" is a record of research work done independently by Ms. Lakshmi Muralikrishna **(2018-11-063)** under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship to her.

Vellanikkara
19/09/2020

Dr. Jayasree Krishnankutty M.
(Major advisor, Research Advisory Committee)
Professor and Head
(Agricultural Extension)
Communication Centre
Mannuthy, Thrlssur

CERTIFICATE

We, the undersigned members of the advisory committee of **Ms. Lakshmi Muralikrishna (2018-11-063),** a candidate for the degree of Master **of Science in Agriculture** with major field in Agricultural Extension agree that this thesis entitled “Environmental pollution experienced by agricultural systems: A stakeholder perspective” may be submitted by **Ms. Lakshmi Muralikrishna,** in partial fulfilment of the requirement for the degree.

Dr. Jayasree Krishnankutty M.

Chairperson ofAdvisory Committee

Professor and Head,

(Agricultural Extension)

Communication Centre

Mannuthy, Thrissur

Dr. Binoo P. Bonny

(Member, Advisory Committee)

Professor and Head,

Department of Agricultural Extension

College of Horticulture

Ve1lanikara,Thrissur

Dr. Ajitha.T. K

(Member, Advisory Committee)

Associate Professor

Department of Agricultural Statistics

College of Horticulture,

Vellanikara, Thrissur

Dr. Sulaja 0. R.

(Member, Advisory Committee)

Assistant Professor

Department of Agricultural Extension,

College of Horticulture,

Vellanikkara, Thrissur

ACKNOWLEDGEMENT

With immense gladness I take this opportunity to express my gratitude to my major advisor ***Dr. Jayasree Krishnankutty M.****, Professor (Agricultural Extension) and Head, Communication Centre, Mannuthy, and chairperson of my advisory committee for her valuable advice, constant guidance, practical suggestions, constant patience, persistent help and pleasant approach at various stages of my research work and thesis preparation which will be remembered with utmost gratitude forever.*

I sincerely thank ***Dr. Binoo P. Bonny, Dr. Ajitha T.K and Dr. Sulaja O. R.*** *for their encouragement, support and critical examination of the manuscript that has helped me for the improvement and preparation of the thesis throughout the course of my research.*

I express my heartiest gratitude to ***Dr. P. Indira Devi, Dr. Jiju. P. Alex, Dr. Mercykutty M.J ,*** *and* ***Dr. Sulaja O.R*** *from the Dept. of Agricultural Extension for their ever-willing help, valuable guidance and creative suggestions throughout the period of my study.*

I am especially grateful to ***Dr. Ajitha T. K.****, Department of Agricultural Statistics, College of Horticulture, Vellanikkara for her sincere guidance, valuable suggestions and immense support during the period of my study.*

I express my gratitude to ***Dr. Diji Bastian****, Professor (Academics) and* ***Dr. Sharon C.L,*** *Academic officer (PG), College of Horticulture for their cooperation and support during the research work*

I am extremely thankful to all the respondent farmers of Thrissur and Palakkad districts for sparing their valuable time and giving valuable responses..I would like to express my extreme gratitude to all the Krishi Bhavan Agricultural Officers, Panchayath Members, Development Officers, NGO's and general public for having helped me during the data collection. I express my heartfelt gratitude to my batchmates ***Aysha, Gayathri, Joseph, Rashida and Mahesh.***

Immense gratitude to my batchmates especially **Jyothish, Anju, Femi, Haritha, Mounisha** and **Swega** for their help. I am extremely grateful to my senior **Akhil Ajith** for the unconditional and timely help offered.

I appreciate all my seniors **Shilpa Karat, Ahaljith, Ajit, Vivek S, Nadhika, Poornima, Silpa** and **Salpriya** for their guidance and emotional support. I thank my roommates **Swathi S** and **Anjitha AR** for their constant encouragement. I thank all my juniors of College of Horticulture and batch mates who have helped me in one way or the other. I am extremely thankful to **Mr. Rajesh** and **Mrs. Sindhu** .I thankfully reminisce the services rendered by all the staff members of Student's computer club, College Library, Office of COH and Central library, KAU. I am thankful to Kerala Agricultural University for the technical and financial assistance for persuasion of my study and research work.

I cannot express the quantum of love and gratitude to all my friends and seniors of UAS Dharwad, **Manasa Hegde, Aavandhika Babu, Pallavi Bhat, Adersh S, Akhil Sarath, Leema Antony** , **Tushar Bhat** and **Vishnu M S,** for being the source of encouragement and strength throughout my ups and down.

I am eternally grateful to my parents, **Muralikrishna K** and **Sindhu V G,** and my sister **Devi Muralikrishna** for their unconditional love, fidelity, endurance and encouragement.

A word of heartfelt apology to those I have not mentioned in person and a note of thanks to everyone who helped for the successful completion of this study.

LAKSHMI MURALIKRISHNA

CONTENTS

LIST OF TABLES

…Contd.

Contd

…Contd.

…Contd.

LIST OF FIGURES

APPENDICES

PLATES

CHAPTER 1

INTRODUCTION

"A nation that destroys its soil destroys itself. Forests are the lungs of our land purifying the air and giving fresh strength to our people"

Franklin D Roosevelt

Pollution is considered to be the necessary evil of development. But in the process of environmental degradation it is considered otherwise. There is an evident lack of a culture that promotes the development of pollution control measures that has resulted in the consequences of heavy backlog of various kinds of pollutants in environment. Pollution is a recent environmental concern that has affected the world. Most of the pollution is anthropogenic in nature, mainly a by product of the various activities of the effluent nations.

Every bit of natural resource is being manipulated and misused by several countries to convert them into comfort goods to boost their economy by exporting them to the developing countries. As a result of this behaviour, a lot of pollutants are dumped into the environment by the industrialized countries. In other ways, one can say that pollution is being "exported" globally by the developed countries.

Pollution has been defined by Webster in 2010 as, "an undesirable change in the physical, chemical or biological characteristics of air, water and soil that may harmfully affect the life or create potential health hazard to any living organism". Pollution can also be defined as, "the direct or indirect change in any component of the biosphere that is harmful to the living components and in particular undesirable for man, affecting adversely the industrial progress, cultural and natural assets or general environment of living society" (Beil and Laura, 2015).

When our natural surroundings which we inhabit are polluted, several changes are brought about that adversely affects our normal lifestyles. The key elements and the detrimental factors of pollution are the wasteful matters occurring in different forms called "pollutants" and causes imbalance in our ecosystem and environment.

Pollution is now thriving in its pinnacle, due to modernization and developmental activities taking place globally, thus causing global warming and various illnesses previously unheard of.

The major types of pollution and their impact on the environment and man

There are different forms of pollution *viz.*, air, water, soil, radioactive, noise, heat/ thermal and light pollution of which the first three types are of foremost importance to the agricultural field.

Point source pollution consists of pollutants that are discharged from any identifiable, singular source, such as a pipe, ditch, channel, drain, well, vessel, tunnel, conduit, or container. In contrast to that, nonpoint is due to broadly distributed and disconnected sources.

Most of the pollution related activities are anthropogenic in nature. Though natural disasters such as active volcanoes and forest fires can cause environmental pollution, most of the pollution has an anthropogenic source. Many major pollutants are in fact useful to and are sometimes inevitable to human beings like fuel from vehicles, burnt coal that generates electricity, and garbage from industries. Almost all the living beings right from the microbes to the blue whales would be threatened if pollution were to prevail.

The three major types of pollution with regard to agriculture and plays a role in farmers" health and welfare are air pollution, water pollution, and land/soil pollution.

a) Air pollution

Most air pollution is anthropogenic in nature, with the major causatives being the burning of fossil fuels like coal, oil, and natural gas. The exhaust fumes of gasoline used in automobiles contain carbon monoxide, a colourless, odourless gas which is a major air pollutant. Air pollution can be visible sometimes with dark smoke from the exhaust pipes of factories and heavy vehicles. But most of the times, air pollution is invisible to the naked eye. But even though it is invisible, air pollution has so many detrimental effects on human health being and can be the causative of various respiratory disorders and even cancer.

Hydrocarbon and the oxides of nitrogen and sulphur produced from factories are the major common air pollutants. Smog is produced as a consequence of the reaction of these chemicals with sunlight, which makes respiration difficult especially among vulnerable citizens like children and old people. In case of severe smog, several countries e.g. Hong Kong will issue warnings to venture outside to its citizens.

Acid rain is an indirect result of air pollution, when air pollutants such as nitrogen oxide and sulphur dioxide mix with rainwater, they convert into acids. They fall to earth as acid rain. But the victims are often unpredictable since the wind carries this acid rain to places away from the source of pollution there have been major instances of acid rain in Spain and Norway destroying forest trees and creating "dead lakes" killing all the fish population.

Another major causative of air pollution are the greenhouse gases due to anthropogenic activities like burning of fossil fuels and has made the 21^{st} century the warmest century on record. Glacier melting and ocean acidification, and habitat shrinking are the results of this global warming. Governments of many countries like Australia. United States of America now limit the production of Chloro Fluoro Carbons (CFCs) that causes global warming.

b) Water Pollution

Water pollution can occur naturally when natural gas and oil from natural underground oil reserves. An example of naturally occurring water pollution is the largest petroleum seep in the world, the Coal Oil Point Seep, in California, USA, where tar balls are washed up on the shores of nearby beaches. But water pollution can also be caused due to the activities of human beings. Factory effluents like hazardous chemicals and toxic oils are seeped into water bodies and are called as chemical runoff. These runoffs are effective breeding grounds for cyanobacteria, also called blue green algae which results in harmful algal blooms or HAB. Aquatic ecosystem cannot survive in water bodies with HAB and these results in the formation of "dead zones".

Polluted water is hazardous for consumption and usage for daily activities. Several people around the world are facing chronic illnesses due to the utilization of polluted and harmful bacteria containing water. The United Nations in 2018, estimated that every day four thousand children die around the world due to the consumption of polluted water.

The other major causes of water pollution are oil spills, acid mine drainage, buried chemical waste, radio wastes, untreated sewage, usage of chemical fertilizers in agriculture and also by eliminating simple garbage like plastic into the water bodies.

c) Soil Pollution

Almost all the pollutants that cause water pollution pollute the soil as well. One of the major causes for soil pollution is agriculture, where the chemical fertilizers and pesticides are logged in the soil and can thus cause bio magnifications when higher organisms consume it. An example is the use of a pesticide called DDT (dichlorodiphenyltrichloroethane) which was ardently used earlier to control insect pests like mosquitoes. In countries like Sri Lanka and Taiwan the instances of malaria have decreased due to the usage of DDT. But in 1962, Rachel Carson, a biologist from America wrote a book *Silent Spring* which discussed about the potential hazards of DDT on human health and biodiversity. The United States banned DDT in 1972, but it is still in use in many parts of the world today due to anti- malarial-properties.

Trash dumping is another causative of land or soil pollution. It is a major menace around the world, especially in developing countries where paper, plastic wastes, glass cans, and electronic appliances are dumped and thus damage the quality and beauty of the landscape. The producers in the food web cannot produce essential nutrients due to the presence of this unchecked litter lying around. There have been several instances of livestock animals dying due to consumption of plastic wastes. Litter makes it difficult for plants and other producers in the food web to create nutrients.

Hazardous toxic compounds can be found is garbage, which can seep into the soil to cause harm to plants, animals and human beings.

A major contributor of soil pollution is inefficient collection of garbage. Garbage is often dumped or buried in landfills. Enormous amount of garbage is being generated and the subsequent landfill leaks can prove to be detrimental to herbivores and subsequently to the predators causing bioaccumulation. A massive garbage landslide occurred in a landfill near Quezon City, Philippines, was the site of a land pollution tragedy in 2000 killing two hundred people who recycled and sold items collected from trash.
Pollutants leaked from landfills also leak into local groundwater supplies causing severe health hazards to human beings and the aquatic ecosystem.

Pollution due to agricultural activities

Agricultural pollution refers to the environmental and ecosystem degradation as a result of biotic and abiotic by products. It causes injury to human beings and negatively affects the economy. The origin can be through point or nonpoint sources. A major contributor of agricultural pollution is the usage of chemical herbicides and fertilizers which persist in the soil and prove to be toxic to life. Organic contaminants containing pharmaceutical and personal care products (PPCPs) are also major agricultural polluters. The US Environmental Protection Agency (EPA) conducts tests on sewage sludge from wastewater treatment plants to assess the PPCP levels. Heavy metals like lead, cadmium and arsenic, which are industrial by products, are often recycled into fertilizers and can lodge in downstream water reservoirs that can be hazardous to plants, animals and human beings.

Soil erosion and sedimentation occurs due to various agricultural activities and causes considerable decline in the fertility of soil and transport capacity of water channels. Tillage operations increase the nitrous oxide emissions.

According to the United Nations Food and Agriculture Organization (FAO) 18 per cent of the anthropogenic greenhouse gases are due to livestock rearing and are even higher than the transport sector. Animal waste is a major contributor of environmental pollution and the USDA in 2015 reported that 335 million tons of "dry matter" waste (the waste after water is removed) is produced annually on farms in the United States.

Unless suitable measures are taken, modernization and mechanization in agriculture would always be a double edged sword with the environment at stake.

Steps taken at the global level to address environmental pollution

The United Nations Conference on the Human Environment was held at Stockholm from 5 to 16 June 1972. This conference proclaimed that man was both the creature and moulder of his environment, which enables him the opportunity for intellectual, moral, social and spiritual growth. The protection and improvement of the human environment is a major issue which it is an urgent desire of the Government of almost all the countries.

Under-development is the major causative of pollution in the developing countries. Millions of people across the globe are deprived of basic facilities like food, shelter, clothing, sanitation, education, health and lives miles away from a decent human existence. Therefore, developmental efforts in this direction must be made by the countries with top priority given to safeguard the environment and improve the present condition. Developed countries face the foremost problems of industrialization, technology boom and population explosion. The most precious resource of any nation is its people who propel progress socially, scientifically, technologically and economically. Therefore the citizens of a nation must be made environmentally aware that, they must shape their actions wherein there is a prudent care for the environment and consequences of environmental damage.

World Commission on Environment and Development in its Conference held in 1987 proposed long term development strategies for sustainable development for the twenty first century, *via* international co-operation and „mutually supportive objectives' so that international communities can deal more effectively with regards to the concerns of the environment, and so that long-term environmental issues are identified and necessary efforts needed to protect and enhance the environment are undertaken.

The Earth Summit of the United Nations Conference on Environment and Development (UNCED) held at Rio de Janeiro, Brazil in 1992 showcased the efficiency of the UN from raising the environmental consciousness of its member nations to setting of agendas to effective action to be taken up by the member nations to a follow up to provide assistance to the needy nations. This summit brought forth the universality of the menace called environmental pollution. Media attention was actively sought out, to capture the attention of billions of people around the world to enhance their awareness and to understand the looming issues due to environmental pollution.

The United Nations General Assembly special session to review implementation of agenda 21 which was held on 23-27 June 1997 came to a conclusion that member nations must develop national forest programmes and international organizations must collaborate in the

Inter-Agency Task Force on Forests. The session also highlighted the importance of forest resources on the indigenous people. "Appropriate national action" to reduce the impact of fossil fuel and hazardous waste management with GHG stabilization must be undertaken by the countries and for the inclusion of "time bound" commitments to transfer relevant technology to the developing nations.

The World Summit on Sustainable Development 2002 also called as the Earth Summit 2002, which was convened to discuss the progress of the 1992 Earth Summit in Rio de Janeiro, was held in South Africa. It was a World Summit for Sustainable agriculture. The major emphasis was to focus the world's attention towards conserving our natural resources in a world that is reeling under the detrimental effects of environmental pollution and population explosion.

The UN Conference on Sustainable Development (2012), also known as Rio+20 and the United Nation‟s Sustainable Development Summit (2015) emphasized on transforming the world by sustainable development to create the future we want, focusing on lesser usage of chemical fertilizers and pesticides.

Major environmental legislations in India

The Ministry of Environment and Forests is a nodal agency to plan, promote, co-ordinate and oversee the implementation of the environmental and forestry programmes. It is also the nodal agency of the United Nations Environmental Programme (UNEP). The various activities include conservation of flora and fauna, prevention of pollution, afforestation, regeneration of land that has been degraded, and environmental protection.

MoEF, which was established in 1985, along with the Central and State Pollution Control Boards together form the regulatory and administrative core of the sector.

These important environment legislations for environmental protection in India are:

- The National Green Tribunal Act, 2010

The National Green Tribunal Act was passed in 2010 to provide for establishment of a National Green Tribunal (NGT) for the effective and expeditious conservation of forests and natural resources.

- The Air (Prevention and Control of Pollution) Act, 1981

The Air (Prevention and Control of Pollution) Act, 1981 or the "Air Act” has established Boards at the Central and State levels with a view to counter air pollution related problems, prohibiting the use of fuels and substances that cause pollution and acting with the State Government in declaring air pollution areas within the state.

- The Water (Prevention and Control of Pollution) Act, 1974

The Water Prevention and Control of Pollution Act, 1974 or the "Water Act" has been enacted to prevent of water pollution and to maintain or restore the purity of water for the country. Discharge of toxic wastes and pollutants into water bodies is polluted and offenders will be punished under this Act. Water cess is also levied on the amount of water consumed by persons carrying out certain industry related activities.

- The Environment Protection Act, 1986

The Environment Protection Act, 1986 or the "Environment Act" undertakes various regulatory measures at the Central level to improve environmental quality by setting emission and discharge standards, regulation of industrial locations, waste management, and public health protection. In case of any non-compliance of the Environment Act, the violator would be liable to imprisonment or a fine of up to Rs. 1, 00,000 or both.

- Hazardous Wastes Management Regulations

Hazardous waste means any waste which possesses toxic, explosive or reactive characters due to its physical and chemical properties. There are several legislations that deal with hazardous waste management. They are the Factories Act, 1948, the Public Liability Insurance Act, 1991, the National Environment Tribunal Act, Hazardous Wastes (Management, Handling and Transboundary) Rules, 2008**,** Biomedical Waste (Management and Handling) Rules, 1998**,**Municipal Solid Wastes (Management and Handling) Rules, 2000, E - Waste (Management and Handling) Rules, 2011 and the Batteries (Management and Handling) Rules, 2001**.)**

Vulnerability of farming systems to the ill effects of environmental pollution

Vulnerability is defined as the “inability of a system or a unit to withstand the effects of an environment that is hostile” (Sanchez-Gonzalez, 2011). In relation to pollution, vulnerability is a concept that links the people‟s relationship with their environment to the social forces, institutions and cultural values that sustain them. It is the propensity or the predisposition of a system to be adversely affected (IPCC, 2014). Vulnerability is a function of exposure, sensitivity and adaptive capacity.

Exposure is the presence of livelihood, people, ecosystems or species, services, environmental functions, infrastructure, socio-cultural assets and resources in places or settings that could potentially be adversely affected (IPCC, 2014). More exposure implies more vulnerability.

Sensitivity is defined as, the degree to which a system is either adversely or beneficially affected, by environmental-related stimuli (UNEP, 2005). As the sensitivity of a system increases, it is put at a higher risk of vulnerability.

Adaptive capacity is the ability of an individual, household or community to be resilient and accommodate themselves to the impending environmental threats. It is a function of access to educational, financial, technical and community resources. Increasing the adaptive capacity reduces the vulnerability of a system (UNEP,2005).

According to the United Nations Environment Programme in 2018, apart from the young and old people, farmers are also found to be more vulnerable to environmental hazards due to persistent exposure to the various environmental pollutants.

Impact of environmental pollution on the health of farmers

The modern agriculture industry has now turned into one of the most hazardous sectors that human beings can work in. According to UNEP statistics, seven hundred occupational fatalities and 1, 20,000 crippling injuries occur per year in the United States of America alone, while the other countries paint an even grimmer picture.

Several studies have concluded the fact that better health conditions are found among non farming community than the farming community. Since farmers face direct exposure to chemical fertilizers, pesticides and fumes from farm automobiles, they are put at higher risks of chronic respiratory disorders, certain types of cancers, liver diseases, unintentional fatal injuries, cognitive and emotional disorders as reflected by their higher suicide rates as well as mental impairments. Farming is a stress inducing profession due to its uncertain nature that can be further aggravated due to environmental pollution. This has been driving farmers all over the world into despair and thus, they suffer from various mood disorders. Feelings like isolation and uneasiness aggravate common depressive symptoms that other people may have been able to cope with.

Many farmers continue to work despite being plagued by various health disorders due to the fear of losing their income and losses of productivity. As many farmers reside in the interiors of rural areas, timely availability of healthcare facilities is also a problem. At present, the only preventive measures being followed on a practical basis are some farm based safety initiatives about the ergonomic risk factors, and the use of protective personal equipment. In this regard, the awareness of farmers regarding the ill effects of environmental pollution on agriculture is of prime importance to safeguard their health and nutrition since farmers are the backbones of every nation‟s progress.

Hence it was felt necessary to study the environmental pollution experienced by agricultural systems, from the perspective of farmers and other stakeholders comprising of Agricultural Officers, Panchayath members, Development Officers, NGO‟s and the general public.

Objectives of the study

- The study will explore the ways in which agricultural systems experience environmental pollution.
- It will address the source, extent and ill effects of pollution based on farmer responses.
- Further a vulnerability index will be developed to categorize the farms based on level of exposure, sensitivity and adaptive capacity.

Scope of the study

Environmental pollution can be considered as one of the most challenging problems that has plagued farmers. A study on the extent of environmental pollution and its effect on farmers can address the major challenges that the farmer faces as a hindrance to further development. Several studies relating to „environmental awareness and vulnerability to pollution among farmers‟ have been taken up in some ICAR Universities, but so far, no research has been taken up in Kerala Agricultural University regarding the same.

The outcome of this study helps to understand the basic details of the farms and farmers, along with the type and extent of major environmental pollution they face in their respective farms. Apart from that, the study also focuses its attention on the ill effects of each type of pollution as perceived by the stakeholders. The level of exposure, sensitivity and adaptive capacity of each agricultural system will be found out and the vulnerability status of the farms is found out. The awareness levels of the farmers about the causes and impact of pollution on agricultural systems will be assessed in the study. The study also focuses on the constraints expressed by the farmers and the legislative support and Government schemes available to safe guard the farmers and farming from ill effects of environmental pollution. Further, suggestions and recommendations to safeguard the farmers against the ill effects of environmental pollution will also be provided.

Limitations

Although utmost care has been given to the investigation to ensure the accuracy of the study, certain limitation still existed. The current study, being a part of masters‟ degree programme faced the normal inherent limitations usually encountered by a student researcher. Some of other limitations suffered by the study are narrated below:

1. The research was confined to only 120 respondents, representing 90 farmers (30 paddy growers, 30 banana growers and 30 vegetable growers) and 30 other stakeholders comprising of Agricultural Officers, Panchayath members, Development Officers, NGO‟s and the general public from 6 Panchayaths of Thrissur and Palakkad districts, hence the findings of the study may not be generalized.
2. The investigation faced limitations due to inadequacy of time, money and other facilities usually encountered by a student researcher. Other than that, the study experienced difficulties due to the CoVid 19 restrictions, in data collection, consultation with experts and writing of thesis.
3. The findings of the study were based on the responses indicated by the farmer and stakeholder respondents. Hence the precision of the study relied on the unbiased or biased responses of the respondents.
4. Though sincere and deliberate efforts were taken while selecting the variables for the current research, some more variables may be still missing.

Presentation of the study

The report of the study is presented in five chapters. The first chapter comprises of a brief introduction, objectives, scope and limitation of the study. The second chapter mainly includes the review of literature relevant to the problem. The materials and methods which have a bearing on measurement of variables along with the statistical procedure used are clearly described in the third chapter. While the results and discussion based on the obtained results have been explained in the fourth chapter. Finally, the fifth chapter deals with summary and conclusions of the thesis followed by bibliography. The appendices and the abstract of the study are given at the end.

CHAPTER 2

REVIEW OF LITERATURE

2.1. Environmental pollution in agricultural systems

World Bank (1992), defines environment as the natural and social conditions surrounding all mankind, including future generations. Pollution involves introduction of contaminants into the environment that causes harm to human beings and other organisms, which can be in the form of chemical substances, heat, light or noise in excess of natural levels. Environmental pollution is considered to be the main threat to the environment.

Hatano and Lipiec in 2004, have stated that, though carbon dioxide is inevitable for the photosynthesis, respiration and growth of the crop plants, *i.e.*, carbon fertilization, at elevated concentrations they prove to be detrimental to the plant growth. It is mainly produced by industries, burning of fossil fuels, and by the manure and is responsible for 60 to 70 per cent of the greenhouse effect.

The persistent organic pollutants (POPs) like organochlorine pesticides (OCPs) are more bio accumulative and highly toxic in nature and even after a ban on their use in 1983, their presence in cultivated crop and vegetable fields is detected. (Wang *et al* .2008).

EPA in 2009 reported that, due to the increased food intake around the world, a variety of pesticides are being drastically used, relative to increased crop production, resulting in their misuse and is the cause of major environmental pollution and health hazards.

Phosphate fertilizers are an inevitable part of agriculture as phosphorus is a major primary nutrient. As compared to other fertilizers, they are an important cause of cadmium metal accumulation. Apart from fertilizers, the other sources of heavy metals are other agrochemicals such as pesticides, livestock manure, and the usage of polluted water for irrigation (Longhua *et al.*2009).

Pesticides containing heavy metals like cadmium, mercury and lead contaminate and decrease the fertility of soil. These heavy metal-containing pesticides were prohibited in 2002. An estimated total input of 5,000 and 1,200 tons of Cu and Zn, respectively, were applied in agricultural areas of China in agrochemical form.

Pimental in 2009, has stated that to meet the food requirements of a booming population, pesticide application is inevitable to assure maximum productivity, but their overuse and abuse can cause severe health and environmental complications and their by-products can escape into the environment, soil, or rivers causing an accumulation of hazardous toxic substances. E.g. DDT (dichlorodiphenyltrichloroethane), chlorinated hydrocarbons, dieldrin, and organophosphates that gains access to human biological systems to cause different diseases.

A study by Xiong *et al*. in 2010 found out that, in the agricultural industry, heavy metals like cadmium, zinc, lead and copper cause the contamination of different agricultural soils and crops especially in rice fields. posing a complication in agriculture and causes hazardous effects on their health. They also found out that copper is a widely used additive in animal feeds, thus increasing the threat of pollution in the soil by the addition of copper containing manure in crops.

Pesticides containing heavy metals like cadmium, mercury and lead contaminate and decrease the fertility of soil. These heavy metal-containing pesticides were prohibited in 2002. An estimated total input of 5,000 and 1,200 tons of Cu and Zn, respectively, were applied in agricultural areas of China in agrochemical form.

Pimental in 2009, has stated that to meet the food requirements of a booming population, pesticide application is inevitable to assure maximum productivity, but their overuse and abuse can cause severe health and environmental complications and their by-products can escape into the environment, soil, or rivers causing an accumulation of hazardous toxic substances. E.g. DDT (dichlorodiphenyltrichloroethane), chlorinated hydrocarbons, dieldrin, and

organophosphates that gains access to human biological systems to cause different diseases.

The soil structure, pH, efficiency and yield potential of the field crops are decreased due to the application of fertilizers containing high levels of sodium and potassium, decrease the soil pH, destroy the soil structure, and reduce the efficiency of field crops (Savci, 2012).

Excessive application of organic fertilizers in the soil under the impression that it would increase the yield causes increased discharge of CO_2 , which enters through stomata of leaves and would cause necrotic lesions on the leaves and thus indirectly reduces the yield, especially in crops like tomato and cucumber (Griffiths, 2013).

Maqsood *et al.* in 2013, quoted that the quality of agricultural soils are used for growing crops to meet the increasing demand of food is affected due to its disproportionate use and this is called as land degradation caused by an increased cultivation, excessive grazing, desertification, booming industrialization, the menace of deforestation, and inappropriate, excessive use of fertilizers which in turn affects the agricultural systems as well as the biodiversity.

As an indirect effect of environmental pollution there would be an abundant increase or resurgence of pests, pathogens and weed pollinators that could indirectly adversely affect agriculture. Without successful and comprehensive adaptation and mitigation strategies that intend to overcome or reverse these environmental changes and their ramifications, there could be a severe diminution of global food security, human health and well-being (IPCC, 2014).

2.2. Basic details of the farms and farmers

2.2.1. Age

Bhosale in 2010, in his study found out that 60 per cent of the paddy farmers 15 per cent of old aged farmers respectively.

According to a study conducted by Rathod *et al*. (2012) on socio-personal profile of dairy farmers it was found that 56.00 per cent of dairy farmers belonged to the middle aged category followed by 34 per cent of farmers who belonged to the young category. Only 10 per cent of the farmers were of old age.

Chaudhary in 2013 reported that 52.50 per cent of the potato farmers belonged to the middle aged group (31-50 years), while young farmers constitiuted 32.50 per cent (below 31 years), and old farmers were 15 per cent (above 50 years).

A study conducted by Bhati *et al.* in 2014 found that 30 per cent of the rural women entrepreneurs (30.00 per cent) belonged to the age group of 18-30 years, whereas, 41 per cent belonged to the age group of 31-45 years. The women entrepreneurs who belonged to the age group of 46-60 were 39 per cent.

2.2.2. Education

Badhe in 2012 came to a conclusion that both the primary and higher secondary educated farmers constituted 27 per cent respectively. It was followed by 27.5 per cent and 18.5 per cent farmers who possessed secondary and college levels respectively.

Chaudhury in 2013, based on his study came to a conclusion reported that 41.6 per cent of the farmers possessed education levels of primary and 31.66 per cent of them had levels of higher secondary and 14.5 per cent of the farmers had graduation. Illiteracy was found only in 12.5 per cent of the population.

According to the study conducted by Kumar (2017) it was revealed that 31.50 per cent of the dairy farmers in Jaipur belonged to illiterate category, 23.50 per cent had education up to primary school level, 19.75 per cent completed middle school level, 10.25 per cent up to matriculation, 8.50 per cent completed higher secondary level, 4.00 per cent were graduates and only 2.50 per cent respondents had completed their post graduate degree.

Shivachandran (2014) reported that 66.84 per cent of the rural youth were educated up to college and , 33.16 per cent had education up to high school.

Badhe in 2012 came to a conclusion that both the primary and higher secondary educated farmers constituted 27 per cent respectively. It was followed by 27.5 per cent and 18.5 per cent farmers who possessed secondary and college levels respectively.

2.2.3. Experience of farming

Ram (2015) concluded that 46.66 per cent of the farmers had low experience in farming followed by medium with 40 per cent and high with 13.34 per cent respectively.

Badhe (2012) based on his study revealed that medium level of farming experience was possessed by 56 per cent of the farmers, while 32 per cent farmers had high experience followed by 12 per cent who had low experience.

Sabale *et al.* (2014) mentioned that a majority (65.80 per cent) of the farmers in Marathwada had medium level of farming experience, followed by 21 per cent low and 15.20 per cent high farming experience.

Sharma *et al*. (2014) found that majority of the potato growers were of the medium farming experience (67.67 per cent),which was followed by high (20.11 per cent) and low (12.22 per cent).

2.2.4. Size of land holding

Sonawane in 2010 reported that, 33.33 per cent of the banana farmers were medium farmers, while 25.83, 21.83 and 19.00 per cent of the farmers were classified into small, marginal and large farmers based on their area of land holding respectively.

Tekale et al. conducted his study in 2013 to observe that slightly more than half half (52.00 per cent) dairy farmers possessed semi medium land holding, followed by medium (16.00 per cent), 12.00 per cent had small area of land holding, 13.00 per cent had marginal and 7.00 per cent respondents had large area of land holding.

Sabale et al. (2014) found in his study that nearly half (42.40 per cent) farmers in Marathwada belonged to medium farmer category followed by 40.80 big farmers and a small percentage belonged to the category of small farmer (16.80 per cent).

Nearly 41 per cent of farmers had medium land holding (2-4 ha), while 34.67 per cent of farmers had a small size of land holding (<2 ha), and 16.67 per cent had marginal land holding and 8.00 per cent farmers had large area of land holding (Ram, 2015).

2.2.5 Occupation

According to Singh in 1992, occupation of farmer had a major role to play in his awareness about pollution. A high majority of farmers who were fully aware about environmental pollution had occupation of farming and business.

Rath and Mohapathra in 1997, revealed that the respondents who belonged to the category of „Agricultural labourers‟ had the least awareness about environmental pollution

2.2.6 Social participation

Swathilekshmi and Annamalai in 2010 revealed that social participation had a negative and non-significant correlation with awareness of rural women to developmental programmes

Ramlakshmidevi *et al*. revealed that in a study conducted by them in 2013, a majority of the (68.50 per cent) of sugarcane farmers in Chittoor had medium social participation followed by high (19.83 per cent) and low (11.67 per cent) levels of social participation.

Raghunath (2014) reported that 44.33 per cent of the nursery owners had medium level of social participation, followed by 40.67 per cent of them belonged to low social participation and rest of them (15.00 per cent) belonged to high social participation levels.

Shivachandran (2014) observed that 41.84 per cent of the rural youth in Hyderabad held non-official position in socio-political organization, while 39.00 per cent of the respondents held official position in one or more organization, 11 per cent of the respondents held official position in social/ political/ formal committees and 8.16 per cent involved in community work as a member.

2.2.7 Mass media contact

Vasava in his study conducted in 2005 reported that 60 per cent of the farmers had medium levels of mass media exposure.

Ram in 2015 reported that 53.00 of the farmers had medium levels of mass media exposure followed by low, high, and very high levels at 20.00 ,19.00 and 2.00 per cent respectively.

Sowmya (2009) reported that a high majority (76.00 per cent) of the rural women in Mandya district of Karnataka belonged to medium mass media contact category, followed by high (15.83 per cent) and low (9.17 per cent) levels of mass media contact.

Tamilselvi and Sudhakar (2010) revealed that a very majority (94.33 per cent) of the vegetable growers in Tamil Nadu made medium utilization of information sources , followed by high (5.67 per cent) and none of the respondents possessed low mass media participation categories.

Ram in 2015 reported that 53.00 of the farmers had medium levels of mass media exposure followed by low, high, and very high levels at 20.00 ,19.00 and 2.00 per cent respectively.

2.2.8 Training received

Anitha (2004) reported that 49.00 per cent of the farm women in Bangalore had undergone training while 51.00 per cent of them had not undergone trainings of any sort.

Shelake in 2015 revealed that none (0 per cent) of the respondent farmers had undergone any sort of training related to fertilizers, pesticides, insecticides, implements and their use. Chaudhary in 2013 revealed in his study that 71 per cent of the farmers were trained and 21 per cent were untrained.

2.2.9 Proximity to industrial area

Bergstra et al. in 2018 reported that, persistent exposure to PM2.5 and NOx from industries resulted in decreased lung function of the farmers living in the vicinity of industrial areas. According to Concentrated Animal Feeding Operations (CAFOs) and industrial production of crops can contribute to GHG emissions and harm the surrounding farming communities and farm animals (Hribar, 2019)

2.2.10 Water source

According to the USBS in 2003, 80 per cent of the farmers use surface water sources for irrigation, while only 20 per cent of the farmers withdraw water from the ground water resources.

On an average, farmers around the world withdraw 80 per cent of the freshwater from rivers to carry out agricultural operations and produce food (USDA, 2015).

According to the Minor Irrigation Census Reports of 2015, between 2007 and 2017, 89 per cent of groundwater was extracted for irrigation and 21.52 million wells and tube wells were used for agriculture purpose in India.

2.3 Sources of agricultural pollution

2.3.1. Agriculture as a polluter

Due to the negative impact it causes on the environment the use of fertilizers has been drastically decreased in the developed nations of the world, but in underdeveloped countries is still used in excessive quantity mainly due to the ignorance about the ill effects they pose on the environment. Due to the use of fertilizers, 1.2 % of greenhouse gases are emitted into the environment (Kongshaug, 1998).

Werther *et al.*in 2000, studied that, The by products that are produced from the process of burning agricultural waste material for the purpose of clearance of land, shrubs, pests, and production of better quality crops by getting nutrients from the land, include certain chemical substances, smoke, and particulate matter, which pollute the air and are harmful for health. Carbon, carbon dioxide, carbon monoxide, and sulfur dioxide, are the main

pollutants which affect the atmosphere as well as the crops a combustion process carried out at low temperature causes the release of these contaminants.

According to a study by Tilman in 2001, it is estimated that in the next 50 years further 109 hectares of natural landscapes will be used for agriculture, thus increasing eutrophication by two- to threefold. This includes one-third of all landscapes impossible to harvest or at least very difficult to cultivate. This includes the landscapes like deserts, tundra, and taiga where harvesting and cultivation are difficult or impossible to do.

Wang *et al.* 2003, notably concluded that lead and manganese, the toxic metals in petrol and diesel fuel used in farm machinery are emitted to the atmosphere through exhaust.

According to a study conducted by Williams *et al*. in 2004, certain unknown species, also referred to as biocides have spent less time in the process of evolution, cannot survive and sustain themselves for a longer time as they have an underdeveloped defensive mechanism. Hence they cannot be kept in natural aquatic habitats. Thus agriculture plays a negative effect on ecological functioning and aquatic biodiversity.

The decomposition of organic matter produces carbon dioxide, hydrogen gas, and acetate. The methanogenic bacteria convert these substances into methane gas, which pollutes the air (Sandin, 2005

Environmental pollution may induce a major alteration in prey-predator relationship due to eutrophication by favoring the production of specific invasive fish species hence resulting in the distortion of the web chains. (Vanni *et al.*2005).

According to Dyer and Desjardins (2006), farm machine manufacturing releases almost the same amount of GHG into the atmosphere as much as that of machine operation.

Many toxic gases are emitted as a result of residual wastes of rice and wheat. Though the practice of agricultural burning is usually performed for the purpose of crop waste management, it causes the menace of pollution. Therefore some guidelines to be followed by the farmers, while performing such activities, must be brought about and enforced (Venkataraman*et al.*,2006).

A study by Aneja *et al.*, in 2008, confirmed that emissions due to agricultural activities could occur at any point along the food supply chain-production, processing, distribution, and consumption configurations. The air pollution caused due to routine agricultural activities have been extensively studied by Mosier *et al.* (1998), Sommer and Hutchings (2001), Stehfest and Bouwman (2006), and they have all reached a common conclusion that, the additional emissions due to agricultural operations, such as emissions from transportation and agro-input manufacturing industries, are usually given a back seat by researchers, which would only give a lopsided view of the role of agriculture in air pollution.

Convention on Biological Diversity conducted a research in 2008 and concluded that water biodiversity is seriously hampered by the landscapes selected and used for agriculture. Agriculture is a basic necessity for human beings, and without agriculture, it is impossible to feed this magnanimous huge human population. Therefore agriculture can never be ignored as it is an inevitable part for human and economic development.

A study by Zhuang *et al.* in 2009 concluded that the rice fields are a source of Methane gas. The paddy fields are flooded with water and they are an important source of methane gas production. These flooded fields are conducive to the growth of methanogenic bacteria as they provide favourable conditions like humidity, organic substances, and an environment limited in oxygen supply

FAO, in 2010 reported that a significant source of agricultural air pollution is the use of farm machinery. According to this report, FAO indicated that, in 2010, GHG emissions from energy use for agricultural production exceeded 785 million tonnes of CO2 eq.

Fertilizer pollution means that, due to large amounts of fertilizer application, there is an occurrence of water, soil and air pollution. In China, agricultural production has become increasingly dependent at an alarming rate, on chemical fertilizers with the use of fertilizers reaching a national average of 301.9kg/hm^2, while the world average is only 93.5kg /hm^2.

In 2005, 48,975,000 tons of fertilizer was produced in China, with an import of 13.97 million tonnes, excluding the number of domestic exports, compared with 43,395,000 tons in 2003, indicating the fertilizer use increase of about 1,500 tons. The demand for fertilizers increased by 1.04 million tonnes in 2009 than that in 2005. The total demand of fertilizer was about 51.21 million in 2009. These data prove that China's fertilizer usage is increasing year by year at an incremental rate (Hannink, 2010).

Plastic film technology was introduced from Japan in 1978, which led to an increase in the levels of production. This technology is predominantly used in the production of major food crops and cash crops like grain, cotton, oil, vegetables, fruits, tobacco, sugarcane, drugs, hemp, tea, forestry and forty other kinds of crops. But film pollution mainly caused due to the residual film causes adverse effects on soil and crop by destroying the soil structure diminishes the drought resistance of the farmland, and prevent the germination and growth of the seed. According to this research, the land with plastic film of 3.9 kg per acre can reduce 11 -23 percent of corn production, 9 -16 percent wheat production, 14.6 -59.2 percent vegetables production and 4.6 -8.1 percent cotton production (Xuedong, 2011).

Notable research has been conducted by Cromwell in 2012, according to which, feed-additive antibiotics have been used extensively in livestock production systems to promote animal growth and augment feed efficiency. The manufacture and application of these antibiotics, along with agrochemicals pose a serious threat of air pollution. But only limited studies have been conducted pertaining to this issue.

Savci in 2012 concluded that, if increased quantity of chemical fertilizers is applied to plants, which contain Nitrogen, Phosphorus and Potassium as primary nutrients they release nitrogen oxides such as NO, NO_2 , and N_2O causing air pollution. But these chemical and mineral fertilizers are inevitable in the production of major food crops like corn.

According to FAO, in 2013, livestock took up the largest part of global land resources and used one-third of cultivable land to plant fodder and feed crops and more than 40 per cent of world cereal production is harvested by this sector. The animal production activities change the landscape and could potentially change the GHG emission globally. Air pollution directly affects animal health as well as it threatens the fodder crops supply and thus, indirectly affects livestock production.

Long-term application of fertilizers can cause rivers, lakes and coastal pollution, water resources‟ nutrition and soil structure‟s destruction etc.is caused due to long term application of chemical fertilizers (Katabami, 2016).

According to the same research, poultry industry pollution refers to the untreated manure, sewage and residual feed easily discharged into water bodies and according to an environmental assessment 60 percent of farms lack separation of wet and dry wastes. Eighty percent of large-scale farms lack the necessary prerequisite of pollution control investment. This can become a troublesome problem, as there are lots of poultry points that are largely pollutant emitters possessing low levels of pollutant treatment.

According to Feifei Sun *et al.* (2017), potent toxic chemicals are released due to waste recycling, which is an important source of air pollution.

FAO has cautioned that serious risks to human health and the global ecosystems are posed due to water pollution and this problem is often underestimated by both the farmers as well as the policymakers. Surprisingly, agriculture is the biggest source of water pollution today in most of the countries, and not cities or industry. In the global scenario, nitrate found in groundwater aquifers produced due to farming activity is the most common chemical contaminant, according to More People, More Food, Worse Water: A Global Review of Water Pollution from Agriculture, launched by FAO and the International Water Management Institute at a conference in Tajikistan (19-22 June,2020).The report also says that modern agriculture is the main cause responsible for large quantities of agrochemicals, organic matter, sediments and saline trading being deposited into the water bodies.

2.3.2. Environmental pollution experienced in agriculture

According to Ikerd (1999), those with strong vested interests in industrialization discourage efforts to document and validate negative linkages between industrial pollution and the natural environment. Thus, the ecological threats to agricultural productivity will remain largely undocumented, unmeasured, unverified and thus uncertain.

According to a study conducted by Agrawal (2003), six hours mean concentrations were monitored for SO2, NO2 and O3 and plant responses were measured in terms of physiological characteristics, pigment, biomass and yield. Parameter reductions in mung bean (*Vigna radiata)*, Palak *(Beta vulgaris*), wheat (*Triticum aestivum*) and mustard (*Brassica campestris*) grown within the urban fringes of Varanasi, India correlated directly with the gaseous pollutant levels. The magnitude of response involved all three gaseous pollutants at a peri-urban site. The study concluded that air pollution could negatively influence crop yield.

Li *et al*.in 2004, have studied that the manufacture, operation, repair and maintenance, and recycling of agricultural irrigation equipment are major sources of air pollution. The compounds produced from these activities, in the dry and windy weather are blown into the atmosphere to form the particulate matter, a major contributor of air pollution.

Solid waste pollutants serve as an external force affecting the physico-chemical characteristics of soil ultimately contributing towards the poor production of crops. (Papa Georgiou, 2006).

Only a small percentage of freshwater is easily accessible, though freshwater makes up 2.5 per cent of the world water resources (Oki and Kanae 2006).

Livestock production and husbandry play a key role in air pollution. Therefore, Weber and Matthews (2008), suggest replacing red meat and dairy products by chicken, fish, eggs, and a vegetable-based diet.

A household"s rational consumption and production behaviors are highly correlated with air pollution (Kamenica *et al.* 2011).

According to a study conducted by Singh *et al*. in 2012, waste water collected from sewages is being widely used for field irrigation, due to the depletion of good quality water.

Prompt drainage at an appropriate time could significantly reduce global paddy-derived methane and nitrous oxide emissions can be significantly reduced by the provision of prompt drainage facilities at an appropriate time (Hou *et al.*2012).

However, studies conducted by Bao *et al.* in 2014 have shown that prolonged usage of sewage water for irrigation, especially in developed countries, results in the transfer of large amounts of heavy metals and persistent organic contaminants to the soil.

The GHG emission in paddy fields can be optimized by appropriate production technology irrigation management (Yang *et al.*2012; Nguyen *et al.*2015).

According to Gilbert *et al.*in 2013, farmers generally have a tendency to apply fertilizers above agronomically recommended rates, due to excessive subsidies on fertilizers and a view to enhance agrochemical use efficiency. A cost-efficient spraying pattern must be

developed to evade the loss during spraying of pesticides and liquid fertilizers. Improving human capital, rationally applying agrochemicals, enhancing pest and disease forecasting and management, developing improved varieties, expanding irrigation land, adopting advanced wastewater treatment technology, optimizing animal feed, and improving livestock housing environment can be used to increase productivity, and in turn reduce the GHG emission.

Government policies promote the utilization of agricultural waste as feedstock to avoid combustive air pollution. Air pollution can be reduced by dietary shift (Carlsso and Kanyama, 2013; Weber and Matthews, 2013; Friel *et al.*2009; Garnett 2014).

Farm population aging is becoming increasingly popular in many parts of the world (Clawson 1963; Davis and Bartlett 2008; Zhong 2011; Burholt and Dobbs, 2012). It is a reflection of not only the changes in fertility and mortality, but also the social consequence of immigration (Davis and Bartlett, 2008; Zhong, 2011; Li and Sicular, 2013).

The aging of the rural labor force will have a significant influence on agricultural production due to the dramatic substitution of machinery and agro-chemicals for human labour. It will indirectly lead to environmental pollution. Air pollution has a chronic and acute negative impact on human health, especially on the elderly (Seaton *et al.* 2015). Thus the vicious cycle continues. Today, both researchers and policymakers face a hounding question as to how to balance food security with the sustainability of agricultural production in an aging world.

About 70 per cent of India's surface water resources and a growing percentage of its groundwater reserves are contaminated by biological, toxic, organic and inorganic pollutants due to mismanaged disposal of industrial effluents and domestic wastes thus rendering the water unsafe for irrigation and farming practices, Pathak *et al.* (2015).

Tanentzap *et al.* (2015) stated that the conflict between agriculture and the environment will be best resolved by policies dedicating high-quality habitat towards nature on environmental impacts. Measures that make farmland itself more benign also called “land-sharing” approaches also deliver local environmental and social benefits.

In Nigeria, environmental pollution due to oil production activity affects the agricultural productivity of the people by causing stunted growth and other adverse effects on the yield of such crops as yam, cassava, and plantains among others, Chigozie *et al.*(2016).

According to Saha *et al.* (2017), soil pollution declines soil productivity and crop diversity. Soil and water pollution has caused 15-20% decline in yield and ruined the traditional agricultural system. Heavy metal, especially Chromium toxicity has led to the replacement of wheat with other hardy shrubs near Kanpur tannery on the banks of the Ganges.

In Indonesia, household trash, diapers, sanitary napkins, dead animals, lamp tubes and glass are mainly dumped in the paddy fields and evokes repulsive emotions in the farmers as they fill the canals and are stranded in the farms and pollute the irrigation water (Sulaeman *et al.*, 2018).

2.3. Vulnerability

2.3.1. Definitions of vulnerability

Liverman (1990), stated that vulnerability "has been related or equated to concepts such as resilience, marginality, susceptibility, adaptability, fragility, and risk""

According to Turner *et al*.in 2003, „vulnerability" can be defined as the degree to which a system is likely to experience harm or damage due to hazardous exposures. In other words, it is the capacity of a system to be wounded. The word „vulnerability" can scientifically pertain to geography, natural hazards research and disaster recuperation studies.

time frame within which all the defensive methods turn futile or are compromised is called the Window of Vulnerability (WOV).

Vulnerability in cases of natural disasters and manmade hazards is a linking concept of environment and people to social forces and the cultural values that help in sustaining and harbouring them. The multi-dimensionality of disasters is expressed here by focusing on the totality of relationships in a social situation under study which combines with the environmental forces, to produce a disaster (Gow, 2005).

The term „vulnerability" is applied in a descriptive manner by natural scientists and engineers whereas social scientists use it in the context of a specific explanatory model (O"Brien *et al*., 2004).

Vulnerability is now a central concept in varied research areas like ecology, public health sector, poverty and development, secure livelihoods and famine, sustainability science, land change, and climate impacts and adaptation. It is conceptualized in very different ways by different knowledge domains (Bharwani, 2011).

Bharwani also stated that vulnerability research is a multidisciplinary and complex field including development and poverty studies, climate studies, public health, engineering, security studies, political ecology, geography, and disaster risk management. Interdisciplinary research on vulnerability is being conducted by Expert Working Groups (EWG) to define and measure vulnerability.

2.3.2. Types of vulnerabilities in environmental disaster management

According to the Office of Disaster Preparedness and Management in 2018, a set of prevailing conditions can adversely affect the community‟s ability to prepare itself for mitigating or for showing timely response to a hazard thus affecting the vulnerability levels. It can also be characterized by the absence of coping strategies. The types of vulnerabilities that affect environmental disaster management are:

2.3.2.1. Physical Vulnerability

An area is physically vulnerable if it has geographical proximity to the source and origin of the disasters and pollution. The areas that are near the coast lines, unstable hills, fault lines, heavily industrialized, highly polluted etc. are more disaster prone than an area far away. It also comprises the difficulty to access water resources, police stations, hospitals, means of communication, transportation, roads, bridges and also exit points in times of disasters. The lack of proper planning and implementation in constructing commercial and residential buildings that are weaker and unsuitable during natural calamities are also the causes for physical vulnerability (Williams, 2016).

2.3.2.2. Economic Vulnerability

The varied sources of income of a society, the ease of access and availability to means of production and capital, the control over means of production like farmland, livestock, irrigation, capital etc. determine the economic vulnerability of a society. It also depends on the adequacy of the fall back mechanisms, economic resilience and the availability of natural resources in an area (Briguglio, 2009).

2.3.2.3. Social Vulnerability

The inability of people, society and organization to resist the damages due to multiple environmental stresses makes them socially vulnerable. The various stressors can be environmental hazards, abuse and social exclusion. These can be due to certain tendencies in their social interactions, institutions and cultural values in a system.

A socially vulnerable community possesses weak family structure, lack of a suitable leader for decision making and to resolve conflicts, weak organization of a community, and a society which differentiates its citizens based on racial, ethical religious, linguistic and religious basis. Culture, religion, norms and values, and political stability also determines the social vulnerability of a community (Fatemi, 2017).

2.3.2.4. Attitudinal Vulnerability

According to Rana (2018), a community that resists change and has a negative attitude towards any forms of modernization and lack initiative in life are more attitudinally vulnerable. This makes them rely more on external support as they cannot act independently. Their livelihood is homogeneous without a variety, is absent in collectivism and lacks entrepreneurship. They are soon bound to become victims of despair, conflict, hopelessness and pessimism, which hinders their capacity of collectively coping up with a natural hazard.

2.3.3 Vulnerability assessment

The assessment of vulnerability can be done specifically for farming systems, populations any geographical location for their exposure levels to different types of climatic shocks and extremes like temperature, sea level rise and rainfall on a spatial and temporal plane. But

depending upon the way the concept is treated, the way the concept is approached varies (Devi *et al.*, 2014).

According to the IPCC in 2019, vulnerability has three components namely exposure, sensitivity and adaptive capacity.

2.3.3.1. Exposure

The exposure is the state of being unprotected from something harmful. i.e. the factor/s (its magnitude and/ or frequency) that causes the stress on the system. It may be represented as either long-term changes in environmental conditions, or by changes in environmental variability, including the magnitude and frequency of extreme events (IPCC, 2001). There are two main elements to consider in exposure. Things that can be affected by environmental change (populations, resources, property, and so on) and the change in environment itself.

2.3.3.2. Sensitivity

Sensitivity is the degree to which a system is modified or affected by an internal/ external disturbances or a set of disturbances (Gallopin, 2003). It is the degree to which a system will be affected by, or responsive to climate stimuli (Smith et al., 2001).It is the responsiveness of the system to the exposure. Sensitivity is basically the biophysical effect of climate change, but it is also influenced by the by socio- economic changes.

2.3.3.3. Adaptive capacity

Adaptive Capacity refers to the potential or capability of a system to adjust to climate change, including climate variability and extremes, so as to moderate potential damages, to take advantage of opportunities, or to cope with consequences (Smit and Pilifosova, 2001).

As the name suggests, adaptive capacity is the capability of a system to adapt to impacts of climate change.

The effect of exposure and sensitivity on vulnerability, in general is direct while that of

adaptive capacity is inverse. In other words, the greater the exposure or sensitivity, the

greater is the vulnerability. Therefore, reducing vulnerability would involve reducing

exposure through specific measures or increasing adaptive capacity Gbetibouo and Ringler (2009).

2.3.4. Vulnerability Index

A vulnerability index is the measure of exposure of a population to some hazard. The index is a composite of multiple quantitative indicators that via some formula, delivers a single numerical result. Diverse issues in varied fields can be combined through an index into a standardized framework. For instance, physical sciences, psychology and medical sciences can be combined in vulnerability assessment of disaster planning (O"Connor, 2011).

In 2001 International Policy on Climate Change (IPCC) accepted vulnerability as one of its key categories. They developed a vulnerability indexing model to analyze the vulnerability of a US coastal community to the rising sea levels.

The “Climate Vulnerability Index” was presented in Oxford in 2008, to protect the tourist economies which could prove beneficial to the small island states. Vulnerability indices were also accepted as governance tools. Vulnerability assessments heavily depend on the availability and reliability of data, the extent, rating and scale of the indicators of vulnerability, and the interpretation of "vulnerability" (Wirehn, 2017).

2.4. Adaptation mechanisms against environmental pollution

Resilience is defined as "the propensity of a system to retain its organizational structure and productivity following a perturbation" (Holling 1973).

Even if challenged by severe drought or by a large reduction in rainfall, a resilient agroecosystem will continue to provide vital service such as food production. In agricultural systems, stress and resilience can be linked by crop biodiversity, because diversity of organisms is required for the functioning and to provide the services (Heal, 2000). Removing entire trophic levels or entire functional groups of species can cause a shift in ecosystems to an undesirable state, affecting their capacity to generate ecosystem services. This effect highlights the possibility that agricultural systems may be already existing in an undesirable state to continuously provide ecosystem services (Folke *et al*., 2004).

Crop diversification is an integral resilience strategy for agroecosystems is crop diversification. Agricultural systems possess enormous diversity, and there are various forms of diversification, (genetic variety, species, structural) and over different scales like crop, field and landscape level, giving farmers a lot of options to implement this strategy. Diversification at the within-field scale may be represented by trap crops or natural enemy habitat planted between and around the fields. At the landscape scale, diversification is the integration of multiple production systems, such as mixing agroforestry management with cropping, livestock, and fallow to create a highly diverse piece of agricultural land (Gurr *et al*., 2006). Diversity can be both temporal and spatial.

Crop diversification improves resilience by providing a greater ability to suppress pest outbreaks and pathogen transmission, and by buffering crop production from the effects of extreme environmental pollution. But the adoption of crop diversification is hindered by the provision of economic incentives for a few selected major crops, the push for biotechnology strategies, and the belief that monocultures are more productive. Therefore, crop diversification has to be implemented in such a way that farmers can choose strategies that increases resilience as well as provides economic benefits (Altieri, 2006).

In China, the Ministry of Agriculture formally launched the Action Plan for Pollution- free Agricultural Products (APPAP) in 2001, which now acts as the compulsory agri-food standard in China. Action Plan for Pollution- free Agricultural Products is now managed as a certification scheme. The APPAP is implemented by MoA, while it is enforced by the

agricultural departments at various government levels. Practical and applicable plans are worked out by the local governments to enforce the APPAP according to the local situation.

The main objective of the APPAP is to establish a sound system to inspect and control the whole process of agricultural production and marketing for food safety needs and to also improve the agri-food safety in China (Zhang, 2014).

Pollution-free food (also known as "hazard-free" or "no public harm" food) is characterized as being of good quality, nutritious and safe and abstains from the presence of harmful or toxic residues, such as fertilizers, pesticides, heavy metals, and nitrates. The chemical residues are controlled within limits set by national standards (Huang *et al.*, 2014).

In pollution-free farming, vegetable farming plays a major role in pollution-free farming. Vegetable farming is characterized with complex crops rotation, short growth cycle, more disease and insect pests, and high-water demand. Therefore, pollution free vegetable cultivation, to ensure safe consumption requires elaborate safety control. Farmers" knowledge of cultivation and management of vegetables is also essential. Pollution-free vegetable farming (PFVF) must be sped up to meet domestic consumers" increasing demand but also strengthen international competition in the vegetable industry sector (Xiong, 2016).

2.5. Constraints experienced by farmers

Reiff in 1987 made some important discussions about the impact of agriculture on water quality. He found out that there is strong evidence of an increase in the incidence of malaria due to reservoir construction for irrigation (particularly in Latin America). Schistosomiasis infects two hundred million individuals all over the world in 70 tropics and subtropics. Farmers and children who bathe in infected water are more vulnerable.

The incidence of cancer is generally low in agricultural workers, but according to some studies certain types of cancers prevail more commonly. These cancers that are found more frequently in farmers include leukemia (cancer of white blood cells), multiple myeloma (cancer of plasma cells in bone marrow), non-Hodgkin"s lymphomas (NHL), and skin, prostate, brain, lip, and stomach cancer. This is mainly because farmers and agricultural labourers are exposed to a number of pesticides and other chemicals that increase the probability of cancer in them. People living in the proximity of farms are indirectly exposed to these harmful chemicals. These chemicals can also contaminate air by becoming a part of dust particles (Blair, 2002).

Most of the economies based on agriculture have few other livelihood strategies (Tilman *et al*., 2002), and small family farms have little capital to invest in expensive and labour requiring environmental pollution adaptation strategies. As a result, the vulnerability of rural agricultural communities to a changing environment is increased. The research community is facing the challenge of developing resilient agricultural systems using rational and affordable strategies in a way that ecosystem functions and services are maintained and livelihoods are protected.

According to Zhang (2011), non-point source pollution are also the causatives for serious health threats. Diseases that are commonly caused due to microbial contamination include typhoid, cholera, ascariasis (caused by *Ascaris lumbricoides*), amoebiasis (*Entamoeba histolytica*), giardiasis (*Giardia lamblia*), and *Escherichia coli*.Mostly these diseases are caused due to the consumption of ground crops such as cabbage, carrots, or strawberries. Inhalation of antigens like organic dust causes hypersensitivity reactions in the lungs called hypersensitivity pneumonitis (allergic alveolitis) or alveolar inflammations. This disease is very common among farmers.

According to a study conducted by Dhongre in 2012, in the Vidarbha region of Maharashtra, the main reasons as perceived by farmers for farmer suicides are debt, addiction, environmental problems, poor prices for farm produce, stress and family responsibilities, government apathy, poor irrigation, increased cost of cultivation, private money lenders, use of chemical fertilizers and crop failure. Participants suggested solutions such as self-reliance and capacity building among farmers, a monitoring and support system for vulnerable farmers, support and counseling services, a village-level, transparent system for the disbursement of relief packages.

Regulating environmental pollution in agriculture is a daunting task as it is not always easy to identify sources of nonpoint source pollution. Secondly, policies to reduce pollution are not in direct compliance with the massive subsidization of the agriculture sector in rich countries. Efforts to reform subsidy regimes have proved to be futile because subsidies create „economic rents" to which farmers adhere, sometimes even declaring they have some „right" to subsidies (Zhang, 2012).

. The over-use of pesticides and chemical fertilizers needed to successfully grow the genetically modified seeds are depleting the nutrients in soil. The consequence of this is the loss of land productivity and the future generations of farmers at even greater risk of poverty. According to the study, participants suggested the promotion of organic farming and reducing the usage of chemical fertilizers, pesticides, and genetically modified seeds (Behere, 2013).

In rural China, chronic pesticide exposure was associated with suicidal tendencies, which supports findings from previous studies. Given the high level of suicide risks, a development of appropriate interventions must be the top priority for public health and health policy (Behere, 2013).

Farmers stand a chance of higher risk of respiratory disease compared with other occupational groups, as they tend to be exposed to a high concentration of hazardous substances (Karjalainen *et al.* 2003; Bang *et al.* 2006; Lovelock 2012).

The first study that assessed the environmental effect on farm productivity, conducted by Zivin and Neidell in 2013 found out that a 10 ppb increase in average ozone exposure would lead to a 5.5 per cent decrease in worker productivity. Therefore, air pollution might consequently result in a reduction in farmers‟ productivity or change their working time and thus, as a result affect agricultural production.

One of the most severe barriers to rice production in many parts of the World, especially South Asia is land constraints. A severe hindrance for rice cultivation in both South Asia and Sub-Saharan Africa are limited water supplies that are unpredictable in nature ,and unsanitary fields are frequently considered more severe for root crops than the cereals which are more susceptible to various abiotic constraints (Reynolds *et al.*,2015).

The primary concerns of agricultural producers in the process of production are about their product output, and environmental pollution is of least importance as it will not cause any economic loss. Agricultural products with residues of chemical pesticides are generally sold on the markets. As pesticides, fertilizer and plastic film bring about an increase in production, farmers will not reduce or eliminate the use of pesticides, fertilizer and plastic film voluntarily (Van Maele-Fabry *et al*., 2016).

Agricultural producers are in the pursuit of personal interests that create an increase in production. The increased cost of chemical inputs is less than productive gains. Therefore, producers will continue to incrementally use them. Government is concerned about the public interest, concerns for environmental pollution control. Government and agricultural producers have inconsistent goals (Van Maele-Fabry *et al*., 2016).

According to cost-benefit analysis, Yang (2006) compared the prices of pollution-free vegetables and traditional vegetables, and found that pollution-free vegetables cost 40 per cent higher than traditional vegetables. An earlier survey in China showed that the profits of pollution-free tomatoes and celeries were separately 44.1 per cent and 12.4 per cent lower than those of traditional tomatoes and celeries (Liu, 2004). As far as developed countries are concerned, several studies supported the idea that farmers adopted the techniques followed in intensive farming.

Zhang (2011) also found that although input costs of pollution-free vegetables were higher than that of traditional vegetables, the profits of pollution-free vegetables were still higher due to higher production and price.

„Farmer"s lung" or „farmer"s hypersensitivity pneumonitis (FHP)" is a disease that is caused mainly due to the inhalation of agriculturally produced dusts like mold spores, straw, feed, and hay dusts. Specific allergen causatives of „Farmer"s lung" are spores of *Micropolyspora faeni, Saccharopolyspora rectivirgula, Aspergillus* species, and Thermophilic actinomycetes. Long-term exposure to antigens of FHP can cause fibrotic changes in lungs and subsequently cause emphysema (Sforza, 2017).

Agriculture plays a major role in the determination of water quality. The polluted water is the breeding ground for several waterborne diseases. According to the World Health Organization (WHO) in 2018, about four million children die each year due to diarrhea, a waterborne disease. Due to poor water management, coliform bacteria present in human excrement gets mixed in drinking water leading to diarrhea.

The UNDP in 2006 reported that more than 60 per cent of the people of Nigeria were dependent on the natural environment for their livelihood. The principal food source is the environmental resources base, which is used for agriculture, fishing, and the collection of forest products. Oil spills, waste dumping, and gas flaring are hazards that are endemic to this area and have tormented the area for decades, damaging the soil, air, water, and quality of life. The poorest and most vulnerable rural marginal farmers who rely mainly on traditional occupations such as fishing and agriculture are most likely to be affected. (Chigozi, 2019).

2.6. Detrimental effects of pollution in agriculture

Developing countries like Nigeria have depleted much of their habitable environment due to environmental degradation and pollution. Due to pollution, crops and aquaculture have been destroyed through the contamination of waterways, ground water, and soil. It also causes flaring of associated gas. The mismanagement of the land resources is also rampant. These negatively impact the crop yield and land productivity, which results in further impoverishment the already poor farmers in such places and farmers have been forced to seek non-existent alternative means of livelihood by abandoning their lands (Chigozi, 2009).

Atmospheric pollution might prove fatal to agricultural production in turn. For example,sulfates, nitrates, dusts, and heavy metals which are toxic air pollutants can accumulate in the food chain by diffusion, settling, and precipitation. These subsequently harm plants and animals (McCormick 1989; Nagajyoti *et al.*2010).

An increase of 100 unit in AQI (Air Quality Index) decreases the prices for Chinese cabbage and tomatoes by 1.19 per cent and 0.89 per cent, respectively, whereas an increase of 100 $\mu g/m^3$ in PM 2.5 concentration decreases the prices of Chinese cabbage and tomatoes by 0.64 per cent and 0.55 per cent respectively. The preceding analysis concluded by demonstrating that in the long term, though air pollution may have a minor impact on food demand, it may cause a considerable reduction in food supply (Gibson and Kim, 2012).

Air pollution affects both the demand and supply of food. It would ultimately embody food price changes through market equilibrium shift. Using daily price data from the outdoor wholesale market in Beijing, Sun *et al. (*2017) found that air pollution can significantly reduce vegetable prices, but it has no significant impact on the prices of pork.

Livestock farming, which is a major and prevalent form of farming in pastoralism based Northern and North central regions of Nigeria also has a major polluting impact on the land. Trampling and compaction of the soil are the major problems faced due to heavy grazing of cattle, thus reducing its water holding capacity and simultaneously altering the physical properties. Also, a major problem due to this is the washing away of these fecal matter into the streams and rivers, which are a source of drinking water during rainy seasons. These can be the cause for outbreaks of waterborne diseases and health hazards like typhoid, cholera *etc* (Chigozi, 2019).

2.7 Perspective and awareness of the farmers about environmental pollution

A study was done by Islam *et al.*, in 2014 among eighty farmers of AshrafpuVillage under Meherpur district of Bangladesh to determine the farmer's awareness on environmental degradation. Modern agricultural technologies were used by exploring the relationships between ten selected characteristics of the farmers and their awareness. The study concluded that among these eighty respondents 37.5 per cent had low, 51.25 per cent respondents had medium and only 11.25 per cent of the respondents had high knowledge about modern agricultural technologies. While 35 per cent respondents had low, 55 per cent respondents had medium and only 10 per cent had high knowledge about environmental degradation. Among the respondents 25 per cent had poor, 61.25 per cent respondents had medium and only 13.75 per cent had high awareness about environmental degradation caused by the use of modern agricultural technologies.

From generations of experimentation and experiences in their local conditions, farmers have acquired knowledge. Yet many farmers around the world lack knowledge regarding scientific approaches which is evident in their farmers‟ soil knowledge (FSK) and site-specific soil information (Bicalho, 2016).

The soil variability within their farms and fertility differences are identified and understood by the farmers, but FSK is deficit in identifying yield-limiting nutrients. Thus FSK in complementation with scientific soil knowledge must be utilized in site-specific soil management practices (MINECOFIN, 2017).

According to a study conducted on the awareness of farmers on diffuse water pollution and the steps taken by them to mitigate it, a conclusion was reached wherein though public efforts to create awareness in farmers is important, awareness alone is not sufficient to improve health and resilience of the socio-economic systems. Farmers must also engage in environmental management action strategies and have a deeper understanding of the consequences. Creation of tacit knowledge and understanding the ways to mitigate diffuse water pollution through experiential learning can create new values (Chigozi,2018).

To take scientific control to manage the pollution, understanding the behavior of farmers is highly essential. According to the theory of planned behavior (TPB) the farmers" attitudinal behaviour (AB), subject norm (SN) and perceived behavioural control (PBC) significantly and positively influenced their environmental behaviour. SN was considered to be the key factor,that directly influenced farmers attitudes, but PBC had no direct effect. The relation between PBC and environmental intention could be negatively moderated by environmental knowledge. PBC showed a greater impact on the environmental intention on poor environmental knowledge possessing farmers, compared to those with plenty environmental knowledge (Hall, 2019).

2.8. Management strategies

Cereal cropping systems can be diversified by alternating crops, such as oilseed, pulse, and forage crops. This is an effective strategy for managing plant disease risk (Krupinsky *et al*. 2002). Disease cycles can be interrupted through crop rotation by interchanging cereal crops with legumes and broadleaf crops that are not susceptible to those diseases. Soil biodiversity could be enhanced by reduced tillage, that results in greater disease suppression, and the density of the crops are adjusted in such a way, so as to allow for better microclimatic adjustments to ward away disease growth.

Undiluted animal manure is hundred times more pathogenic than industrial sewage that contains *Cryptosporidium*, *an* intestinal parasite. The right manure management system can prevent hazards due to this. Composting, anaerobic digestion of liquid animal wastes, biological treatment lagoons to break down solid wastes etc. are the other effective ways to manage pollution due to manures and are also found to considerably reduce GHG emissions (USDA, 2006).

The USDA also concluded that agriculture carried out to produce according to necessity without infringing the sustenance of future generations for the same is sustainable agriculture. Several scientists have laid claims that the lower yields associated with global warming can support the ever exponentially booming population. Agriculture can also adversely affect biodiversity as well. Organic farming is a component of sustainable agriculture and is associated with lower nutrient losses, ammonia emissions, leaching ofnitrogen and emissions of nitrogen oxides. It has 30 per cent more species richness and 50 per cent more organisms than conventional farming.

The government must set regulations on the amount of pesticides to be used per acre of land, thus bringing a control on the amount of pesticide utilized. The government should also implement a registration system wherein each family must compulsorily register for the purchase of pesticides. Families must be allowed to purchase pesticides based on the area of their land holdings and any excess purchase of pesticides should be banned. Plastic films and chemical fertilizers must also be banned accordingly (Suri and Choubey, 2011).

Agricultural markets selling pollution-free products can help build pollution free markets where the price of the commodities must be increased to make up for the increased pollution-free production costs. A logo must also be posted on the pollution-free products to make the consumers aware (Zhang, 2011).

CHAPTER 3.

METHODOLOGY

Research methodology has been defined as the systematic and theoretical analysis of the procedures applied in the field of study. Methods and procedures followed in the study to obtain rational, logical and meaningful inferences are described in this chapter. In order to accomplish the objectives of the study, appropriate data collection tools and analytical methods were employed and the details are presented under the following subheads.

3. 1 Research design

3.2 Locale of the study

3.3 Selection of the respondents

3.4 Measurement of independent variables

3.5 Measurement techniques

3.6 Measurement of dependent variable

3.7 Data collection procedure

3.8 Statistical tools used in the study

3.1 Research design

Ex post facto research design was used in the present research. Ex post facto research is the causal comparative method of determining the possible antecedents of events, or independent variables that have already occurred and hence, cannot be manipulated by the researcher.

3.2. Locale of the study

Thrissur and Palakkad districts were purposively selected for the study since there are a large percentage of farmers in these two districts and are the major producers of paddy, banana and vegetables in Kerala state. Three major crops taken by farmers of Kerala will be selected for the study, namely rice, vegetables and banana. For rice-based systems, Puzhakkal Kole area Panchayath from the 29 Kole area Panchayaths of Thrissur district and Alathur, a major rice growing Panchayath from 70 rice growing village Panchayaths of Palakkad district were randomly selected for the study. For vegetables and banana, two major banana growing Panchayaths viz, Puthur and Pananchery and two major banana cultivating Panchayaths viz., Nadathara and Madakkathara of Thrissur district were randomly selected in similar fashion.

3.3. Selection of the respondents

From each agricultural system, 30 farmers (15 farmers from each Panchayath) and 30 other stakeholders comprising of administrators, development personnel, local governance, general public and NGOs from Thrissur and Palakkad districts were interviewed. The total sample size does not exceed 120. The farmers were randomly chosen after discussing with respective agricultural officers.

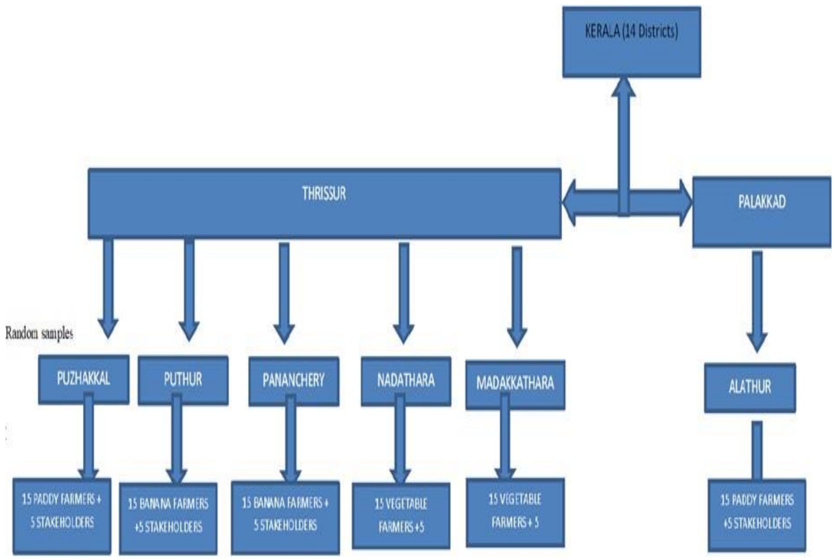


Figure 1 Flowchart for selection of Panchayaths and respondents

3.4. Measurement of independent variables

By reviewing the past studies and consulting the subject experts, eleven independent variables were identified. The selected variables are as follows

3.4.1 Age

3.4.2 Education

3.4.3 Experience of farming

3.4.4 Size of land holding

3.4.5 Occupation

3.4.7 Water source

3.4.8 Proximity to industrial area

3.4.9 Mass media contact

Sl. No.	Independent variable	Scale used
1	Age	Scale developed by Chaudhury, 2013
2	Education	Scale followed by Nargave (2016) with due modification
3	Experience of farming	Scale developed by Mohapathra and Rath, 1997
4	Size of land holding	Scale developed by Pandya (2010) with modification
5	Occupation	Scale developed by Mohapathra and Rath, 1997
6	Water source	Scale developed by Salman (2019) and modified
7	Proximity to industrial area	Scale developed by Kumar, 2013
8	Massmediacontact	Scale used by Chaudhury, 2013

3.4.1 Age

The number of years completed by the respondent at the time of conducting the interview constituted the age. Based on their ages, the respondents were classified into four categories viz, ‘Up to 40 years’, ‘41-50 years’, ‘51-60 years’ and ‘more than 60 years’. To calculate the relationship of age with the dependent variables, the categories were scored 1, 2,3 and 4 respectively (Scale developed by Chaudhury, 2013). The variable is described by frequency distribution and percentages.

Sl. No.	Categories	Score
1	Up to 40 years	1
2	41-50 years	2
3	51-60 years	3
4	>60 years	4

3.4.2 Education

Education is the process of receiving or systematic instruction, conducted especially at a school or university. In the present study, the operationalization of the variable was done based on the number of years of formal education received by the respondents. Based on the scale developed by the respondents were categorized into 5 categories viz, ‘Illiterate’, ‘Primary’, ‘High school’, ‘Higher secondary’, ‘Graduation and above’ with scores of 0,1,2,3,and 4 respectively (Scale developed by Nargave, 2016). The variable is described by frequency distribution and percentages.

Sl. No.	Categories	Score
1	Illiterate	0
2	Primary	1
3	High school	2
4	Higher secondary	3
5	Graduation and above	4

3.4.3 Experience of farming

It indicates the number of years the respondent has engaged himself in agriculture. Based on the experience of farming the farmers are categorized into ‘less than 5 years’, ‘5-10 years’, and ‘10-20 years ’, ‘20-30 years’, ‘30-40 years and more than 40 years' with scores of 0, 1, 2, 3, 4 and 5. This scale was developed by Mohapathra and Rath in 1997. The variable is described by frequency distribution and percentages.

Sl. No.	Categories	Score
1	<5 years	0
2	5-10 years	1
3	10-20 years	2
4	20-30 years	3
5	30-40 years	4
6	>40 years	5

3.4.4 Size of land holding

This is one of the most important variables which describes the social as well as economic status of a farmer. The operational definition of the variable was the number of hectares possessed by the farmer. The size of land holdings were categorized into four, viz, 'Marginal' (< 1 ha), 'Small' (1-2 ha), 'Medium' (2-10 ha), and 'Large' (>10 ha). The variable is described by frequency distribution and percentages.

Sl. No.	Category	Score
1	Marginal (< 1 ha)	1
2	Small (1-2 ha)	2
3	Medium (2-10 ha)	3
4	Large (>10 ha)	4

3.4.5 Occupation

In the present study, occupation is the major source from which the respondents sustain their livelihood by earning. They are classified into five categories viz, ‘Agriculture’, ‘Business’, ‘Service’, ‘Other’ and ‘Agriculture allied’ occupation and each category was scored 1, 2, 3, 4, and 5 respectively (Mohapathra and Rath, 1997).

The variable is described by frequency distribution and percentages.

Sl. No.	Occupation	Score
1	Agriculture	1
2	Business	2
3	Service	3
4	Other	4
5	Agriculture allied	5

3.4.6 Water source used by the farmer

The water source used by the farmer which is committed for food production and collection of further resources. Rain water, well, canal, stream and tubewell were assigned scores of 1, 2,3,4,and 5 respectively . This scale was developed by Salman in 2019, and was used with due modification. The variable is described by frequency distribution and percentages.

Sl. No.	Water source	Score
1	Rain water	1
2	Well	2
3	Canal	3
4	Stream	4
5	Tube well	5

3.4.7. Proximity to industrial area

The proximity of the farm to an industrial area was operationalized as the kilometres from the farm to the nearest industry. The respondents were categorized in to four groups based on the distance to an industry (Scale developed by Kumar, 2013). The variable is described by frequency distribution and percentages.

Sl. No.	Distance from industrial area	Score
1	<1 km	0
2	1-3 km	1
3	3-6 Km	2

4	>6 km	3

3.4.8. Mass media contact

This is the frequency with which the respondents read farm magazines and other literature pertaining to agriculture (pamphlets, leaflets, folders etc.) and newspapers in addition to radio and television (Scale used by Chaudhury, 2013).

The quantification of the variables was done by assigning the scores as given in Table. The variable is described by frequency distribution and percentages.

Sl. No.	Category	Score
1	Regularly	3
2	Frequently	2
3	Occasionally	1
4	Never	0

On the arbitery basis, the respondents were categorized into the following four categories based on frequency of using different mass media

Sl. No.	Category	Category classification	Score
1	No mass media contact	0	0
2	Low mass media contact	1-7	1
3	Medium mass media contact	7-9	2
4	High mass media contact	>9	3

3.5 Measurement techniques

3.5.1 Types and extent of environmental pollution faced in different agricultural systems

There are mainly three types of pollution that adversely affect the agricultural systems, viz, water pollution, soil pollution, and air pollution. In order to find the types and extent of water pollution, soil and air pollution faced by agricultural systems based on farmers' responses, a list of nine, ten and nine statements were used for water, soil and air pollution respectively (Mohapathra and Rath, 1997). The farmer respondents were asked to indicate their responses as given below in Table

Sl. No.	Response category	Score
1	Highly disagree	1
2	Disagree	2
3	Undecided	3
4	Agree	4
5	Highly agree	5

After recording the responses of the farmers, the total score as well as an index for all the statements were calculated. To find the extent of water, soil and air pollution in each agricultural system, the index of each statement as well as the mean index were calculated.

$$\textit{Index of each statement} = \frac{\textit{total score of each statement}}{\textit{Maximum score of each statement}} \times 100$$

The extent of water pollution in all the six agricultural systems was then categorized into three categories by taking the Mean and Standard Deviation. The categories are as shown in Table

Sl. No.	Extent of pollution	Criteria
1	High	More than Mean + 1 S.D
2	Moderate	In between Mean +/- 1 S.D
3	Low	Less than Mean – 1 S.D.

3.5.2 Ill effects of pollution as perceived by the stakeholders

The ill effects due to environmental pollution on agriculture can be categorized as due to three, viz, 'Ill effects due to agri-intensive cultivation' consisting of 12 statements, 'Ill effects due to integrated farming of crops with livestock' with 7 statements and 'ill effects due to threat to human health by farming system practices' consisting of 9 statements (Mohapathra and Rath, 1997). The responses from the stakeholders of each farming system were recorded as shown in Table

Sl. No.	Response categories	Score
1	Strongly Agree	5
2	Agree	4
3	Undecided	3
4	Disagree	2
5	Strongly Disagree	1

The total score for each respondent was computed by summing the scores of all the statements in each category and the index was found for each respondent. Overall index was also found by using the sum of the three categories.

***Index of each respondent = total score of each respondent* X 100**

Maximum score of each respondent

The extent of ill effects faced by the farming system based on stakeholder perception is as shown in Table

Sl. No.	Category	Criteria
1	High	More than Mean + 1 S.D
2	Moderate	In between Mean +/- 1 S.D
3	Low	Less than Mean – 1 S.D.

3.5.3. Awareness of the farmers about the causes and impact of environmental pollution on agricultural systems

In order to find the awareness of the farmers about the causes and impact of environmental pollution on agricultural systems based on farmers' responses, a list of eight and nine statements prepared by Chaudhury in 2013 were used for causes and impact of environmental pollution on agricultural systems respectively. The farmer respondents were asked to indicate their responses as given below in Table

Sl. No.	**Response Category**	**Score**
1	Unaware	0
2	Made aware by friends	1
3	Made aware by mass media	2
4	Made aware by experience	3

Further, in order to find the extent of awareness of the farmers about the causes and impact of environmental pollution on agricultural systems, The total score for each farmer respondent was also computed by summing the scores of all the statements in and the index was found for each respondent farmer.

$$\text{Index of each farmer} = \frac{\text{total score of each farmer}}{\text{Maximum score of each farmer}} \times 100$$

The farmers were categorized into three categories using Mean and Standard deviation as shown in Table

Sl. No.	Awareness Category	Criteria
1	High	More than Mean + 1 S.D
2	Moderate	In between Mean +/- 1 S.D
3	Low	Less than Mean – 1 S.D.

3.5.4 Level of exposure, sensitivity and adaptive capacity of each agricultural system

In order to find the level of exposure, sensitivity and adaptive capacity of each agricultural system based on farmers' responses, a list of nine, seven and four statements were used for exposure, sensitivity, and adaptive capacity respectively (Raghuvanshi and Ansari, 2019).

The farmer respondents were asked to indicate their responses as given below in Table .After recording the responses of the farmers, the total score as well as an index for all the statements were calculated. To find the level of exposure, sensitivity and adaptive capacity of each agricultural system, the index of each statement as well as the index mean were considered.

The level of exposure, sensitivity and adaptive capacity in all the six agricultural systems was then categorized into three categories by taking the Mean and Standard Deviation as shown in Table .

Index of each statement = total score obtained by the statement

$$\text{Index of each statement} = \frac{\text{total score obtained by the statement}}{\text{Maximum possible score of the statement}} \times 100$$

Sl. No.	Response categories	Score
1	Strongly Agree	5
2	Agree	4
3	Undecided	3
4	Disagree	2
5	Strongly Disagree	1

The total score for each farmer respondent was also computed by summing the scores of all the statements in each category and the index was found for each respondent, which was used to compare the different agricultural systems based on exposure, sensitivity, and adaptive capacity levels.

$$\textit{Index of each farmer} = \frac{\textit{total score of each farmer}}{\textit{Maximum score of each farmer}} \times 100$$

3.5.6 Vulnerability status of the farmers of different agricultural systems

A vulnerability index can be computed using exposure index, sensitivity index and adaptive capacity index of each farmer. The formula to calculate vulnerability index is,

Vulnerability index = Exposure index + Sensitivity index – Adaptive capacity index

The farmers can be classified into three categories based on the vulnerability of their agricultural systems to the ill effects of environmental pollution using vulnerability index by Mean and Standard Deviation as shown in Table

Sl. No.	Category	Criteria	Score
1	High	More than Mean + 1 S.D	2
2	Moderate	In between Mean +/- 1 S.D	1
3	Low	Less than Mean – 1 S.D.	0

3.5.7. Constraints expressed by the farmers

With respect to the different constraints expressed by the farmers, a list consisting of 7 statements was prepared in consultation with experts in related field (Vaidya, 2004).

Based on the degree of importance, the respondents were asked to score the statements on a 6 point scale as shown in Table

Sl. No.	Response categories	Score
1	Not at all important	0
2	Least important	1
3	Less important	2
4	Important	3
5	More important	4
6	Most important	5

The total score and index of the farmer respondents for each agricultural system was computed separately. Ranking was done in order to find out the major constraints faced by the farmers in mitigating the effects of environmental pollution.

3.5.8. Suggestions and recommendations to the farmers

With respect to the different aspects of the control and remediation of environmental pollution, a list consisting of 11 statements was prepared in consultation with experts in related field (Mohapathra and Rath, 1997). Based on the degree ofimportance, the respondents were asked to score the statements on a 6 point scale as shown in Table

Sl. No.	Response categories	Score
1	Not at all important	0
2	Least important	1
3	Less important	2
4	Important	3
5	More important	4
6	Most important	5

The total score and index of the farmer respondents for each agricultural system was computed separately. Ranking was done in order to find out the importance of the statements.

3.6 Measurement of dependent variable

The dependent variable is 'Vulnerability'.

It is operationalized as the degree to which a system is susceptible to, or is unable to cope up with the adverse effects of environmental pollution, including environmental extremities and variability. It is a function of the character, magnitude and the rate of environmental pollution and variation to which the system is exposed (four statements were used for exposure), its, sensitivity, and its adaptive capacity. The effect of exposure and sensitivity on vulnerability, in general is direct while that of adaptive capacity is inverse. In other words, the greater the exposure or sensitivity, the greater is the vulnerability. Therefore, reducing vulnerability would involve reducing exposure through specific measures or increasing adaptive capacity Gbetibouo and Ringler (2009).

3.6.1 Exposure

The exposure is the state of being unprotected from something harmful. i.e. the factor/s (its magnitude and/ or frequency) that causes the stress on the system.

It may be represented as either long-term changes in environmental conditions, or by changes in environmental variability, including the magnitude and frequency of extreme events (IPCC, 2001).

3.6.2 Sensitivity

Sensitivity is the degree to which a system is modified or affected by an internal/ external disturbances or a set of disturbances (Gallopin, 2003). It is the degree to which a system will be affected by, or responsive to climate stimuli (Smith et al., 2001).It is the responsiveness of the system to the exposure. Sensitivity is basically the biophysical effect of climate change, but it is also influenced by the by socio-economic changes.

3.6.3 Adaptive capacity

Adaptive Capacity refers to the potential or capability of a system to adjust to climate change, including climate variability and extremes, so as to moderate potential damages, to take advantage of opportunities, or to cope with consequences (Smit and Pilifosova, 2001).

In order to find the level of exposure, sensitivity and adaptive capacity of each agricultural system based on farmers' responses, a list of nine, seven and four statements were used for exposure, sensitivity, and adaptive capacity respectively

(Raghuvanshi and Ansari, 2019). The farmer respondents were asked to indicate their responses as given below in Table

Sl. No.	Response categories	Score
1	Strongly Agree	5
2	Agree	4
3	Undecided	3
4	Disagree	2
5	Strongly Disagree	1

The respondents were asked to rate the statements representing selected dimensions with scores of 1,2, 3, 4 and 5, which was reversed for negative statements. The total score of each farmer was used to calculate the index of each statement .The following formula was used for calculating the index:

$$\textit{Index of each farmer} = \frac{\textit{Total score of each farmer}}{\textit{Maximum possible score of each farmer}} \times 100$$

$$\textit{Composite index} = \frac{\sum X}{M \times N \times S}$$

$\sum X$ = sum of total scores of all farmers

M = Maximum possible score of each farmer

N = Number of farmers

S = Number of statements

A vulnerability assessment done on the basis of this definition has indicators representing the index can be computed using exposure index, sensitivity index and adaptive capacity index of each farmer. The formula to calculate vulnerability index is,

Vulnerability index = Exposure index + Sensitivity index – Adaptive capacity index

The farmers can be classified into three categories based on the vulnerability of their agricultural systems to the ill effects of environmental pollution using vulnerability index by Mean and Standard Deviation as shown in Table

Sl. No.	Category	Criteria	Score
1	High	More than Mean + 1 S.D	2
2	Moderate	In between Mean +/- 1 S.D	1
3	Low	Less than Mean – 1 S.D.	0

3.7 Data collection procedure

3.7.1 Instruments used for the study

With a regard to the objectives of the study, a detailed interview schedule was prepared in consultation with the major advisor. A pilot study was carried out with twenty paddy farmers from Wayanad district as the respondents, and the prepared interview schedule was administered. The responses from the respondents were evaluated and based on this, modifications were made in the interview schedule. The modified interview adopted for the study is given in Annexure II.

3.7.2 Method of data collection

For primary data collection, the pretested interview schedule was administered individually to the respondents consisting of farmers, and other stakeholders comprising of Agricultural Officers, local governance members, Development

Officers, NGO's and general public. It was ensured that the questions were comprehended accurately by the respondents.

Secondary data will be collected from literature in the form of journals, annual reviews, office records, internet and textbooks.

3.8 Statistical frame work for analysis of data

3.8.1 Arithmetic mean

It is defined as the sum of all values of observations divided by the total numberof observations. Symbolically represented as X.

3.8.2 Standard deviation

It is the positive square root of the mean of the squared deviations taken from arithmetic mean. It is represented by σ.

3.8.3 Frequency and percentages

Frequency distribution and percentages were used to know the distribution pattern of respondents according to variables. Percentages were used for standardization of sample by calculating the number of individuals that would be under the given category.

3.8.4 Kendall's coefficient of concordance (W)

It was used to determine the association among K sets of rankings. To compute 'W'the sum of ranks (Rj) in each column of a K/N table is found out. W is computed using the formula,

$$W = \frac{12S}{K^2(N^3 - N)}$$

S = sum of squares of the observed deviations from the mean of Rj.

Where, **S=** $\sum$ **Rj** $-\sum$**Rj** ^{2}

—

N

Where,

K= Number of rankings

N= no of entities or objects ranked

3.8.5 Kruskal – Wallis one way analysis of variance by ranks

The Kruskal-Wallis one way analysis of variance by ranks is used to determine whether k independent samples are from different populations for at least ordinal level of measurements. It tests the null hypothesis that the k samples come from the same population or from identical population with respect to averages

$$\sum (\quad)$$

k = number of samples

nj = number of cases in the jth sample

N = $\sum$ nj, the number of cases in all samples combined

R = sum of ranks in the jth sample (coloumn)

$\sum$ = directs to sum over k samples (columns)

3.8.6 Spearman's coefficient of correlation (r_s)

In order to determine the relationship between the dependent and independent variables, coefficient of correlation was worked out using the formula,

$$r_s = 1 - \frac{6\sum D^2}{n^3 - n}$$

where, r_s – Spearman's correlation coefficient

D – difference between ranks

n- number of pairs of data

3.8.7 Principal Component Analysis

It is a multivariate technique that can capture the underlying patterns in data with high dimensions to reduce the number of dimensions without much loss of information. Multivariate technique of Principle Component Analysis can capture underlying patterns in data of high dimensions to reduce the number of dimensions without much loss of information.

PCA is a technique for extracting from a set of variables those few orthogonal linear combinations of variables that most successfully capture the common information. The first principal component of a set of variables is the linear index of all the variables that capture the largest amount of information common to all the variables (Gbetibouo and Ringler, 2009).

In the present study PCA is used to find out the number of components that best describe the responses of the statements to quantify the dependent variable i.e., vulnerability and the per cent variance contributed by each component.

Extraction communalities are estimates of the variance in each variable accounted for by the factors in the factor solution. Small values indicate variables that do not fit well with the factor solution, and should possibly be dropped from the analysis.

One arbitrary rule-of-thumb is to consider the principal components, which have eigenvalues of one or greater as having practical significance. An eigenvalue of the diagonal matrix represents a variance and the eigenvector that correspond to the eigenvalue is a vector that represents the direction of the variance. Hence arranging the eigenvalues in the order of highest to the lowest gives an ordered orthogonal basis that in the order of greatest variance to the smallest.

Another rule-of-thumb used to decide the number of practically significant PCs, is to use a Scree plot. A Scree Plot is a plot of number of principal components versus eigenvalue. The way to determine the number of PCs is to ‘keep only PCs before the elbow in the Scree Plot.

The Kaiser-Meyer-Olkin Measure of Sampling Adequacy is a statistic that indicates the proportion of variance in your variables that might be caused by underlying factors. High values (close to 1.0) generally indicate that a factor analysis may be useful with your data. If the value is less than 0.50, the results of the factor analysis probably won't be very useful.

Bartlett's test of sphericity tests the hypothesis that your correlation matrix is an identity matrix, which would indicate that your variables are unrelated and therefore unsuitable for structure detection. Small values (less than 0.05) of the significance level indicate that a factor analysis may be useful with your data.

These two tests are used to find out if the sample is adequate to carry out Principal Component Analysis.

3.8.8 Multinomial Logistic Regression

Multinomial Logistic Regression is an extension of binary logistic regression with multiple explanatory variables. It is used to model the relationship between a polytomous response variable and a set of independent variables.

The polytomous response could be ordinal (ordered categories) or nominal (unordered categories). This model permits the comparison of more than one contrast simultaneously.

In logistic regression, the categorical response has only two values.

Generally, 1 is for success and 0 for failure. Logistic regression uses a logit function to link the probability of success and predictors, and applies maximum likelihood estimation method to estimate parameters. The multinomial logit compares multiple groups through a combination of binary logistic regressions.

This allows each category of the dependent variable to be compared to a reference category. Normally, the category with the highest numeric score is chosen as the reference category. As a general rule, when there are, say, n possible levels of the dependent variable, the Multinomial Logistic Regression model will consist of n – 1 equation.

The logistic regression extends to models with multiple predictors. For example, for a ‘k’ class scenario,

$$P(R) = \frac{\exp(RHS\text{-}R)}{(1+ \exp(RHS\_A) + \exp(RHS\_B)+\ldots\ldots\exp(RHS\_(K\text{-}1))}$$

Where,

RHS_A = intercept_1+ b1*x1+ b2*x2….

p(A)/p(C) = exp(RHS_A)

RHS-B = intercept_2 +b2*x1+ b2*x2….

p(B)/p(C) = exp(RHS_B)

Likelihood ratio, chi square test, Deviance and Pearson’s chi-square test were used to determine if the model exhibits a good fit to the data. The impact of predictor variables are explained in terms of the odds ratio.

Exp (B) represents the ratio change in the odds of the event of interest for a one unit change in the predictor. The corresponding probability is given by,

$$\frac{\mathbf{Exp(B)}}{\mathbf{1+Exp(B)}}$$

In the study this model was used to explain the relationship, i.e. predict the probabilities of the different possible outcome of the multiclass dependent variable *i.e.,* vulnerability with a set of selected independent variables.

4. RESULT AND DISCUSSION

4.1. Basic details of the farms and farmers

4.1.1 Basic details of the farms and farmers of Puzhakkal *Kole* Panchayath (N=15)

The basic details of the farmers and their respective farms including personal and socio-economic details were collected. The characters included were age, gender, educational qualification of the farmers, major occupation, type of family system, mass media participation, experience in farming, total area cultivated by the farmer, water sources used, proximity of the farm to an industrial area, produce consumption and the Government Schemes or legislative support benefited from.

4.1.1.1. Age

Table 1. Distribution of farmers according to their age

Sl. No.	Categories	Frequency	Percentage
1	Up to 40	4	26.66
2	41-50	6	40
3	51-60	5	33.33
4	Above 60	0	0
Total		**15**	**100**

The data from table shows that 40 per cent of the selected farmers from Puzhakkal *Kole* Panchayath belonged to the age group of 41-50 followed by 33.33 per cent of farmers in the age group of 51-60 years. The farmers who were up to 40 years of age were 26.67 per cent and none (0 per cent) of the farmers belonged to the age group of more than 60 years.

4.1.1.2 Education

Table 2. Distribution of farmers according to their education

Sl. No.	Categories	Frequency	Percentage
1	Illiterate	0	0
2	Primary	1	6.66
3	High school	4	26.66
4	Higher secondary	2	13.33
5	Graduation and above	8	53.33
Total		**15**	**100**

The data from table shows that a majority (53.33 per cent) of the selected farmers from Puzhakkal *Kole* Panchayath had education levels of „graduation and above‟. The farmers with education up to high school were 26.67 per cent. Higher secondary level of education was possessed by 13.33 per cent farmers, while 6.67 per cent farmers had education levels of primary. None (0 per cent) of the farmers were found to be illiterate.

4.1.1.3. Main occupation of the farmer

Table 3. Distribution of farmers according to their occupation

Sl. No.	Categories	Frequency	Percentage
1	Farming	11	73.33
2	Business	0	0
3	Service	4	26.66
4	Other	0	0
5	Agriculture allied	0	0
Total		**15**	**100**

From the table it could be interpreted that, 73.33 per cent of the paddy farmers from Puzhakkal *Kole* Panchayath had farming as their main occupation. The farmers whose main occupation lies in service sector was 26.67 per cent. None of the farmers (0 per cent) had business, agriculture allied or any other occupation respectively.

4.1.1.4 Mass media participation

Table 4. Distribution of farmers according to their mass media contact

Sl. No.	Categories	Frequency	Percentage
1	Never	0	0
2	Low	1	6.66
3	Medium	7	46.66
4	High	7	46.66
Total		**15**	**100**

The data from the table shows that none (0 per cent) of the farmers reported no usage of mass media, while 6.67 per cent of the farmers belonged to the category of low. Medium and High category had 46.67 per cent each of the farmers.

4.1.1.5 Experience in agriculture

The data from the table reveals that 46.67 per cent of the Puzhakkal farmers had 20-30 years of experience in agriculture, followed by 26.67 per cent farmers who had 5-10 years and 10-20 years of experience respectively. None (0 per cent) of the farmers had less than 5 years of experience and more than 40 years of experience in agriculture respectively.

Table 5. Distribution of farmers according to their experience in agriculture (years)

Sl. No.	Categories	Frequency	Percentage
1	**<5**	0	0
2	**5-10**	4	26.66
3	**10-20**	4	26.66
4	**20-30**	7	46.66
5	**30-40**	0	0
6	**>40**	0	0
Total		**15**	**100**

4.1.1.6 Total area possessed by the farmer

Table 6. Distribution of farmers according to their total area possessed

Sl. No.	Categories	Frequency	Percentage
1	<1 ha (Marginal)	2	13.33
2	1-2 ha (Small)	5	33.33
3	2-10 ha (Medium)	8	53.33
4	>10 ha (Large)	0	0
Total		**15**	**100**

The data from the table reveals that 53.33 per cent respondent farmers of Puzhakkal were medium farmers, while 33.33 per cent farmers were of small category. The percentage of marginal farmers was 13.33 per cent. None (0 per cent) of the farmers belonged to large category.

4.1.1.7 Main water source used by the farmer

Table 7. Distribution of farmers according to their main water source

Sl. No.	Categories	Frequency	Percentage
1	Rain water	1	60
2	Well	3	20
3	Canal	9	6.67
4	Stream	0	0
5	Tube Well	2	13.33
Total		**15**	**100**

The table shows that 60 per cent of the respondent farmers of Puzhakkal had rain water as their main water source, followed by 20 per cent farmers who reported the use of well water for irrigation. Tube wells were used by 13.33 per cent of the farmers, while 6.67 per cent farmers used canals. None (0 per cent) farmers used stream water.

4.1.1.8. Proximity of the farms to an industrial area

Table 8. Distribution of farmers according to the proximity of farms to industrial area

Sl. No.	Categories	Frequency	Percentage
1	<1 km	5	33.33
2	1-3 km	5	33.33
3	3-6 km	3	20
4	>6 km	2	13.33
Total		**15**	**100**

The table shows that 33.33 per cent of the farmers of Puzhakkal had their farms at less than 1km from an industry and 1-3 km from an industry respectively, while 20 per cent of them had their farms at 3-6 km. Only 13.33 per cent farmers reported their farms at more than 6 km.

4.1.2 Basic details of the paddy farm and farmers of Alathur Panchayath

4.1.2.1. Age

The data from table reveals that a high majority of 86.67 per cent of the farmers selected from Alathur Panchayath were 40 years or lesser. A per cent of 13.33 was observed for farmers above 60 years of age. None (0 per cent) of the farmers belonged to the age group of 41-50 and 51-60 years.

Table 9. Distribution of farmers according to their age

Sl. No.	Categories	Frequency	Percentage
1	Up to 40	13	86.66
2	41-50	0	0
3	51-60	0	0
4	Above 60	2	13.33
Total		**15**	**100**

4.1.2.2 Education

The data from table indicates that the paddy farmers of Alathur who belong to the category of „High School" and „Graduation and above" were 40 per cent each. The farmers who had an education level of „Higher secondary" were 20 per cent.

None 90 per cent) of the farmers had education levels of „Primary" and „Illiterate". A per cent of 13.33 was observed for farmers above 60 years of age. None (0 per cent) of the farmers belonged to the age group of 41-50 and 51-60 years.

Table 10. Distribution of farmers according to their education

Sl. No.	Categories	Frequency	Percentage
1	Illiterate	0	0
2	Primary	0	0
3	High school	6	40
4	Higher secondary	3	20
5	Graduation and above	6	40
Total		**15**	**100**

4.1.2.3 Occupation

Table 13. Distribution of farmers according to their occupation

Sl. No.	Categories	Frequency	Percentage
1	Farming	14	93.33
2	Business	0	0
3	Service	1	6.66
4	Other	0	0
5	Agriculture allied	0	0
Total		**15**	**100**

From the table it could be interpreted that, a vast majority of 93.33 per cent of the paddy farmers from Alathur Panchayath had farming as their main occupation. The farmers whose main occupation lies in service sector was just 6.67 per cent.

None of the farmers (0 per cent) had business, agriculture allied or any other occupation respectively.

4.1.2.4. Mass media participation

The results from the table indicate that, a very high (73.33 per cent) of the farmers of Alathur had high mass media contact, followed by a medium percentage of 26.67. None (0 per cent) of the farmers belonged to the category of Low or Never.

Table 14. Distribution of farmers according to their mass media participation

Sl. No.	Categories	Frequency	Percentage
1	Never	0	0
2	Low	3	20
3	Medium	10	66.66
4	High	2	13.33
Total		**15**	**100**

4.1.2.5 Experience in agriculture

The data from the table shows that 33.33 per cent of the Alathur farmers had 5-10 years of experience in agriculture, followed by 26.67 per cent farmers who had 10-20 years and 20-30 years of experience respectively. The farmers who had an experience of 30-40 years and more than 40 years were 6.67 per cent respectively. None (0 per cent) of the farmers had less than 5 years of experience.

Table 15. Distribution of farmers according to their experience in agriculture

Sl. No.	Categories	Frequency	Percentage
1	**<5**	0	0
2	**5-10**	5	33.33
3	**10-20**	4	26.66
4	**20-30**	4	26.66
5	**30-40**	1	6.66
6	**>40**	1	6.66
Total		**15**	**100**

4.1.2.6 Area of land holding

Table 16. Distribution of farmers according to their area of land holding

Sl. No.	Categories	Frequency	Percentage
1	<1 ha (Marginal)	0	0
2	1-2 ha (Small)	3	20
3	2-10 ha (Medium)	9	60
	>10 ha (Large)	3	20
Total		**15**	**100**

It can be observed from the Table that, among the paddy farmers of Alathur, 60 per cent belonged to medium category, while 20 per cent each belonged to small and large category. None (0 percent) of the farmers were marginal.

4.1.2.7 Main water source used by the farmer

Table 17. Distribution of farmers according to the main water source

Sl. No.	Categories	Frequency	Percentage
1	Rain water	0	0
2	Well	0	0
3	Canal	7	46.66
4	Stream	8	53.33
5	Tube Well	0	0
Total		**15**	**100**

It was found out from the table that 53.33 per cent farmers of Alathur Panchayath depended on streams for farming, while 46.67 per cent farmers depended on canal water. None (0 per cent) farmers depended on rain water, well or tube wells.

4.1.2.8 Proximity of the farm to an industrial area

Table 18. Distribution of farmers according to the proximity of farm to industrial area

Sl. No.	Categories	Frequency	Percentage
1	<1 km	2	13.33
2	1-3 km	4	26.66
3	3-6 km	8	53.33
4	>6 km	1	6.66

It could be inferred from the table that 53.33 per cent farmers of Alathur had their farms at 3-6 km from industrial area, while 26.67 per cent had at a distance of 1- 3 km. The farmers who had their farms at <1 km from industries was 13.33 per cent, while 6.67 per cent were at more than 6 km from industrial areas.

4.1.3 Basic details of the banana farm and farmers of Puthur Panchayath

4.1.3.1 Age

Table concludes that 46.67 per cent of the farmer respondents selected from Puthur Panchayath belonged to the age group of 41-50 years. Both the categories of 41-50 years and 51-60 years had 26.67 per cent of farmers each. None (0 per cent) of the farmers had ages above 60 years.

Table 19. Distribution of farmers according to their age

Sl. No.	Categories	Frequency	Percentage
1	Up to 40	4	26.66
2	41-50	7	46.66
3	51-60	4	26.666
4	Above 60	0	0
Total		**15**	**100**

4.1.3.2 Education

Table 20. Distribution of farmers according to their education

Sl. No.	Categories	Frequency	Percentage
1	Illiterate	0	0
2	Primary	2	13.33
3	High school	4	26.67
4	Higher secondary	1	6.67
5	Graduation and above	8	53.33
Total		**15**	**100**

It could be inferred from table that the paddy farmers of Alathur who belong to the category o „Graduation and above" were 53.33 per cent whereas farmers who had an education level of „High school" were 26.67 per cent.

The farmers with educational levels up to primary were 13.33 while 6.67 per cent had up to Higher Secondary. None of the farmers were observed to be illiterate

4.1.3.3 Occupation

Table 21. Distribution of farmers according to their occupation

Sl. No.	Categories	Frequency	Percentage
1	Farming	12	80
2	Business	0	0
3	Service	2	13.33
4	Other	1	6.66
5	Agriculture allied	0	0
Total		**15**	**100**

From the table it could be interpreted that, a majority of 80 per cent of the paddy farmers from Puthur Panchayath had farming as their main occupation. The farmers who had their main occupation in service sector was just 13.33 per cent, while none of the farmers (0 per cent) had business, or agriculture allied occupations. A per cent of 6.67 farmers had other professions as their main occupation.

4.1.3.4 Mass media participation

Table 22. Distribution of farmers according to their mass media participation

Sl. No.	Categories	Frequency	Percentage
1	Never	0	0
2	Low	3	20
3	Medium	10	66.66
4	High	2	13.33
Total		**15**	**100**

The table shows us that 66.67 per cent farmers had medium mass media exposure, while 20 per cent had low. Only 13.33 per cent had high and none (0) never used mass media.

4.1.3.5 Experience in agriculture

It could be concluded from the table that 66.66 per cent of the Puthur farmers had an agricultural experience of 10-20 years, followed by 13.33 per cent farmers who had 5-10 years and 20-30 years of experience respectively.The farmers who had an experience of <5 years were 6.67. None (0 per cent) of the farmers had an experience of 30-40 years and >40 years.

Table 24. Distribution of farmers according to their education

Sl. No.	Categories	Frequency	Percentage
1	**<5**	1	6.666667
2	**5-10**	2	13.33333
3	**10-20**	10	66.66667
4	**20-30**	2	13.33333
5	**30-40**	0	0
6	**>40**	0	0
Total		**15**	**100**

4.1.3.6 Area of land holding

Table 25. Distribution of farmers according to their area of landholding

Sl. No.	Categories	Frequency	Percentage
1	<1 ha (Marginal)	3	20
2	1-2 ha (Small)	9	60
3	2-10 ha (Medium)	3	20
4	>10 ha (Large)	0	0
Total		**15**	**100**

The data from the table concludes that 60 per cent of the farmer respondents of Puthur were small farmers and 20 per cent each were marginal and medium farmers. None (0 per cent) of the farmers were large farmers.

4.1.3.7 Main water source used by the farmer

Table 26. Distribution of farmers according to their main water source

Sl. No.	Categories	Frequency	Percentage
1	Rain water	0	0
2	Well	5	33.3333333
3	Canal	8	53.3333333
4	Stream	0	0
5	Tube Well	2	13.3333333
Total		**15**	**100**

The table shows that 53.33 per cent of the respondent farmers of Puthur used canal water as their main water source, followed by 33.33 per cent farmers who reported the use of well water for irrigation. Tube wells were used by 13.33 per cent of the farmers, while none (0 per cent) farmers used canals used stream and rain water.

4.1.3.8 Proximity of the farms to an industrial area

Table 27. Distribution of farmers according to the proximity of the farms to industrial area

Sl. No.	Categories	Frequency	Percentage
1	<1 km	0	0
2	1-3 km	3	20
3	3-6 km	5	33.3333333
4	>6 km	7	46.6666667
Total		**15**	**100**

The table shows that 46.67 per cent of the farmers of Puthur had their farms at more than 6 km from an industry and 33.33 per cent had at 3-6 km from an industry respectively, while 20 per cent of them had their farms at 1-3 km. none (0 per cent) farmers reported their farms at less than 1 km.

4.1.4 Basic details of the banana farm and farmers of Pananchery Panchayath

4.1.4.1 Age

Table 28. Distribution of farmers based on age

Sl. No.	Categories	Frequency	Percentage
1	Up to 40	4	26.66667
2	41-50	8	53.33333
3	51-60	2	13.33333
4	Above 60	1	6.666667
Total		**15**	**100**

It could be observed from table that from the farmers selected from Pananchery Panchayath, a majority (53.33 per cent) of them belonged to the age group of 41-50 years, while 26.67 per cent farmers belonged to the age group of up to 40 years. The farmers in the age group of 51-60 years were 13.33 per cent. The per cent of farmers above 60 years of age was 6.67 per cent.

4.1.4.2 Education

Table 29. Distribution of farmers based on education

Sl. No.	Categories	Frequency	Percentage
1	Illiterate	0	0
2	Primary	0	0
3	High school	4	26.6666667
4	Higher secondary	4	26.6666667
5	Graduation and above	7	46.6666667
Total		**15**	**100**

The data from the table shows us that 46.67 per cent of the farmers were graduates, while both high school and higher secondary educated farmers were 26.67 per cent. None (0) of the farmers were illiterate or primary educated.

4.1.4.3 Occupation

Table 30. Distribution of farmers based on occupation

Sl. No.	Categories	Frequency	Percentage
1	Farming	10	66.66667
2	Business	0	0
3	Service	4	26.66667
4	Other	1	6.666667
5	Agriculture allied	0	0
Total		**15**	**100**

The table reveals that a majority (66.67 per cent) of the banana farmers of Pananchery had farming as their main occupation. The farmers who had main occupation in the service sector were 26.67 per cent. None (0 per cent) of the respondent farmers have professions related to business or allied to agriculture. The farmers who had occupation other than the above mentioned constituted 6.67 per cent.

4.1.4.4 Mass media participation

Table 32. Distribution of farmers based on mass media participation

Sl. No.	Categories	Frequency	Percentage
1	Never	0	0
2	Low	2	13.33333
3	Medium	3	20
4	High	10	66.66667
Total		**15**	**100**

A very high majority of the farmers in Pananchery Panchayath reported a high (66.67 per cent) per cent of mass media contact, followed by 20 per cent of farmers who reported medium levels. None (0 percent) of the farmers „Never" or „Low" levels of mass media contact.

4.1.4.5 Experience in agriculture

Table 33. Distribution of farmers based on experience in agriculture

Sl. No.	Categories	Frequency	Percentage
1	**<5**	0	0
2	**5-10**	5	33.33333
3	**10-20**	5	33.33333
4	**20-30**	3	20
5	**30-40**	2	13.33333
6	**>40**	0	0
Total		**15**	**100**

It could be concluded from the table that among the farmers of Pananchery Panchayath, both the categories of 5-10 years and 10-20 years had 33.33 per cent of the farmers respectively. This was followed by 20 per cent of the farmers who had an experience of 20-30 years. A per cent of 13.33 farmers showed a per cent of 30-40 years of experience in farming. None (0 per cent) of the farmers had an experience of <5 years and >40 years.

4.1.4.6 Area of land holding

Table 34. Distribution of farmers based on area of land holding

Sl. No.	Categories	Frequency	Percentage
1	<1 ha (Marginal)	3	20
2	1-2 ha (Small)	9	60
3	2-10 ha (Medium)	2	13.33
4	>10 ha (Large)	1	6.66
Total		**15**	**100**

4.1.4.8 Main water source used by the farmer

Table 35. Distribution of farmers based on main water source

Sl. No.	Categories	Frequency	Percentage
1	Rain water	0	0
2	Well	2	13.33
3	Canal	6	40
4	Stream	7	46.66
5	Tube Well	0	0
Total		**15**	**100**

The table shows that 46.67 per cent of the respondent farmers of Pananchery used stream water as their main water source, followed by 40 per cent farmers who reported the use of canal water for irrigation. Wells were used by 13.33 per cent of the farmers, while none (0 per cent) farmers used canals used tube well and rain water.

4.1.4.8 Proximity of the farms to an industrial area

Table 36. Distribution of farmers based on proximity to industrial area

Sl. No.	Categories	Frequency	Percentage
1	<1 km	0	0
2	1-3 km	4	26.66
3	3-6 km	9	60
4	>6 km	2	13.33
Total		**15**	**100**

The table shows that 60 per cent of the farmers of Pananchery had their farms at 3 to 6 km from an industry and 26.66 per cent had at 1-3 km from an industry respectively, while 13.33 per cent of them had their farms at >6 km. none (0 per cent) farmers reported their farms at less than 1 km.

4.1.5 Basic details of the vegetable farm and farmers of Nadathara Panchayath

4.1.5.1 Age

Table 37. Distribution of farmers based on age

Sl. No.	Categories	Frequency	Percentage
1	Up to 40	5	33.33
2	41-50	6	40
3	51-60	2	13.33
4	Above 60	2	13.33
Total		**15**	**100**

The findings from table show that, the farmers selected from Nadathara Panchayath, 40 per cent of them belonged to the age group of 41-50 years, while 33.33 per cent farmers had their ages up to 40 years. In the age groups of 51-60 and above 60 years, 13.33 per cent farmers were found respectively.

4.5.2 Education

Table 38. Distribution of farmers based on education

Sl. No.	Categories	Frequency	Percentage
1	Illiterate	0	0
2	Primary	0	0
3	High school	4	26.66
4	Higher secondary	4	13.33
5	Graduation and above	7	60
Total		**15**	**100**

4.1.5.3 Occupation

Table 39. Distribution of farmers based on occupation

Sl. No.	Categories	Frequency	Percentage
1	Farming	10	66.66
2	Business	0	0
3	Service	4	26.66
4	Other	1	6.66
5	Agriculture allied	0	0
Total		**15**	**100**

The table reveals that a majority (66.67 per cent) of the vegetable farmers of Nadathara had farming as their main occupation. The farmers who had main occupation in the service sector were 26.67 per cent. None (0 per cent) of the respondent farmers have professions related to business or allied to agriculture. The farmers who had occupation other than the above mentioned constituted 6.67 per cent.

4.1.5.4 Mass media participation

A very high majority of the farmers in Nadathara Panchayath reported a high (80 per cent) per cent of mass media contact, followed by 20 per cent of farmers who reported medium levels. None (0 percent) of the farmers „Never" or „Low" levels of mass media contact.

Table 41. Distribution of farmers based on mass media participation

Sl. No.	Categories	Frequency	Percentage
1	Never	0	0
2	Low	0	0
3	Medium	3	20
4	High	12	80
Total		**15**	**100**

4.1.5.5 Experience of farming

Table 42. Distribution of farmers based on experience of farming

Sl. No.	Categories	Frequency	Percentage
1	**<5**	0	0
2	**5-10**	2	13.33
3	**10-20**	8	53.33
4	**20-30**	4	26.66
5	**30-40**	1	6.66
6	**>40**	0	0
Total		**15**	**100**

The table reveals that 53.33 per cent of the farmers of Nadathara Panchaytath had a farming experience of 10-20 years. This was followed by 26.67 per cent of the farmers who reported an experience of 20-30 years, while 13.33 per cent of the farmers reported 5-10 years. The per cent of farmers who had an experience of

30-40 years was 6.67 and none (0 per cent) of the farmers had an experience of <5 years and >40 years.

4.1.5.6 Area of land holding

Table 43. Distribution of farmers based on area of land holding

Sl. No.	Categories	Frequency	Percentage
1	<1 ha (Marginal)	3	20
2	1-2 ha (Small)	9	60
3	2-10 ha (Medium)	2	13.33
4	>10 ha (Large)	1	6.66
Total		**15**	**100**

The data from table reveals that 60 per cent of farmer respondents of Nadathara were small farmers, while 20 per cent farmers were marginal. Medium and large farmers were 13.33 per cent and 6.67 per cent respectively.

4.1.5.7 Main water source used by the farmer

Table 44. Distribution of farmers based on main source used by the farmer

Sl. No.	Categories	Frequency	Percentage
1	Rain water	0	0
2	Well	10	66.66
3	Canal	1	6.66
4	Stream	0	0
5	Tube Well	4	26.66
Total		**15**	**100**

The table shows that 66.67 per cent of the respondent farmers of Nadathara used well water as their main water source, followed by 26.67 per cent farmers who reported the use of tube well and 6.67 per cent for canal water irrigation respectively. None (0 per cent) farmers used canals used stream and rain water.

4.1.5.8 Proximity of the farms to an industrial area

The table shows that 46.67 per cent of the farmers of Nadathara had their farms at 3 to 6 km from an industry and 20 per cent had at less than 1 km and more than 6 km from an industry respectively.

Table 41. Distribution of farmers based on proximity to an industrial area

Sl. No.	Categories	Frequency	Percentage
1	<1 km	0	0
2	1-3 km	1	6.66
3	3-6 km	8	53.33
4	>6 km	6	40
Total		**15**	**100**

4.1.6 Basic details of the vegetable farm and farmers of Madakkathara Panchayath

4.1.6.1 Age

Table 42. Distribution of farmers based on age

Sl. No.	Categories	Frequency	Percentage
1	Up to 40	5	33.33
2	41-50	6	40
3	51-60	4	26.66
4	Above 60	0	0
Total		**15**	**100**

The findings from table show that, the farmers selected from Madakathara Panchayath, 40 per cent of them belonged to the age group of 41-50 years, whereas, 33.33 per cent farmers belonged to the age group of up to 40 years. In the age groups of 51-60, 26.67 per cent of farmers were found. None of the farmers (0 per cent) belonged to the category of above 60.

4.1.6.2 Education

Table 43. Distribution of farmers based on education

Sl. No.	Categories	Frequency	Percentage
1	Illiterate	0	0
2	Primary	0	0
3	High school	6	40
4	Higher secondary	4	26.66
5	Graduation and above	5	33.33
Total		**15**	**100**

The findings from table indicate that, the vegetable farmers selected from Madakathara Panchayath, 40 per cent of the farmers were of „High School" level, while 33.33 per cent farmers had their education up to „Graduation and above". „Higher secondary" level of education were possessed by 26.67 per cent farmers. None (0 per cent) of the farmers belonged to the category of „illiterate" or „primary".

4.1.6.3 Occupation

It could be interpreted from table that, a high majority (80 per cent) of the vegetable farmers of Madakathara Panchayath had farming as their main occupation. None of the respondent farmers had occupations related to business, service and agriculture allied professions. Twenty (20) per cent of the farmers had occupations other than the aforementioned.

Table 44. Distribution of farmers based on occupation

Sl. No.	Categories	Frequency	Percentage
1	Farming	12	80
2	Business	0	0
3	Service	0	0
4	Other	3	20
5	Agriculture allied	0	0
Total		**15**	**100**

4.1.6.4 Mass media participation

A very high (86.67 per cent) of farmers of Madakkathara showed „Medium levels of mass media contact, followed by 13.33 per cent of farmers who reported low levels. None of the farmers reported „Never" or „High" categories.

Table 45 . Distribution of farmers based on mass media participation

Sl. No.	Categories	Frequency	Percentage
1	Never	0	0
2	Low	2	13.33
3	Medium	13	86.66
4	High	0	0
Total		**15**	**100**

4.1.6.5 Experience in agriculture

Table 46. Distribution of farmers based on experience in agriculture

Sl. No.	Categories	Frequency	Percentage
1	**<5**	0	0
2	**5-10**	4	26.66
3	**10-20**	8	53.33
4	**20-30**	3	20
5	**30-40**	0	0
6	**>40**	0	0
Total		**15**	**100**

It could be concluded from the table that among the farmers of Madakkathara, 53.33 per cent of the farmers had an experience of 10-20 years, while 26.67 per cent of the farmers showed an experience of 5-10 years. Only 20 per cent of the farmers had an experience of 20-30 years while 0 per cent had experiences of less than 5 and more than 40 years.

4.1.6.6 Area of landholding

Table 47. Distribution of farmers based on area of landholding

Sl. No.	Categories	Frequency	Percentage
1	<1 ha (Marginal)	6	40
2	1-2 ha (Small)	5	33.33
3	2-10 ha (Medium)	3	20
4	>10 ha (Large)	1	6.67
Total		**15**	**100**

It can be observed from the Table that, among the respondent farmers of Madakkathara, 40 per cent belonged to marginal category, while 33.33 per cent each belonged to small and large category. Medium farmers were 20 per cent, while 6.67 per cent were large farmers.

4.1.6.7. Main water source used by the farmer

Table 48. Distribution of farmers based on main water source

Sl. No.	Categories	Frequency	Percentage
1	Rain water	0	0
2	Well	9	60
3	Canal	3	20
4	Stream	0	0
5	Tube Well	3	20
Total		**15**	**100**

Table 49. Summary statistics for the N (90) farmers of the six Panchayaths

Sl.No	Variables	Mean	SD	Range of scores	
				Min.	Max.
1	**Age**	1.9111	0.89499	1	4
2	**Education**	3.1222	0.9341	1	4
3	**Experience**	2.1111	0.90497	0	5
4	**Area of land holding**	2.2333	0.88749	1	4
5	**Proximity to industrial area**	1.8	0.92651	0	3
6	**Mass media contact**	1.3667	0.6439	0	2
7	**Water source**	1.5444	1.19173	1	5
8	**Occupation**	2.8667	1.06944	1	4

It could be inferred that, out of the selected 90 farmer respondents majority (75.2 per cent) of the farmers were aged lesser than 50 years, indicating that most of the selected farmers were young or middle aged middle aged, with only 19 per cent of the famers being above the age of 50.

Forty seven point eight per cent of the farmers were educated up to the graduation level and above graduation. None of the selected farmers were found to be illiterate, and very low per cent (2.2 per cent) farmers discontinued their education after primary. This indicates the higher levels of education of the selected respondents.

A majority (68.6 per cent) farmer had a farming experience of up to 20 years. Only a few (4.4 per cent) farmers had a very high farming experience of more than forty years. Majority (42.2 per cent) farmers were small farmers holding land areas of 1-2 ha. Only 7.8 per cent of the respondents were large farmers with more than 10 ha area.

It was found that a high majority (76.7 per cent) of the farmers had their farms within 6 km from an industrial area, indicating that most farmers carry out their farming practices in close proximity to industries and the resultant pollution. Out of that, 42 per cent farmers had their farms within 3 to 6 kms of an industrial area.

A vast majority (91.2) per cent of the farmers reported frequent usage of mass media. It was also observed that none of the farmers reported to never making use of mass media contact.

Only 11.1 per cent farmers depended entirely on rainwater for carrying out their cultivation, while 88.9 per cent farmers irrigated their land. The data from the farmers also reveals that, 60 per cent farmers used canals and wells for carrying out irrigation.

It can also be inferred that, a high majority (75.6 per cent) of farmers had farming as their main occupation, as compared to 24.4 per cent of farmers who had other occupations in business, service and agriculture allied sectors in addition to farming.

4.2. Type and extent of major environmental pollution faced in different agricultural systems

4.2.1. The extent of water pollution faced by the agricultural systems

The Table presents the composite index to assess the extent of water pollution the six Panchayaths based on the response of the farmers. A list containing 9 statements of water pollution was used in the measurement.

Table 49. The statements are as shown below

Sl. No.	Statement	Indicated by
1	Water is polluted by the excess use of pesticide in crop	WP1
2	Water is polluted due to bathing of man and animals in water bodies	WP2
3	There is water pollution due to the dumping of faecal matter of man and animal into the water bodies	WP3
4	The quality of water is affected due to the use of detergents	WP4
5	Water is polluted due to the let-out of industrial effluents	WP5
6	Water is polluted due to excess use of chemical fertilizers	WP6
7	Water is polluted due to untreated sewage	WP7
8	Water is polluted due release of garbage/plastic to water bodies	WP8
9	Water quality is affected due to fish excrement as a result of pisciculture	WP9

4.2.1.1. Extent of water pollution in Puzhakkal *Kole* Panchayath based on the responses of paddy farmers

It was revealed from the table that a „Moderate" level of water pollution was faced by the paddy farmers of Puzhakkal *Kole* Panchayath with a composite index value of 70.81. It could also be observed from the table 2.1.1 that, high levels were reported for statements (WP1), (WP2), (WP4), (WP5), (WP6), (WP7) and (WP8).

Moderate level was observed for the statement (WP3) and low level for the statement (WP9).

Table 50. Distribution of the water pollution levels in the rice based agricultural system of Puzhakkal *Kole* Panchayath

Sl. No.	Statements	No. of respondents					Index	Category
		HA	A	UD	D	HD		
1	WP1	3	10	2	0	0	81.33	**High**
2	WP2	0	7	7	1	0	68	**High**
3	WP3	2	6	7	0	0	73.33	**Moderate**
4	WP4	0	5	6	3	1	60	**High**
5	WP5	5	4	6	0	0	78.67	**High**
6	WP6	0	8	7	0	0	70.67	**High**
7	WP7	0	6	8	1	0	66.67	**High**
8	WP8	7	5	3	0	0	85.33	**High**
9	WP9	2	3	1	6	3	53.33	**Low**
SD-10.23							**Mean-70.81**	**High**

It was revealed from the table that „Moderate" level of water pollution was faced by the paddy farmers of Puzhakkal *Kole* Panchayath with a composite index value of 70.81.

It could also be observed from the table that, high levels were reported for statements (WP1), (WP2), (WP4), (WP5), (WP6), (WP7) and (WP8).

Moderate level was observed for the statement (WP3) and low level for the statement (WP9).

Table 51. Distribution of the water pollution levels in the rice based agricultural system of Alathur Panchayath

Sl. No.	**Statements**	**No. of respondents**					**Index**	**Category**
		HA	A	UD	D	HD		
1	WP1	5	0	10	0	0	73.33	**High**
2	WP2	0	7	8	0	0	69.33	**High**
3	WP3	3	6	6	0	0	76	**Moderate**
4	WP4	1	4	5	5	0	61.33	**High**
5	WP5	0	4	10	1	0	64	**High**
6	WP6	0	6	8	1	0	66.67	**High**
7	WP7	0	7	5	3	0	65.33	**High**
8	WP8	2	5	8	0	0	72	**High**
9	WP9	0	0	7	8	0	49.33	**Low**
SD-7.94							**Mean-66.37**	**Moderate**

Table 52. Distribution of the water pollution levels in the banana based agricultural system of Puthur Panchayath

Sl. No.	**Statements**	**No. of respondents**					**Index**	**Category**
		HA	A	UD	D	HD		
1	WP1	2	6	7	0	0	73.33	**High**
2	WP2	0	2	6	6	1	52	**Low**
3	WP3	0	4	10	1	0	64	**Moderate**
4	WP4	0	4	8	3	0	61.33	**Moderate**
5	WP5	0	5	9	1	0	65.33	**Moderate**
6	WP6	2	4	8	1	0	69.33	**Moderate**
7	WP7	1	4	4	4	2	57.33	**Moderate**
8	WP8	0	6	9	0	0	68	**Moderate**
9	WP9	0	3	7	5	0	57.33	**Moderate**
SD- 6.77							**Mean** 63.11	**Moderate**

It was revealed from the table that a „Moderate" level of water pollution was faced by the banana farmers of Puthur Panchayath with a composite index value of 63.11. It could also be observed from the table that, high levels were reported for only the statement (WP1). Moderate level was observed for the statements (WP3), (WP4), (WP5), (WP6), (WP7), (WP8), (WP9) and low level for the statement (WP2).

Sl. No.	Statements	No. of respondents					Index	Category
		HA	A	UD	D	HD		
1	WP1	0	5	9	1	0	65.33	**High**
2	WP2	0	1	9	5	0	54.67	**Low**
3	WP3	0	3	7	4	1	56	**Moderate**
4	WP4	0	2	7	6	0	54.67	**Moderate**
5	WP5	0	5	6	4	0	61.33	**Moderate**
6	WP6	1	8	4	2	0	70.67	**Moderate**
7	WP7	0	3	6	5	1	54.67	**Moderate**
8	WP8	2	5	4	3	1	65.33	**Moderate**
9	WP9	0	1	11	3	0	57.33	**Moderate**
SD 5.92							**Mean 60**	**Low**

It was revealed from the table that water pollution levels in Pananchery Panchayath was „Moderate". Statement (1) showed higher levels, while statement (WP2) stood at the level of low.

The remaining statements (WP3), (WP4), (WP5), (WP6), (WP7), (WP8), (WP9) were at „Moderate".

Table 54. Distribution of the water pollution levels in the vegetable based agricultural systems of Nadathara Panchayath

Sl. No.	Statements	No. of respondents					Index	Category
		HA	A	UD	D	HD		
1	WP1	2	4	7	2	0	68	**Moderate**
2	WP2	0	4	4	7	0	56	**Moderate**
3	WP3	0	2	7	6	0	54.67	**Moderate**
4	WP4	0	2	10	3	0	58.67	**Moderate**
5	WP5	1	5	7	2	0	66.67	**Moderate**
6	WP6	3	7	3	2	0	74.67	**High**
7	WP7	0	1	10	4	0	56	**Moderate**
8	WP8	1	7	6	1	0	70.67	**High**
9	WP9	0	0	10	4	1	52	**Low**
SD – 8.142							**Mean** 61.93	**Moderate**

It was found from the table that water pollution levels in Nadathara Panchayath were „Moderate". Statement (WP6) showed higher levels, while statement (WP2) stood at the level of low. The remaining statements WP3, WP4, WP5, WP6, WP7, WP8, WP9 were at „Moderate" levels.

Table 55. Extent of water pollution in Madakkathara based on the responses of farmers

Sl. No.	Statements	No. of respondents					Index	Category
		HA	A	UD	D	HD		
1	WP1	1	7	7	0	0	72	**High**
2	WP2	0	2	12	1	0	61.33	**Moderate**
3	WP3	0	3	11	1	0	62.67	**Moderate**
4	WP4	0	2	8	4	1	54.67	**Low**
5	WP5	1	5	8	1	0	68	**Moderate**
6	WP6	0	6	8	1	0	66.67	**Moderate**
7	WP7	0	4	8	3	0	61.33	**Moderate**
8	WP8	0	9	6	0	0	72	**High**
9	WP9	0	4	7	3	1	58.67	**Moderate**
SD 5.94							**Mean** 64.15	**Moderate**

It was found from the table that water pollution levels in Madakkathara Panchayath was „Moderate". Statement (WP1) and (WP8) showed „High" levels, while Statement (4) showed low.

All the remaining statements showed "Moderate" levels.

Table 57. Classification of the Panchayaths based on water pollution extent

Sl. No.	Panchayaths	Index	Extent of water pollution
1	Puzhakkal	70.81	High
2	Alathur	66.37	Moderate
3	Puthur	63.11	Moderate
4	Pananchery	60	Low
5	Nadathara	61.93	Moderate
6	Madakkathara	64.15	Moderate

4.2.2 The extent of soil pollution faced by the agricultural systems

A list of 9 statements pertaining to soil pollution was used for the measurement. Table 58. The statements are as shown below

Sl. No.	Statements	Indicated by
1	Soil is polluted due to excess use of chemical fertilizers	SP1
2	Soil is polluted by soil borne pathogens	SP2
3	Soil is polluted due to sewage material	SP3
4	Soil is polluted due to indiscriminate pesticide use	SP4
5	Soil is polluted due to industrial and urban waste	SP5
6	Soil is polluted due to use of herbicides	SP6
7	Soil is polluted due to slash and burn agriculture practice	SP7
8	Soil is polluted due to urning of plastic wastes	SP8
9	Soil is polluted due to occurrence of heavy wind and flood	SP9

4.2.2.1 Soil pollution levels in Puzhakkal Panchayath

Table 59. Distribution of the soil pollution levels in the rice based agricultural system of Puzhakkal Panchayath

Sl. No.	Statements	No. of respondents					Index	Category
		HA	A	UD	D	HD		
1	SP1	0	8	6	1	0	69.33	Moderate
2	SP2	0	0	10	5	0	53.33	Low
3	SP3	1	7	6	1	0	70.67	Moderate
4	SP4	4	7	4	0	0	80	Moderate
5	SP5	0	7	8	0	0	69.33	Moderate
6	SP6	0	4	9	2	0	62.67	Moderate
7	SP7	7	6	2	0	0	86.67	High
8	SP8	4	9	2	0	0	82.67	High
9	SP9	0	5	9	1	0	65.33	Moderate
SD				**Mean**			10.5 71.11	**Moderate**

Table 60. Distribution of the soil pollution levels in the rice based agricultural system of Alathur Panchayath

Sl. No.	Statements	No. of respondents					Index	Category
		HA	A	UD	D	HD		
1	SP1	0	6	9	0	0	68	Moderate
2	SP2	0	0	7	8	0	49.33	Low
3	SP3	1	7	6	1	0	70.67	Moderate
4	SP4	0	5	10	0	0	66.67	Moderate
5	SP5	0	4	11	0	0	65.33	Moderate
6	SP6	0	0	10	5	0	53.33	Low
7	SP7	0	5	10	0	0	66.67	Moderate
8	SP8	1	11	3	0	0	77.33	High
9	SP9	1	4	7	3	0	64	Moderate
Mean							64.59	**Moderate**

Table 61. Distribution of the soil pollution levels in Puthur Panchayath

Sl. No.	Statements	No. of respondents					Index	Category
		HA	A	UD	D	HD		
1	SP1	1	7	7	0	0	72	Medium
2	SP2	0	0	4	7	4	42.67	Low
3	SP3	0	12	3	0	0	76	Medium
4	SP4	3	3	4	3	1	64	Medium
5	SP5	4	6	5	0	0	76	Medium
6	SP6	0	2	10	3	0	58.67	Medium
7	SP7	3	7	2	2	1	76	Medium
8	SP8	0	5	4	3	3	52	Medium
9	SP9	0	0	5	7	3	42.67	Low
Mean **SD**							62.22 13.92	Medium

Table 62. Distribution of the soil pollution levels of Pananchery Panchayath

Sl. No.	Statements	No. of respondents					Index	Category
		HA	A	UD	D	HD		
1	SP1	1	7	7	0	0	66.66	Medium
2	SP2	0	2	12	1	0	46.66	Low
3	SP3	0	3	11	1	0	70.66	High
4	SP4	0	2	8	4	1	65.33	Medium
5	SP5	1	5	8	1	0	68	Moderate
6	SP6	0	6	8	1	0	49.33	Low
7	SP7	0	4	8	3	0	53.33	Low
8	SP8	0	9	6	0	0	73.33	High
9	SP9	0	4	7	3	1	46.66	Low
Mean **SD**							60 10.23	

The table shows that (SP3) and (SP8) showed high levels. Low levels were observed for statement (SP2), (SP6) and (SP9). The remaining statements showed moderate levels.

Table 63. Distribution of the soil pollution levels in the vegetable based agricultural system of Nadathara Panchayath

Sl. No.	Statements	No. of respondents					Index	Category
		HA	A	UD	D	HD	69.3	**Moderate**
1	(1)	1	5	9	0	0	69.3	**Moderate**
2	(2)	0	0	7	8	0	49.3	**Low**
3	(3)	2	7	6	0	0	74.6	**High**
4	(4)	0	1	6	7	1	53.3	**Moderate**
5	(5)	4	4	5	2	0	73.3	**High**
6	(6)	0	0	7	7	1	48	**Low**
7	(7)	0	4	9	2	0	62.6	**Moderate**
8	(8)	1	3	10	1	0	65.3	**Moderate**
9	(9)	0	2	8	5	0	56	**Moderate**
Mean							61.33	**Moderate**
SD							10.11	

....

Table 64. Distribution of the soil pollution levels in the vegetable based agricultural system of Madakkathara Panchayath

Sl. No.	Statements	No. of respondents					Index	Category
		HA	A	UD	D	HD		
1	SP1	0	4	6	5	0	58.66	Moderate
2	SP2	0	0	7	8	0	49.33	Low
3	SP3	0	6	5	4	0	62.66	Moderate
4	SP4	0	4	7	3	1	58.66	Moderate
5	SP5	0	8	4	3	0	66.66	Moderate
6	SP6	0	0	6	6	3	44	Low
7	SP7	0	4	9	2	0	62.66	Moderate
8	SP8	0	10	5	0	0	73.33	High
9	SP9	0	5	8	2	0	64	Moderate
Mean **SD**							60 8.84	**Moderate**

Table 65. Classification of the Panchayaths based on soil pollution

Sl. No.	Panchayaths	Index	Extent of water pollution
1	Puzhakkal	70.81	High
2	Alathur	66.37	Moderate
3	Puthur	63.11	Moderate
4	Pananchery	60	Low
5	Nadathara	61.93	Moderate
6	Madakkathara	64.15	Moderate

4.2.3 The extent of air pollution faced by the agricultural systems

Table 66 A set of 9 statements containing air pollution statements were used in the measurement. The statements are as shown in Table 79. below

Sl. No.	Statements	Indicated by
1	There is air pollution due to decomposition of animal carcasses	AP1
2	There is air pollution due to burning crop residues cause air pollution	AP2
3	There is air pollution due to trash and domestic waste burning	AP3
4	There is air pollution by the noises from heavy vehicles	AP4
5	There is air pollution due to automobile emissions	AP5
6	There is air pollution due to fumigant pesticide/fertilizers	AP6
7	There is air pollution due to emission from industries	AP7
8	There is air pollution due to excess use of nitrogenous fertilizers	AP8
9	There is air pollution due to exhaust fumes from agriculture machinery	AP9

Table 67. Distribution of the air pollution levels in Puzhakkal Panchayath

Sl. No.	Statements	No. of respondents					Index	Category
		HA	A	UD	D	HD		
1	AP1	0	1	2	9	3	42.66	**Low**
2	AP2	4	6	4	1	0	77.33	**Moderate**
3	AP3	4	7	4	0	0	82.666	**High**
4	AP4	1	9	5	0	0	85.333	**High**
5	AP5	0	7	6	2	0	70.66	**Moderate**
6	AP6	0	2	9	3	1	58.66	**Moderate**
7	AP7	0	5	7	3	0	66.66	**Moderate**
8	AP8	0	8	6	1	0	73.33	**Moderate**
9	AP9	0	2	9	3	1	58.66	**Moderate**
SD- 13.48							**Moderate**	

Table 68. Distribution of the air pollution levels in the rice based agricultural system of Alathur Panchayath

Sl. No.	Statements	No. of respondents					Index	Category
		HA	A	UD	D	HD		
1	AP1	0	0	9	5	1	50.66	**Low**
2	AP2	4	5	6	0	0	77.33	**High**
3	AP3	3	8	4	0	0	78.66	**High**
4	AP4	0	6	9	0	0	68	**Moderate**
5	AP5	0	5	9	1	0	65.33	**Moderate**
6	AP6	0	4	10	1	0	64	**Moderate**
7	AP7	0	1	8	5	1	52	**Low**
8	AP8	0	2	8	5	0	56	**Moderate**
9	AP9						57.33	**Moderate**
SD -10.22							64	**Moderate**

Table 70. Distribution of the air pollution levels in the banana based agricultural system of Puthur Panchayath

Sl. No.	Statements	No. of respondents					Index	Category
		HA	A	UD	D	HD		
1	AP1	1	2	7	5	0	58.66	**Low**
2	AP2	4	8	3	0	0	81.33	**High**
3	AP3	3	4	4	4	0	68	**Moderate**
4	AP4	1	9	3	2	0	72	**High**
5	AP5	0	3	10	2	0	61.33	**Moderate**
6	AP6	0	5	9	1	0	65.33	**Moderate**
7	AP7	2	4	7	2	0	68	**Moderate**
8	AP8	1	2	10	2	0	62.66	**Moderate**
9	AP9	1	6	6	2	0	68	**Moderate**
SD -6.67							67.25	**Moderate**

Table 71. Distribution of the air pollution levels in the banana based agricultural system of Pananchery Panchayath

Sl. No.	Statements	No. of respondents					Index	Category
		HA	A	UD	D	HD		
1	AP1	1	1	6	6	1	53.33	**Low**
2	AP2	0	2	10	3	0	58.66	**Medium**
3	AP3	2	4	6	3	0	66.66	**Medium**
4	AP4	0	2	7	5	1	53.33	**Low**
5	AP5	0	4	9	2	0	62.67	**Medium**
6	AP6	0	0	14	1	0	58.67	**Medium**
7	AP7	1	8	6	0	0	73.33	**Medium**
8	AP8	0	3	10	2	0	61.33	**Medium**
9	AP9						58.67	**Medium**
SD -10.22							60.74	**Medium**

Table 72. Distribution of the air pollution levels in the vegetable based agricultural system of Nadathara Panchayath

Sl. No.	Statements	No. of respondents					Index	Category
		HA	A	UD	D	HD		
1	AP1	0	2	7	5	1	53.33	**Moderate**
2	AP2	3	3	8	1	0	70.67	**High**
3	AP3	0	5	8	2	0	64	**Moderate**
4	AP4	0	3	5	6	1	53.33	**Moderate**
5	AP5	0	3	9	3	0	60	**Moderate**
6	AP6	0	1	9	4	1	53.33	**Moderate**
7	AP7	0	2	5	6	2	49.33	**Low**
8	AP8	0	5	8	2	0	64	**Moderate**
9	AP9	0	3	10	2	0	61.33	**Moderate**
SD -6.91							58.81	**Moderate**

Table 73. Distribution of the air pollution levels in the banana based agricultural system of Madakkathara Panchayath

Sl. No.	Statements	No. of respondents					Index	Category
		HA	A	UD	D	HD		
1	AP1	0	1	8	6	0	53.33	**Moderate**
2	AP2	0	7	8	0	0	69.33	**High**
3	AP3	0	3	11	1	0	62.67	**Moderate**
4	AP4	0	5	8	2	0	64	**Moderate**
5	AP5	0	4	7	4	0	60	**Moderate**
6	AP6	0	0	4	8	3	41.33	**Low**
7	AP7	0	0	10	5	0	53.33	**Moderate**
8	AP8	0	5	9	1	0	65.33	**Moderate**
9	AP9	1	5	6	3	0	65.33	**Moderate**
SD -8.67							59.40	**Moderate**

4.3 Ill effects of pollution as perceived by the stakeholders

In this section, it was attempted to find out the ill effects of pollution on agricultural systems based on the perception of all stakeholders from each Panchayath. The stakeholders were asked about their perception on three broad aspects of pollution threats i.e. “Due to Agro-intensive cultivation”, “Due to Integrated farming of crops with livestock” and “Due to farming system practices”, which contains 12, 7 and 9 statements respectively. The statements are shown below.

Sl. No.	Panchayaths	Index	Extent of air pollution
1	Puzhakkal	68.44	High
2	Alathur	64	Moderate
3	Puthur	67.25	High
4	Pananchery	60.74	Moderate
5	Nadathara	58.81	Low

Table 74. Statements showing the ill effects due to agri-intensive cultivation

Sl. No.	Due to agri-intensive cultivation
1	Water quality is hampered due to frequent use of pesticides
2	Water quality is affected by chemical fertilizers
3	Beneficial soil microbes are destroyed by chemical fertilizers
4	Debris from plastic mulching causes soil pollution
5	Use of fumigant pesticides cause air pollution
6	Residual toxicity is seen due to pesticide use
7	Soil pollution is caused due to indiscriminate pesticide use
8	Natural predators of pests are killed due to indiscriminate pesticide use
9	Air pollution is caused due to increased application of N and P fertilizers
10	Air pollution is caused due to the burning of agricultural by-products
11	There is a pest resistance and resurgence due to pesticide application
12	Respiratory diseases are caused due to the usage of power threshers

Table 75. Statements showing the ill effects due to integrated farming of crops with livestock

Sl. No.	Due to integrated farming of crops with livestock
1	Water pollution is caused due to livestock manure
2	Air pollution occurs due to noxious odour and methane from livestock waste
3	Environment is polluted due to poultry litter containing ammonia
4	Outbreaks and epidemics in human beings are caused due to uncleaned litter
5	Water is polluted due to application of fish feed
6	Water is polluted due to fish waste and debris
7	Soil pollution is caused due to repeated use of dairy waste in crops

Table 76. Statements showing the threat to human health due to farming system practices

Sl. No.	Due to farming system practices
1	Fluorosis is caused due to contaminated water
2	Blue baby syndrome due to water pollution is seen
3	Neurological disorders due to air and noise pollution is witnessed
4	Sterility disorders in crops are caused due to pollution
5	Automobile exhaust causes plant damage
6	Cardiovascular diseases are caused due to pollution
7	Bronchitis and asthma are caused due to pollution
8	Food poisoning and diarrhoea occur due to pollution
9	Overall unpleasantness in lifestyle as a consequence of pollution

The total score for each respondent was computed by summing the scores of all the statements in each category and the index was found for each respondent. The overall index was also found by summing the farmer responses for the three aspects and computing the index using the formula. Kruskal Wallis test was conducted to compare the ill effects of environmental pollution among the selected Panchayaths.

4.3.4 Comparison of ill effects of environmental threats on agricultural systems as perceived by the stakeholders from the six Panchayaths

The results from the Table 4.3.4 show that there were high statistically significant differences in the ill effects of environmental pollution in the six Panchayaths as perceived by all the stakeholders from the six Panchayaths. From the table, it could be interpreted that the ill effects experienced by the farmers due to „Threats faced due to Agri- intensive cultivation‟, „Threats faced due to Integrated farming of crops with livestock‟, and „Threats to human health due to farming system practices‟ showed a large and significant difference between the six Panchayaths. This reveals the heterogeneity of „perception of the farmers about ill effects of environmental pollution on agricultural systems‟ among the farmers of the six

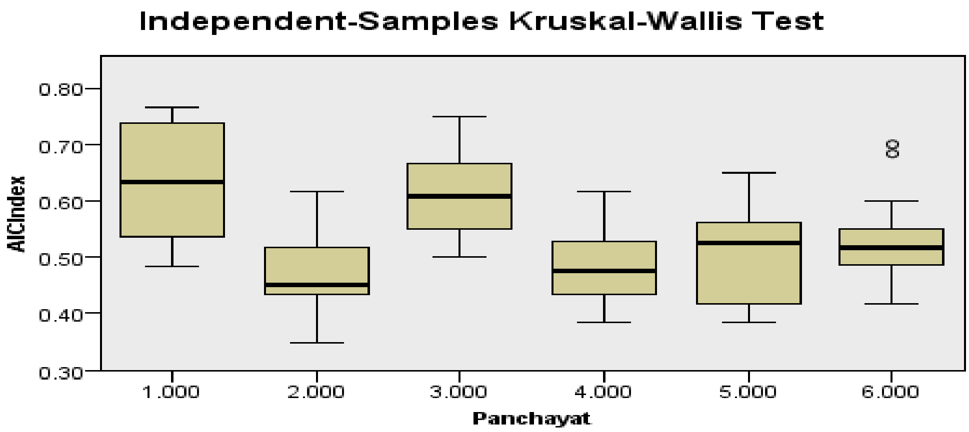
Panchayaths. This may be due to the different levels of exposure, sensitivity and adaptive capacity towards the hazards, by the different farming systems, which is further discussed in detail.

Table 77. Comparison of ill effects of environmental threats on agricultural systems as perceived by the stakeholders from the six Panchayaths

Sl. No.	Threats faced	Mean Rank						Kruskal Wallis H Value	p Value
		Puzhakkal	Alathur	Puthur	Panancher y	Nadat hara	Madakat hara		
1	T1	91.68	36.95	87.75	39.12	50.68	56.82	47.06S	0.000
2	T2	78.95	42.18	64.12	47.88	76.12	53.75	19.089S	0.002

3	T3	84.30	45.15	79.98	40.88	65.48	47.23	29.40S	0.001

S- Significant



Total N	120
Test Statistic	47.064
Degrees of Freedom	5
Asymptotic Sig. (2-sided test)	.000

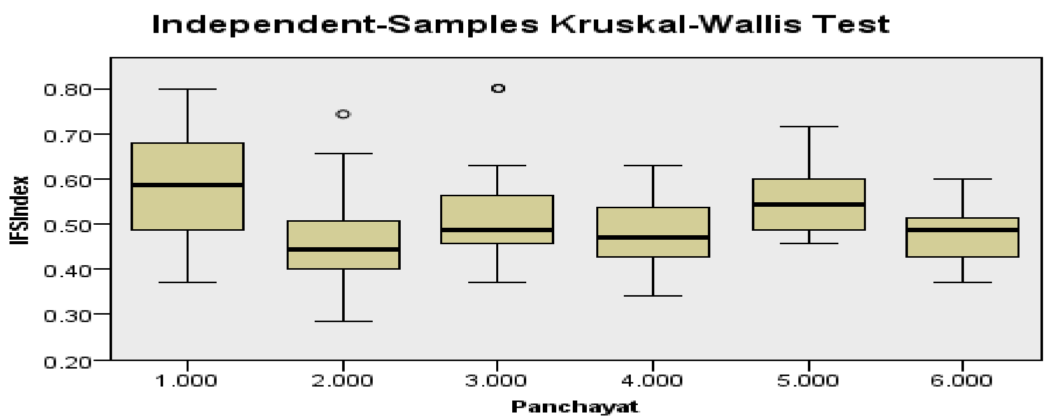
1. The test statistic is adjusted for ties.

Figure 2. Box plot of the six Panchayaths comparing ill effects due to agri-intensive cultivation

It could be interpreted from the Box Plot 1 that the box plot is comparatively short for the Panchayaths Madakkathara, Pananchery and Alathur. This indicates that all the stakeholders in these three Panchayaths have a high level of agreement with each other. **The box plot is comparatively taller for the Panchayaths of Puzhakkal, Nadathara and Puthur which**

indicates that there is a difference of opinion among all the stakeholders of these three Panchayaths.

Also, the six boxes show uneven median (mean rank) which indicates that there is a difference in agreement between the stakeholders across all the six Panchayaths.



Total N	120
Test Statistic	19.089
Degrees of Freedom	5
Asymptotic Sig. (2-sided test)	.002

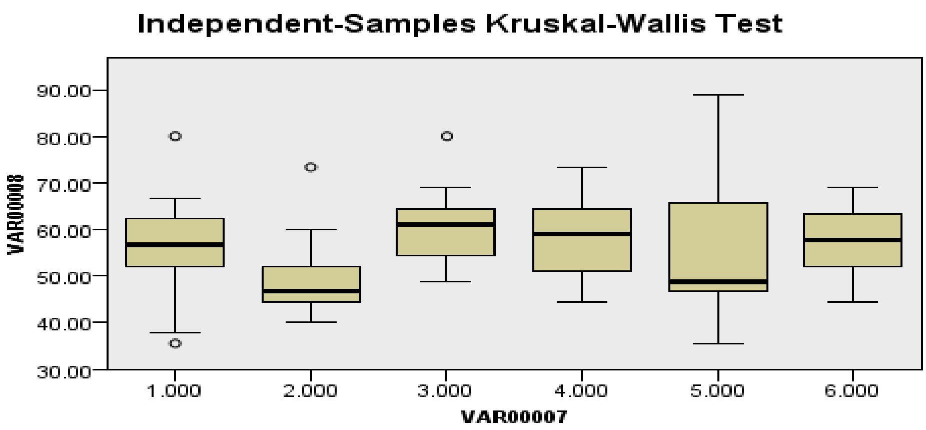
1. The test statistic is adjusted for ties.

Figure 3. Box plot of the six Panchayaths comparing ill effects due to integrated farming system

It could be interpreted from the Box Plot 2 that the box plot is short for the Panchayaths Madakkathara, Puthur, Pananchery,Alathur and Nadathara. This indicates that all the stakeholders in these five Panchayaths have a high level of agreement with each other.

The box plot is comparatively taller for the Panchayath of Puzhakkal, which indicates that there is a difference of opinion among all the stakeholders of the Panchayath.

The six boxes show uneven median (mean rank) which indicates that there is a difference in agreement between the stakeholders across all the six Panchayaths.



Total N	120
Test Statistic	20.120
Degrees of Freedom	5
Asymptotic Sig. (2-sided test)	.001

1. The test statistic is adjusted for ties.

Figure 4. Box plot of the six Panchayaths for threat to human health due to farming system practices

It could be interpreted from the Box Plot 3 that the box plot is comparatively short for the Panchayaths Alathur, Madakkathara, Puthur, Pananchery, and Puzhakkal. This shows that all the stakeholders in these five Panchayaths have a high level of agreement with each other.

The box plot is comparatively taller for the Panchayath of Nadathara, which indicates that there is a difference of opinion among all the stakeholders of the Panchayath. Also the six boxes indicate uneven median (mean rank) which indicates that there is a difference in agreement between the stakeholders across all the six Panchayaths.

4.4. Awareness of the farmers about the causes and effect of environmental pollution

4.4.1 Awareness of the farmers about the causes of environmental pollution

This was measured using a set of 8 statements about causes of pollution. The statements are as shown in Table 4.4.1.

Table 78. Statements on the awareness of the farmers about the causes of pollution faced by agricultural systems

Sl. No	Statement
1	The industrial sludge let into water bodies cause environmental pollution
2	Water quality is hampered due to fish wastes and uneaten feed from aquaculture practice
3	The plastic/domestic wastes dumped by civilians into water bodies causes pollution
4	The recurrent occurrence of wind and flood causes soil erosion
5	The improper burying of biomedical waste causes groundwater pollution
6	Disposal of the chemical pesticide and fertilizer containers near the field or water bodies pollutes them
7	The dumping of domestic wastes in and around the field pollutes the soil
8	The debris left behind from fishing activities pollute the water and destroy aquatic ecosystem

Table 79. Distribution of farmers based on their awareness about the causes of pollution

Separate indices for each farmer were computed using the total scores obtained by them, and were categorized into „High‟, „Medium‟ and „Low‟ awareness by using Mean and SD.

Sl. No.	Categories of awareness	Range of indices	Percentage
1	**Low**	**<45.07**	**18.89**
2	**Medium**	**45.07-79.09**	**60**
3	**High**	**>79.09**	**21.11**
Mean- 62.08			**SD- 17.01**

From the Table, it could be deduced that, 18.89 per cent of the farmers had low awareness about the causes of environmental pollution, while a majority of 60 per cent farmers had medium awareness about the causes of pollution. The percentage of farmers who had high awareness about the causes of pollution was 21.11 per cent.

4.4.2. Awareness of the farmers about the effect of pollution

This was measured by using a list of 8 statements as shown below in Table 4.4.2.

Table 80. Statements on the awareness of the farmers about the effects of pollution faced by agricultural systems

Sl. No.	Statements
1	Poor crop stand and yield is as a result of pollution
2	Presence of dead aquatic animals is a consequence of pollution
3	Respiratory diseases occur in the farmer and his family due to prolonged air pollution
4	Death of livestock and other farm animals occur due to pollution
5	Difficulty in carrying out agricultural operations in the field occurs due to pollution
6	Trash dumped around the field is the breeding ground for pests and diseases
7	Dead aquatic creatures are seen in water bodies due to leftover debris from fishing activities
8	Blue baby syndrome in infants is a consequence of water pollution

4.4.3 Distribution of farmers based on their awareness about the causes of pollution

Individual indices for each farmer were computed using the total scores obtained by them, and were categorized into „High", „Medium" and „Low" awareness by using Mean and SD.

Table 81. Distribution of farmers based on their awareness about the causes of pollution

Sl. No.	Categories of awareness	Range of indices	Percentage
1	Low	<45.18	0
2	Medium	45.18-76.46	17.78
3	High	>76.46	82.22
Mean- 60.82			SD-15.64

From the Table, it was revealed that that, none (0 per cent) of the farmers had low awareness about the effect of pollution, while 17.78 per cent farmers had medium awareness about the causes of pollution. A very high percentage of 82.22 per cent farmers showed high levels of awareness towards the effect of pollution.

4.5. Level of exposure, sensitivity and adaptive capacity of each agricultural system

4.5.1. Level of exposure of each agricultural system

The 15 paddy growing farmer respondents from each Panchayath were asked to respond to 9 statements on „exposure" of their farms to environmental pollution.

Table 82. The statements are given below

Sl. No.	Exposure	Indicated by
1	Agriculture sector has become more vulnerable due to environmental pollution	E1
2	There is an occurrence of pollution caused by both natural changes in environment and human activities	E2
3	Air, water and soil pollution affect the farming practices	E3
4	Pollution has emerged as a major problem in agriculture nowadays	E4
5	There is climate change due to pollution	E5
6	There is an uncertainty in rainfall as an indirect consequence of pollution	E6
7	Extreme weather events in the last few years have affected the adaptation and mitigation practices	E7
8	Biodiversity is threatened as a result of pollution	E8
9	There are dry spells associated with pollution	E9

Table 83. Distribution of exposure levels in rice based agricultural systems of Puzhakkal Panchayath

Sl. No.	Statements	Index	Category
1	E1	82.67	**High**
2	E2	85.33	**High**
3	E3	77.33	**Medium**
4	E4	80	**Medium**
5	E5	61.33	**Medium**
6	E6	72	**Medium**
7	E7	52	**Low**
8	E8	69.33	**Medium**
9	E9	62.67	**Medium**
SD-11.11		**Mean 71.4**	**Moderate**

Table 84. Distribution of exposure levels in rice based agricultural systems of Alathur Panchayath

Sl. No.	Statements	Index	Category
1	E1	68	**Medium**
2	E2	62.67	**Medium**
3	E3	66.67	**Medium**
4	E4	69.33	**High**
5	E5	40	**Low**
6	E6	65.33	**Medium**
7	E7	44	**Medium**
8	E8	33.33	**Low**
9	E9	49.33	**High**
	SD 13.79	Mean 55.43	**Medium**

Table 85. Distribution of exposure levels in Puthur Panchayath

Sl. No.	Statements	Index	Category
1	E1	74.67	**High**
2	E2	82.67	**High**
3	E3	73.33	**Medium**
4	E4	66.67	**Medium**
5	E5	56	**Medium**
6	E6	53.33	**Medium**
7	E7	53.33	**Medium**
8	E8	48	**Low**
9	E9	53.33	**Medium**
	SD 12.24	Mean 62.37	**Medium**

Table 86. Distribution of exposure levels in Pananchery Panchayath

Sl. No.	Statements	Index	Category
1	E1	72	**High**
2	E2	50.67	**Medium**
3	E3	74.67	**High**
4	E4	57.33	**Medium**
5	E5	40	**Low**
6	E6	44	**Medium**
7	E7	46.67	**Medium**
8	E8	54.67	**Medium**
9	E9	48	**Medium**
	SD- 12.03	**Mean 54.22**	**Medium**

Table 87. Distribution of exposure levels in vegetable based agricultural systems of Nadathara Panchayath

Sl. No.	Statements	Index	Category
1	E1	78.67	Medium
2	E2	76	Medium
3	E3	73.33	Medium
4	E4	73.33	Medium
5	E5	76	Medium
6	E6	53.33	Low
7	E7	61.33	Medium
8	E8	40	Low
9	E9	64	Medium
SD 12.89	Mean 66.2		Medium

Table 88. Distribution of exposure levels in Madakkathara Panchayath

Sl. No.	Statements	Index	Category
1	E1	61.33	High
2	E2	57.33	Medium
3	E3	57.33	Medium
4	E4	49.33	Medium
5	E5	46.67	Medium
6	E6	38.67	Medium
7	E7	33.33	Low
8	E8	36	Low
9	E9	46.67	Medium
	SD- 10.00 Mean-47.40		Medium

4.5.2 Ranking the statements for each Panchayath based on mean rank as scored by the farmers

Table 89. Rank of exposure statements of Puzhakkal Panchayath

Sl. No.	Exposure statements	Mean Score	Rank
1	E2	6.97	1
2	E1	6.33	2
3	E4	6.3	3
4	E3	5.7	4
5	E6	5.23	5
6	E8	4.57	6
7	E9	3.83	7
8	E5	3.5	8
9	E7	2.57	9

W-0.334 NS

According to the table the statement E2 was ranked the highest by the paddy growing farmers of Puzhakkal *Kole* Panchayath. This was followed by statements E1 and E4. The exposure statement ranked the least was E7.

Table 90. Rank of exposure statements of Alathur Panchayath

Sl. No.	Exposure statements	Mean Score	Rank
1	E4	6.8	1
2	E1	6.47	2
3	E6	6.3	3
4	E3	6.17	4
5	E2	6.1	5
6	E9	4.4	6
7	E7	3.17	7
8	E5	3.1	8
9	E8	2.5	9

W-0.459

Table 91. Rank of exposure statements of Puthur Panchayath

Sl. No.	Exposure statements	Mean Score	Rank
1	E2	7.53	1
2	E1	6.63	2
3	E3	6.4	3
4	E4	5.53	4
5	E5	4.27	5
6	E6	3.93	6
7	E7	3.73	7
8	E9	3.7	8
9	E8	3.27	9

W-0.377

The table reveals that the highest ranked exposure statements by the banana farmers of Puthur Panchayath are E2, E1 and E3. The least ranked statement was E8.

Table 92. Rank of exposure statements of Pananchery Panchayath

Sl. No.	Exposure statements	Mean Score	Rank
1	E1	7.17	1
2	E3	7.13	2
3	E4	5.5	3
4	E8	4.77	4
5	E2	4.7	5
6	E7	4.47	6
7	E9	4.27	7
8	E6	3.73	8
9	E5	3.27	9

W-0.297

Table 93. Rank of exposure statements of Nadathara Panchayath

Sl. No.	Exposure statements	Mean Score	Rank
1	E1	6.47	1
2	E5	6.33	2
3	E2	6.1	3
4	E3	5.87	4
5	E4	5.73	5
6	E9	4.47	6
7	E7	4.43	7
8	E6	3.6	8
9	E8	2	9

W-0.339

It can be observed from the table that the exposure statements that were more experienced by the vegetable farmers of Nadathara Panchayath were E1, E5 and E2 in that order, while E8 was the least experienced by the farmers.

Table 94. Rank of exposure statements of Madakkathara Panchayath

Sl. No.	Exposure statements	Mean Score	Rank
1	E1	6.5	1
2	E2	6.4	2
3	E3	6.3	3
4	E4	5.5	4
5	E5	5.07	5
6	E9	5.03	6
7	E6	3.8	7
8	E8	3.27	8
9	E7	3.13	9

W-0.273

It can be observed from the table that the exposure statements that were more experienced by the vegetable farmers of Madakkathara Panchayath were E1, E2 and E3 in that order, while E7 was the least experienced by the farmers.

Sl. No.	**Panchayaths**	**Composite index**	**Levels of exposure**
1	**Puzhakkal**	**71.4**	**High**
2	**Alathur**	**55.43**	**Moderate**
3	**Puthur**	**62.37**	**Moderate**
4	**Pananchery**	**54.22**	**Moderate**
5	**Nadathara**	**66.2**	**Moderate**
6	**Madakkathara**	**47.4**	**Low**

Table 95. Comparison of the ranks of exposure statements between the six Panchayaths

Sl. No.	Ranks	Puzhakkal	Alathur	Puthur	Pananchery	Nadathara	Madakkathara
1	1	E2	E4	E2	E1	E1	E1
2	2	E1	E1	E1	E3	E5	E2
3	3	E4	E6	E3	E4	E2	E3
4	4	E3	E3	E4	E8	E3	E4
5	5	E6	E2	E5	E2	E4	E5
6	6	E8	E9	E6	E7	E9	E9
7	7	E9	E7	E7	E9	E7	E6
8	8	E5	E5	E9	E6	E6	E8
9	9	E7	E8	E8	E5	E8	E7
	W	0.334	0.459	0.377	0.297	0.339	0.273

Comparing the columns for the different Panchayaths, it could be observed that E1 was the highest ranked statement in Pananchery, Nadathara and Madakkathara Panchayaths.

E2 was the highest ranked statement in Puzhakkal and Puthur. E1 was the second highest ranked statement in the three Panchayaths of Puzhakkal, Alathur, and Puthur.

E3 was the third highest ranked statement in both Puthur and Madakkathara, while E4 was for Puzhakkal and Pananchery. E8 was the least ranked statement in the three Panchayaths, *viz.* Alathur, Puthur and Nadathara, while E7 was the least ranked statement by Puzhakkal and Madakkathara farmers.

The low W values in all the six Panchayaths indicate that there is very less agreement between the farmers of each Panchayath in ranking the exposure statements.

4.5.3. Level of sensitivity of each agricultural system

The 15 farmer respondents from each Panchayath were asked to respond to 7 statements on „sensitivity" of their farms to environmental pollution. The statements were classified into high, medium using Mean and SD.

Table 96. The statements are given in table

Sl. No.	Sensitivity	Indicated by
1	There is an increased incidence of weeds and insect pest attacks than earlier times	S1
2	There is a decrease in production due to pollution	S2
3	There is increased deforestation as a consequence of pollution	S3
4	There is an increase in soil erosion	S4
5	There is extinction of plant and animal species due to pollution	S5
6	Livestock rearing has become vulnerable because of pollution	S6
7	Productive capacity of livestock is adversely affected due to extreme pollution	S7

Table 97. Level of sensitivity of Puzhakkal

Sl. No.	Statements	Index	Category
1	S1	74.67	**High**
2	S2	65.33	**Medium**
3	S3	62.67	**Medium**
4	S4	72	**Medium**
5	S5	45.33	**Medium**
6	S6	41.33	**Medium**
7	S7	46.67	**Low**
		SD 14.22 Mean54.51	**Medium**

Table 98. Level of sensitivity of rice based agricultural systems in Alathur Panchayath

Sl. No.	Statements	Index	Category
1	S1	64	**Medium**
2	S2	49.33	**Medium**
3	S3	52	**Medium**
4	S4	68	**High**
5	S5	34.67	**Low**
6	S6	42.67	**Medium**
7	S7	61.33	**Medium**
SD 11.96	**Mean 58.29**		**Medium**

Table 98. Level of sensitivity of Puthur Panchayath

Sl. No.	Statements	Index	Category
1	S1	61.33	**Medium**
2	S2	73.33	**High**
3	S3	57.33	**Medium**
4	S4	64	**Medium**
5	S5	50.67	**Medium**
6	S6	50.67	**Medium**
7	S7	50.67	**Medium**
SD 10.88	**Mean 58.28**		**Medium**

Table 99. Level of sensitivity of banana based agricultural systems in Pananchery Panchayath

Sl. No.	**Statements**	**Index**	**Category**
1	S1	57.33	**Medium**
2	S2	49.33	**Medium**
3	S3	52	**Medium**
4	S4	66.67	**High**
5	S5	46.67	**Low**
6	S6	58.67	**Medium**
7	S7	62.67	**Medium**
SD 9.45	Mean 56.19		**Medium**

Table 100. Level of sensitivity of vegetable based agricultural systems in Nadathara Panchayath

Sl. No.	**Statements**	**Index**	**Category**
1	S1	74.67	High
2	S2	68	Medium
3	S3	45.33	Medium
4	S4	48	Medium
5	S5	42.67	Low
6	S6	61.33	Medium
7	S7	62.67	Medium
	Mean	57.52	Medium
SD 13.52			Medium

Table 101. Level of sensitivity of vegetable based agricultural systems in Madakkathara Panchayath

Sl. No.	Statements	Index	Category
1	S1	57.33	Medium
2	S2	56	Medium
3	S3	56	Medium
4	S4	58.67	Medium
5	S5	36	Low
6	S6	60	Medium
7	S7	57.33	Medium
SD 9.59 Mean 54.48			Medium

Table 102 Moderate levels of sensitivity were observed in Madakathara Panchayath, based on the results from the table.

Sl. No.	**Panchayaths**	**Composite index**	**Levels of exposure**
	Panchayaths	**Composite index**	**Levels of sensitivity**
1	**Puzhakkal**	**54.51**	**Low**
2	**Alathur**	**58.29**	**Moderate**
3	**Puthur**	**58.28**	**Moderate**
4	**Pananchery**	**56.19**	**Moderate**
5	**Nadathara**	**57.52**	**Moderate**
6	**Madakkathara**	**54.48**	**Low**

4.5.4 Ranking of sensitivity statements for each Panchayath

Ranking is done based on the mean rank scores of each statement based on farmer‟s scores

Table 103. Ranking of statements for Puzhakkal Panchayath

Sl. No.	Sensitivity statements	Mean Score	Rank
1	S1	5.4	1
2	S4	5.4	2
3	S2	4.83	3
4	S3	4.4	4
5	S5	2.9	5
6	S7	2.8	6
7	S6	2.27	7

Table 104. Ranking of statements for Alathur Panchayath

Sl. No.	Sensitivity statements	Mean Score	Rank
1	S3	5.4	1
2	S1	5.1	2
3	S6	5	3
4	S2	3.87	4
5	S4	3.63	5
6	S7	2.97	6
7	S5	2.03	7

The data from the Table reveals that, S3 and S1 are the highest ranked statements by the paddy farmers of Alathur Panchayath, followed by S6. The statement given the least preference was S5.

Table 105. Ranking of statements for Puthur Panchayath

Sl. No.	Sensitivity statements	Mean Score	Rank
1	S2	5.63	1
2	S4	4.83	2
3	S1	4.33	3
4	S3	3.67	4
5	S6	3.3	5
6	S7	3.17	6
7	S5	3.07	7

The results from table reveal that the highest ranked statement by the banana farmers of Puthur Panchayath was S2, followed by S4 and S1. The statement given the least preference in ranking was S5

Table 106. Ranking of statements for Pananchery Panchayath

Sl. No.	Sensitivity statements	Mean Score	Rank
1	S4	5	1
2	S7	4.47	2
3	S6	4.23	3
4	S1	4.13	4
5	S3	3.73	5
6	S2	3.57	6
7	S5	2.87	7

The data from the table reveals that the highest rank was observed for the statements S4 and S7, followed by S6, while the least ranked statement was S5, for the Pananchery Panchayath, ranked by the banana farmers.

Table 107. Ranking of statements for Nadathara Panchayath

Sl. No.	Sensitivity statements	Mean Score	Rank
1	S1	5.77	1
2	S2	5.07	2
3	S6	4.53	3
4	S7	4.53	4
5	S4	3.03	5
6	S3	2.63	6
7	S5	2.43	7

S1 was the highest ranked statement by the vegetable farmers of Nadathara Panchayath as shown in the Table. This was followed by S2 and S6. S5 was the least ranked statement.

Table 108. Ranking of statements for Madakkathara Panchayath

Sl. No.	Sensitivity statements	Mean Score	Rank
1	S6	4.57	1
2	S4	4.5	2
3	S1	4.43	3
4	S7	4.27	4
5	S3	4.1	5
6	S2	3.97	6
7	S5	2.17	7

Statement 6 was ranked the highest by the vegetable farmers of Madakkathara Panchayath, which was succeeded by S4 and S1. S5 was ranked the lowest.

Table 109. Comparison of the ranks of sensitivity statements between the six Panchayaths

Sl. No.	Ranks	Puzhakkal	Alathur	Puthur	Panchry	Nadathara	Madakkathara
1	1	S1	S3	S2	S4	S1	S6
2	2	S4	S1	S4	S7	S2	S4
3	3	S2	S6	S1	S6	S6	S1
4	4	S3	S2	S3	S1	S7	S7
5	5	S5	S4	S6	S3	S4	S3
6	6	S7	S7	S7	S2	S3	S2
7	7	S6	S5	S5	S5	S5	S5
		W-0.441	W-0.405	W-0.254	W-0.123	W-0.426	W- 0.192

It can be observed from the table that, S1 was the highest ranked statement in both Puzhakkal and Nadathara, while S4 was the second highest ranked statement in the three Panchayaths of Puzhakkal, Puthur and Madakkathara.

S6 was the third ranked statement in Alathur Pananchery and Nadathara, while S1 was in Puthur and Madakkathara. A high majority of 5 Panchayaths had S5 as the least ranked statement.

All the 6 Panchayaths show non low Kendall‟s coefficient of concordance for the mean scores, indicating there is less agreement among the farmers of each Panchayath in ranking the sensitivity statements.

4.5.5. Level of adaptive capacity of each agricultural system

A list of 4 statements on adaptive capacity was given to farmers and the responses were scored. The statements are given below in Table 110.

Sl. No.	Adaptive capapcity	Indicated by
1	Farmers resort to change in cropping pattern and cropping seasons	A1
2	Farmers change their livelihood pattern	A2
3	Farmers change their crop choice and crop cycle	A3
4	Farmers change their land use pattern	A4

Table 111. Level of adaptive capacity of rice based systems in Puzhakkal Panchayath

Sl. No.	Statements	Index	Category
1	A1	64	Medium
2	A2	45.33	Medium
3	A3	49.33	Medium
4	A4	58.67	Medium
	Mean-54.33	SD-8.55	Medium

Table 112. Level of adaptive capacity of Alathur Panchayath

Sl. No.	Statements	Index	Category
1	A1	56	Low
2	A2	58.66667	Medium
3	A3	62.66667	High
4	A4	61.33333	Medium
	Mean 59.66	SD 2.95	Medium

The table shows that medium adaptive capacity was possessed by Alathur Panchayath.

Table 113. Level of adaptive capacity of banana based systems in Puthur Panchayath

Sl. No.	Statements	Index	Category
1	A1	62.67	High
2	A2	52	Medium
3	A3	50.67	Medium
4	A4	57.33	Medium
	Mean 55.66	SD 5.48	Medium

Table 114. Levels of adaptive capacity of banana based systems in Pananchery Panchayath

Sl. No.	Statements	Index	Category
1	A1	49.33	Medium
2	A2	50.67	Medium
3	A3	50.67	Medium
4	A4	38.67	Low
	Mean 47.33	SD 5.81	Medium

Pananchery Panchayath had medium level of adaptive capacity as deduced from the table.

Table 115. Levels of adaptive capacity of vegetable based systems in Nadathara Panchayath

Sl. No.	Statements	Index	Category
1	A1	40	Low
2	A2	54.67	Medium
3	A3	49.33	Medium
4	A4	53.33	Medium
	Mean 49.33	SD 6.62	Medium

Table 116. Levels of adaptive capacity of vegetable based systems in Madakkathara Panchayath

Sl. No.	Statements	Index	Category
1	A1	50.67	Medium
2	A2	49.33	Medium
3	A3	50.67	Medium
4	A4	46.67	Low
	SD 1.88	Mean 49.33	Medium

Sl. No.	Panchayaths	Composite index	Levels of adaptive capacity
1	**Puzhakkal**	**54.33**	**Moderate**
2	**Alathur**	**59.66**	**High**
3	**Puthur**	**55.66**	**Moderate**
4	**Pananchery**	**47.33**	**Low**
5	**Nadathara**	**49.33**	**Moderate**
6	**Madakkathara**	**49.33**	**Moderate**

4.5.6. Ranking of adaptive capacity statements of each Panchayath

The statements of adaptive capacity for each Panchayath were ranked based on their mean rank scores as scored by the farmer respondents.

Ranking of adaptive capacity statements of Puzhakkal Panchayath

Sl. No.	Statement	Mean Score	Rank
1	**A1**	**3.27**	**1**
2	**A4**	**2.57**	**2**
3	**A3**	**2.2**	**3**
4	**A2**	**1.97**	**4**

W-0.250

Ranking of adaptive capacity statements of Alathur Panchayath

Sl. No.	Statement	Mean Score	Rank
1	A4	2.6	**1**
2	A3	2.8	**2**
3	A2	2.33	**3**
4	A1	2.27	**4**

W-0.058

Ranking of adaptive capacity statements of Puthur Panchayath

Sl. No.	Statement	Mean Score	Rank
1	A1	3	**1**
2	A4	2.67	**2**
3	A2	2.17	**3**
4	A3	2.17	**4**

W- 0.126

Ranking of adaptive capacity statements of Pananchery Panchayath

Sl. No.	Statement	Mean Score	Rank
1	A2	2.67	**1**
2	A1	2.57	**2**
3	A3	2.53	**3**
4	A4	2.23	**4**

W- 0.028

Ranking of adaptive capacity statements of Nadathara Panchayath

Sl. No.	Statement	Mean Score	Rank
1	A2	2.83	**1**
2	A4	2.77	**2**
3	A3	2.5	**3**
4	A1	1.9	**4**

W-0.133

Ranking of adaptive capacity statements of Madakkathara Panchayath

Sl. No.	Statement	Mean Score	Rank
1	A1	2.67	**1**
2	A3	2.6	**2**
3	A2	2.43	**3**
4	A4	2.3	**4**

W- 0.021

Table 110. Comparison of the ranks of adaptive capapcity statements between the six Panchayaths

Sl. No.	Ranks	Puzhakkal	Alathur	Puthur	Pananchery	Nadathara	Madakkathara
1	1	A1	A4	A1	A2	A2	A1
2	2	A4	A3	A4	A1	A4	A3
3	3	A3	A2	A2	A3	A3	A2
4	4	A2	A1	A3	A4	A1	A4
	W	0.250	0.058	0.126	0.028 S	0.133	0.021

The results from the table show that A1 was the highest ranked statement in Puzhakkal, Puthur and Madakkathara, while A2 was the highest ranked statement in Pananchery and Nadathara.

The second highest ranked statement was A4 in the three Panchayaths of Puzhakkal, Puthur and Nadathara, while A3 was for Alathur and Madakkathara. A4 was the least ranked statement for the two Paanchayaths,Pananchery and Madakkathara, while, A1 was for Alathur and Nadathara.

Based on Kendall‟s coefficient of concordance, W values it could be inferred from Table 4.5.6.7 that, there was extremely low agreement among the farmers of all the six Panchayath in ranking the adaptive capapcity statements .

4.6 Assessment of vulnerability with exposure, sensitivity and adaptive capacity

The exposure index, sensitivity index and adaptive capacity indices were computed for each Panchayath by finding the individual index for each farmer and computing the composite index from the index values. Vulnerability index for each Panchayath was computed using the exposure index, sensitivity index and adaptive capacity index of each Panchayath. The respective indices for each Panchayath is shown in Table 4.6.

Table 112. Vulnerability index of each Panchayath using exposure sensitivity and adaptive capacity index

Sl. No.	Panchayath	Exposure index	Sensitivity index	Adaptive capacity index	Vulnerability index
1	Puzhakkal	71.40	58.28	54.33	75.35
2	Alathur	55.40	53.142	59.67	48.88
3	Puthur	62.37	58.28	55.67	64.95
4	Pananchery	54.22	56.19	47.33	63.08
5	Nadathara	66.22	57.52	49.33	74.41
6	Madakkathara	47.40	54.47	49.33	52.55

4.6.1 Graphs comparing exposure, sensitivity and adaptive capacity to vulnerability of the six Panchayaths

A comparison between exposure, sensitivity and adaptive capacity can be depicted using the bar diagram as shown below.

In the graphs depicted below, the „x" axis indicates the six Panchayaths numbered as 1 – Puzhakkal, 2 - Alathur, 3 - Puthur, 4 – Pananchery, 5 – Nadathara, 6 – Madakkathara, and „y" axis indicates the respective exposure, sensitivity, adaptive capacity and vulnerability indices of the Panchayaths.

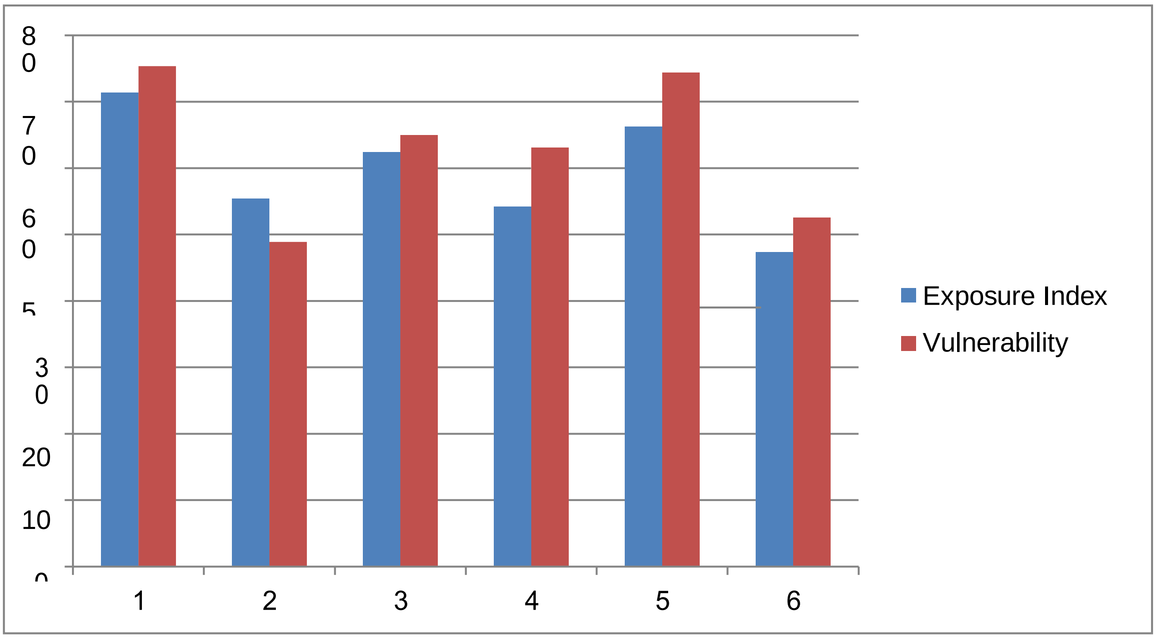


Figure 5. Bar graph depicting comparison of the exposure to vulnerability for the six Panchayaths

From graph 3, it can be inferred that, as perceived by the farmers, Puzhakkal had the highest vulnerability and exposure, followed by Nadathara Panchayath. The Panchayaths of Puthur and Pananchery had lesser vulnerability and lesser exposure than Puzhakkal and Nadathara. Lowest vulnerability and exposure was seen for Alathur and Madakkathara. Thus it can be concluded that as exposure increases, vulnerability also increases.

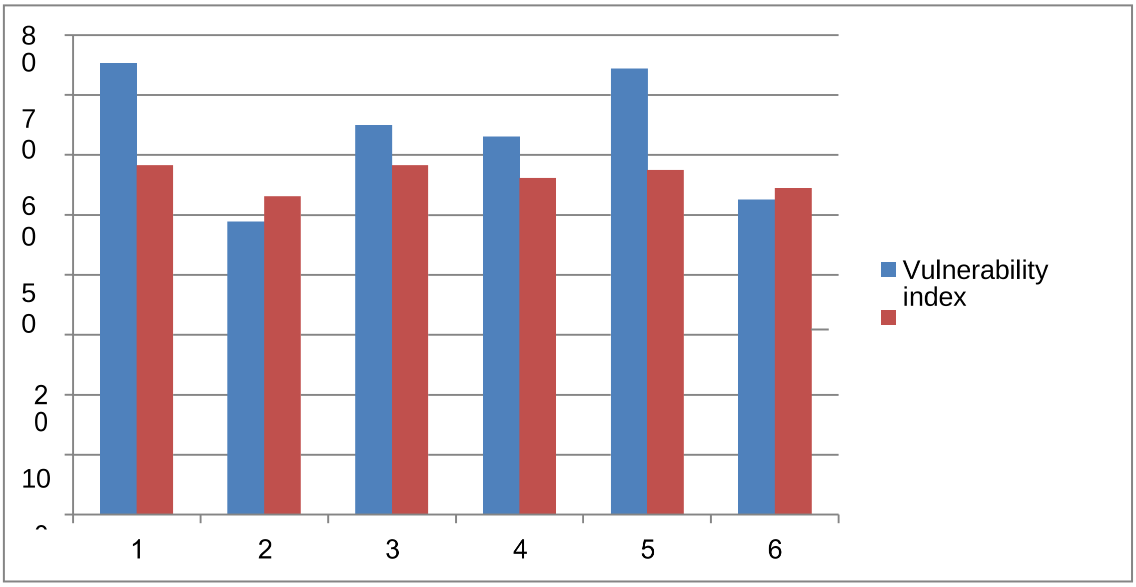


Figure 6. Bar Graph with Comparison of the sensitivity to vulnerability for the six Panchayaths

The bar graph indicates that as perceived by the farmers,Alathur Panchayath has a very low degrees of sensitivity and vulnerability, followed by Madakkathara. Lesser vulnerability was seen in Puthur and Pananchery with lesser sensitivity. The Panchayaths Puzhakkal snd Nadathara showing the highest sensitivity also possessed the highest sensitivity to environmental pollution. Thus it could be inferred that vulnerability increases with sensitivity.

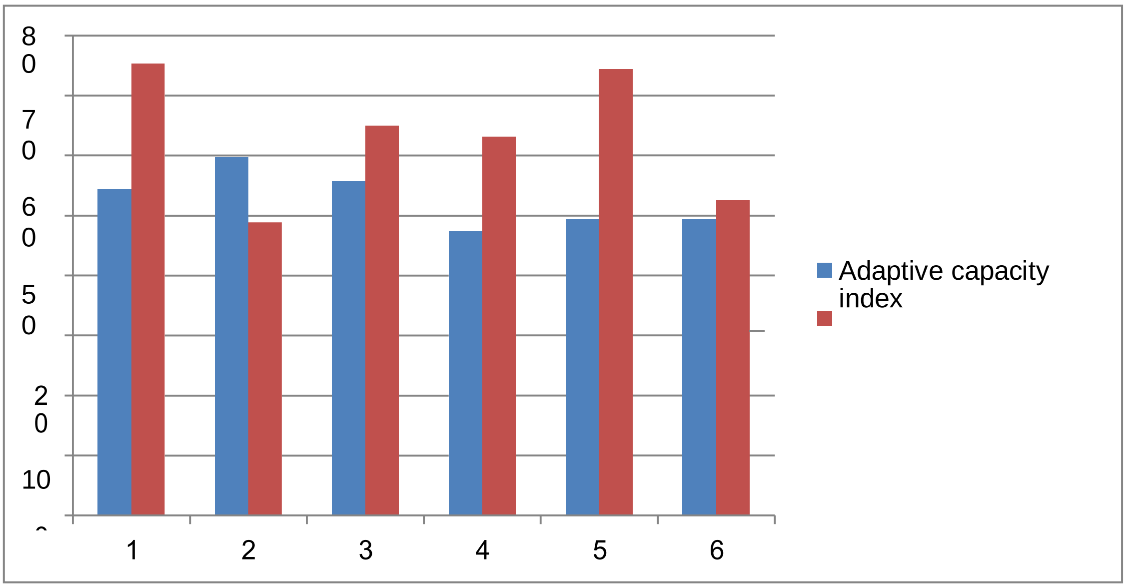


Figure 7. Comparison of the adaptive capacity to vulnerability for the six Panchayaths

The bar graph 7 shows that as perceived by the farmers, the Panchayath having the highest adaptive capacity, *i.e.* Alathur showed the least vulnerability. Madakkathara and Pananchery with high adaptive capacity had lower vulnerability. Puzhakkal and Nadathara, possessing the highest vulnerability had low adaptive capacity. Thus it is revealed that adaptive capacity is inversely related to vulnerability, *i.e.* vulnerability decreases as adaptive capacity increases.

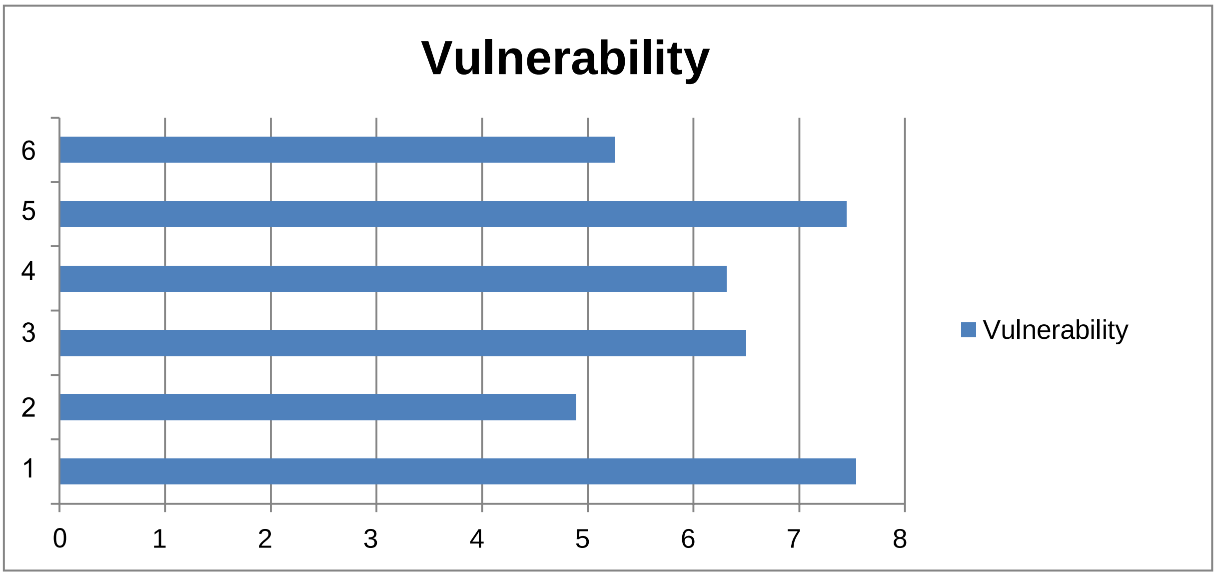
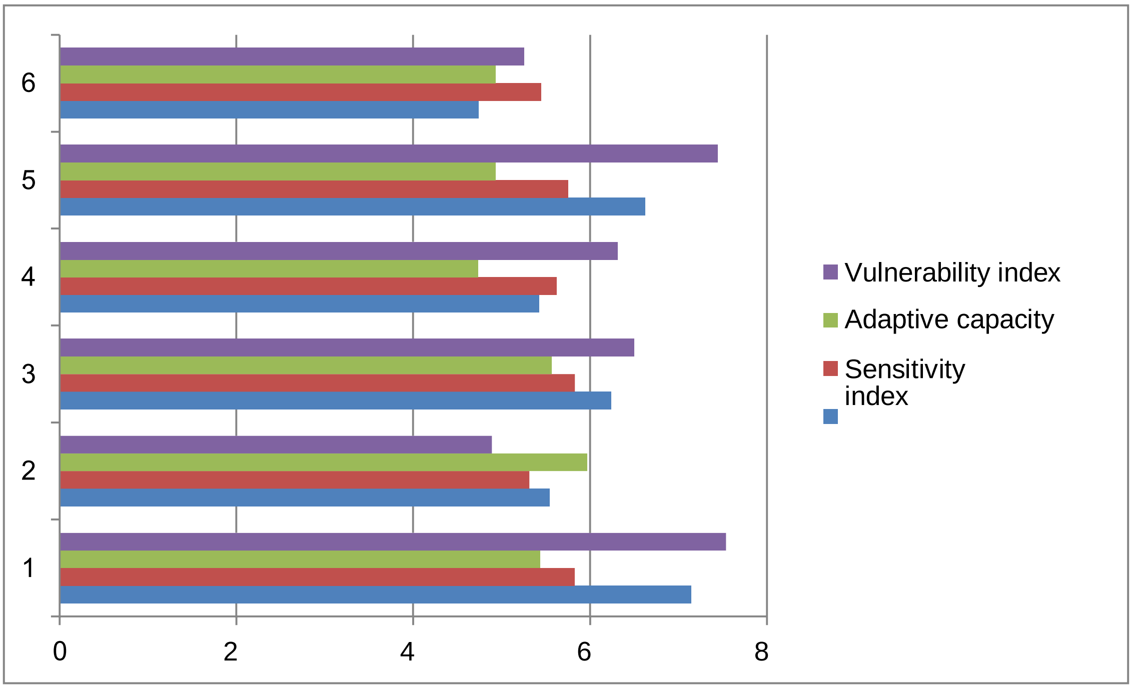


Figure 8. Vulnerability index of the six Panchayaths

It could be inferred from the bar graph that the Panchayath most vulnerable to environmental pollution as perceived by the farmers is Puzhakkal *Kole* Panchayath, followed by Nadathara and Puthur. Alathur was the least vulnerable Panchayath, followed by Madakkathara.



Graph 7. Comparison of vulnerability indices of all the six Panchayaths with respective exposure, sensitivity and adaptive capacity indices

The bar graph comparing all the four indices of the six Panchayaths concludes that vulnerability increases with exposure and sensitivity, but is moderated by adaptive capacity.

High vulnerability is seen in Puzhakkal and Nadathara, which also shows high degree of exposure and sensitivity. The least vulnerable Panchayath was Alathur, which possessed the highest adaptive capacity and low exposure and sensitivity, followed by Madakkathara with the least exposure and low sensitivity.

Puzhakkal

4.6.2. Classification of the Panchayaths based on vulnerability index

Therefore, based on perceived vulnerability of the farming system to environmental pollutionthe six Panchayaths can be ranked as as shown in Table 4.6.2 and the Panchayaths can be classified based on their levels of vulnerability using mean as SD.

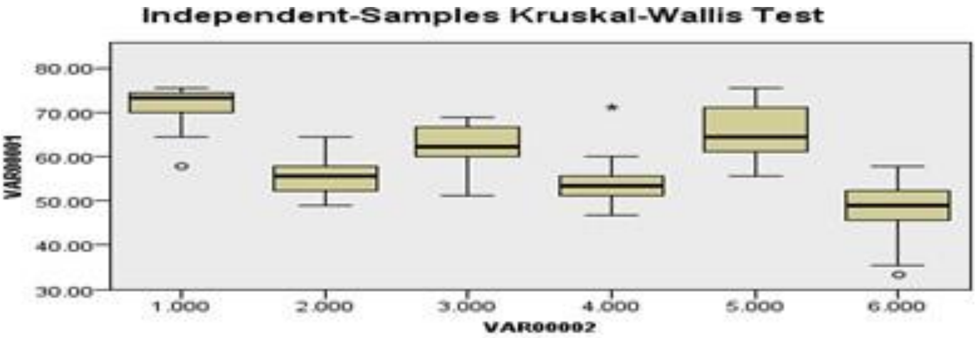
Classification of the Panchayaths based on vulnerability index

Sl. No.	Rank	Panchayath	Vulnerability index	Levels
1	**1**	Puzhakkal	75.35	High
2	**2**	Nadathara	74.41	High
3	**3**	Puthur	64.95	Modera te
4	**4**	Pananchery	63.08	Modera te
5	**5**	Madakkathara	52.55	Modera te
6	**6**	Alathur	48.88	Low

Based on the perception of the farmers, Puzhakkal and Nadathara Panchayaths showed high levels of vulnerability, while Puthur, Pananchery and Madakkathara showed medium levels. Low vulnerability was seen in Alathur Panchayath.

4.6.3 Comparison of Panchayaths using Kruskal Wallis test

The results from Table 4.6.3 indicate that there exists statistically significant difference in the distribution of exposure, adaptive capacity and vulnerability levels across the six Panchayaths as the farmers have perceived. This may be due to the difference in farming practices, and pollution hazard management strategies implemented in the Panchayaths. The sensitivity levels across the six Panchayaths were found to be similar, and may be due to similar socioeconomic characters of the respondent farmers.



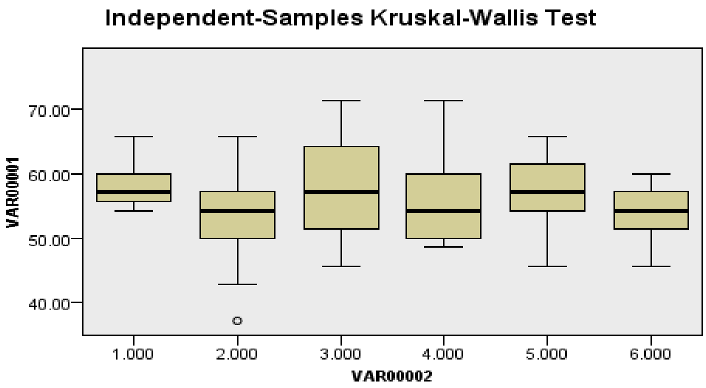
Total N	90
Test Statistic	60.462
Degrees of Freedom	5
Asymptotic Sig. (2-sided test)	.000

1. The test statistic is adjusted for ties.

Box Plot 4. Box plot comparing exposure levels of the Panchayaths

It could be interpreted from the Box Plot 4 that the box plot is short comparatively for the Panchayaths Puzhakkal, Pananchery and Alathur indicating that all the farmers in these four Panchayaths have a high level of agreement with each other. **The box plot is comparatively taller for the Panchayath of Nadathara, which indicates that there is a difference of opinion among all the farmers of the Panchayath.**

The six boxes show uneven median (mean rank) which indicates that there is a difference in agreement between the farmers across all the six Panchayaths about the exposure levels of their farms to pollution.



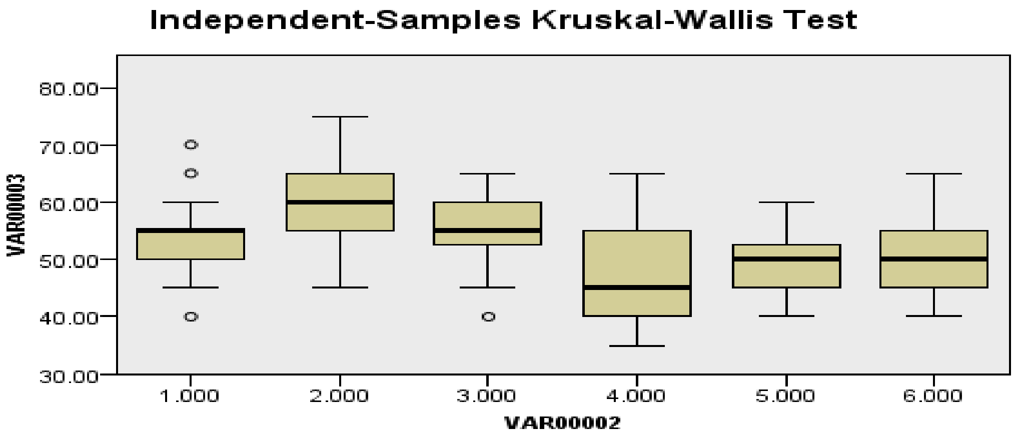
Total N	90
Test Statistic	8.478
Degrees of Freedom	5
Asymptotic Sig. (2-sided test)	.132

1. The test statistic is adjusted for ties.
2. Multiple comparisons are not performed because the overall test does not show significant differences across samples.

Box Plot 5. Box plot comparing sensitivity levels of the Panchayaths

It could be interpreted from the Box Plot 5. that the box plot is short comparatively for the Panchayaths Puzhakkal, and Madakkathara, indicating that all the farmers in these two Panchayaths have a high level of agreement with each other**.** The box plot is comparatively taller for the Panchayath of Puthur and Pananchery which indicates that there is a difference of opinion among all the farmers of these two Panchayath regarding sensitivity levels.

The six boxes show almost even median (mean rank) which indicates that there is a considerable similarity in agreement between the farmers across all the six Panchayaths about the sensitivity levels of their farms to pollution.



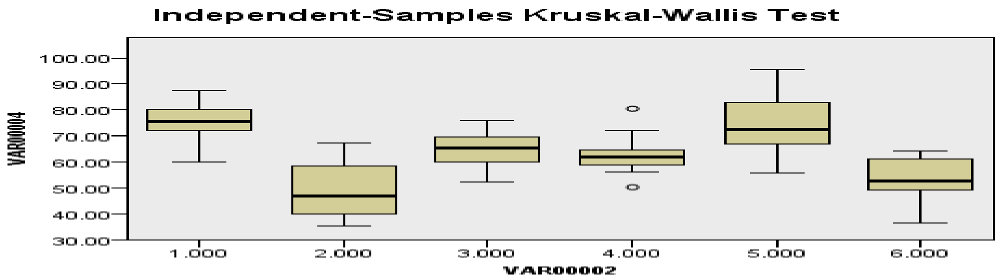
Total N	90
Test Statistic	21.885
Degrees of Freedom	5
Asymptotic Sig. (2-sided test)	.001

1. The test statistic is adjusted for ties.

Figure 9. Box plot comparing adaptive capacity levels of the Panchayaths

It could be interpreted from the Box Plot 6. that the box plot is short comparatively for the Panchayaths Puzhakkal, Nadathara, and Puthur indicating that all the farmers in these three Panchayaths have a high level of agreement with each other. The box plot is comparatively taller for the Panchayath of Pananchery which indicates that there is a difference of opinion among all the farmers of this Panchayath regarding the levels of adaptive capacity.

The six boxes show uneven median (mean rank) which indicates that there is a difference in agreement between the farmers across all the six Panchayaths about the adaptive capacity levels of their farms to pollution.



Total N	90
Test Statistic	50.776
Degrees of Freedom	5
Asymptotic Sig. (2-sided test)	.000

1. The test statistic is adjusted for ties.

Figure 10. Box plot comparing vulnerability levels of the Panchayaths

It could be interpreted from the Box Plot 7. that the box plot is short comparatively for the Panchayaths Pananchery, Puzhakkal and Puthur indicating that all the farmers in these three Panchayaths have a high level of agreement with each other.

The box plot is comparatively taller for the Panchayath of Puthur and Nadathara which indicates that there is a difference of opinion among all the farmers of this Panchayath regarding the levels of overall.

The six boxes show uneven median (mean rank) which indicates that there is a difference in agreement between the farmers across all the six Panchayaths about the overall vulnerability levels of their farms to pollution.

Table 114 Contribution of each factor towards the overall perceived vulnerability of the farmers

Sl. No.		**Mean score**	**Kruskal Wallis H Value**	**p Value**
		High	**Medium**	**Low**
1	**Exposure**	**76.88**	**43.59**	**17.33**
2	**Sensitivity**	66.29	45.97	20.13
3	**Adaptive capacity**	57.06	49.51	**16.90**

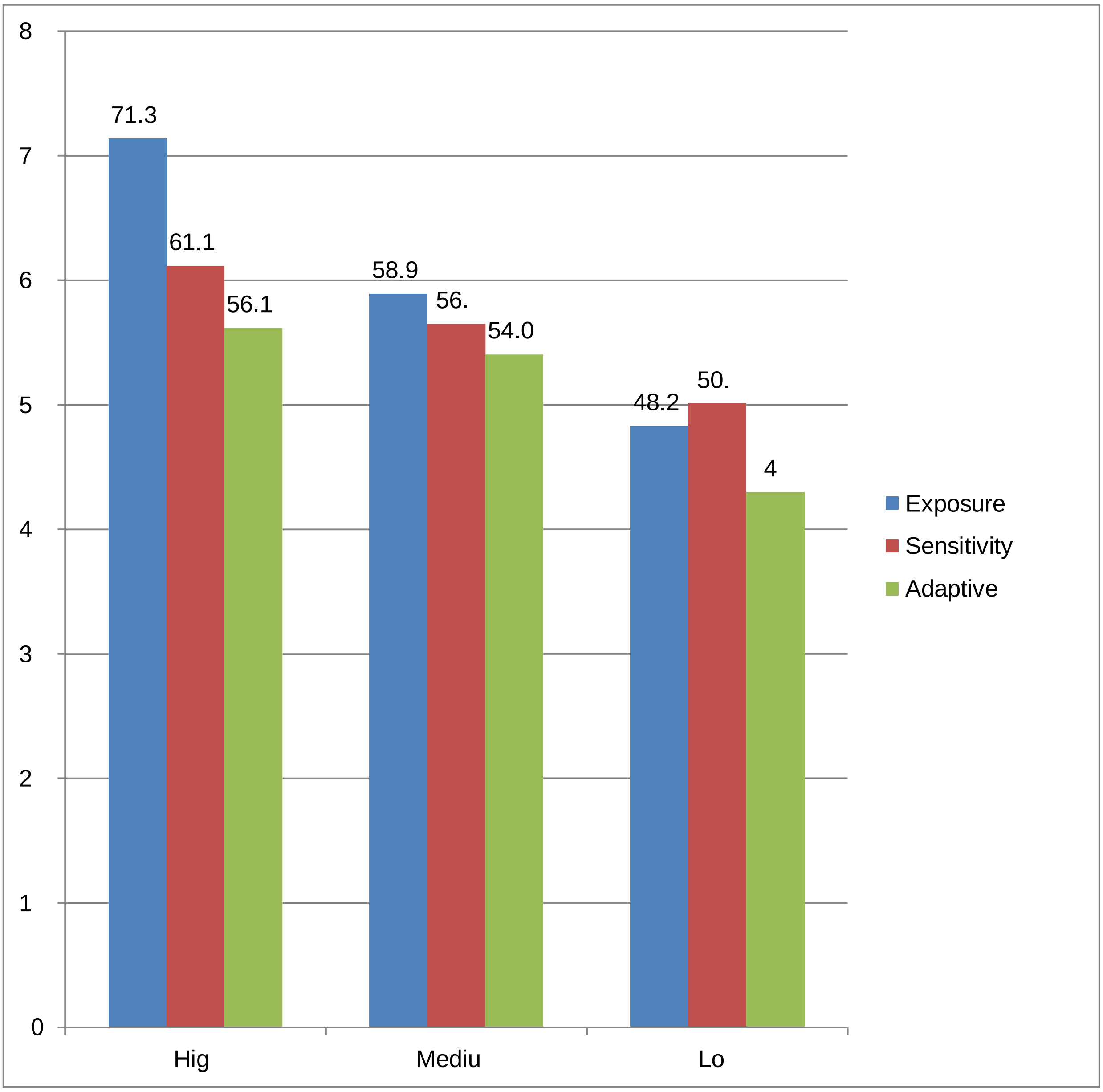


Figure 11 Graphical representation of contribution of each factor towards the overall perceived vulnerability of the farmers

4.6.4. Results of the Principal Component Analysis

The twenty statements pertaining to vulnerability (9 statements of exposure, 7 statements of sensitivity, and 4 statements of adaptive capacity) of the farming system to environmental pollution were ranked according to their mean rank scores separately for all the 6 Panchayaths, and the first 11 ranked statements from each Panchayath were selected to carry out Principal Component Analysis.

Table 115 The twenty statements are given below

Sl. No.	Statements	Indicated by	
1	Agriculture sector has become more vulnerable due to environmental pollution	E1	
2	There is an occurrence of pollution caused by both natural changes in environment and human activities	E2	Exposure statements
3	Air, water and soil pollution affect the farming practices	E3	
4	Pollution has emerged as a major problem nowadays	E4	
5	There is climate change due to pollution	E5	
6	There is an uncertainty in rainfall	E6	
7	Extreme weather events in the last few years have affected the adaptation and mitigation practices	E7	
8	Biodiversity is threatened as a result of pollution	E8	
9	There are dry spells associated with pollution	E9	
10	There is an increased incidence of weeds and insect pest attacks than earlier times	S1	
11	There is a decrease in production due to pollution	S2	
12	There is increased deforestation as a consequence of pollution	S3	
13	There is an increase in soil erosion	S4	
14	There is extinction of plant and animal species due to pollution	S5	
15	Livestock rearing has become vulnerable because of pollution	S6	Sensitivity statements
16	Productive capacity of livestock is adversely affected due to pollution	S7	
17	Farmers resort to change in cropping pattern and cropping seasons	A1	Adaptive capacity statements
18	Farmers change their livelihood pattern	A2	
19	Farmers change their crop choice and crop cycle	A3	
20	Farmers change their land use pattern	A4	

The first 11 statements selected to carry out PCA are shown in Table 130,

Sl. No.	Statement	Mean score	Rank
1	E1	8.39	**1**
2	E3	8.07	**2**
3	E2	7.83	**3**
4	E4	7.44	**4**
5	S1	7.03	**5**
6	S4	6.76	**6**
7	S2	6.18	**7**
8	S7	5.78	**8**
9	E6	5.32	**9**
10	S3	5.08	**10**
11	A1	5.02	**11**

KMO and Bartlett test to test the sample adequacy to carry out PCA

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.	0.663
Bartlett's Test of Sphericity	
Approx. Chi-Square	150.09
df	66
Sig.	0

The results of KMO (>5) and Bartletts test (non significant) show that, the sample is adequate for PCA.

Table 116. Correlation matrix

	E1	E3	E2	E4	S1	S2	S4	S7	E6	S3	A1
E1	1										
E3	0.319	1									
E2	0.205	0.029	1								
E4	0.155	0.278	0.217	1							
S1	0.339	0.037	0.255	0.241	1						
S4	0.023	0.056	-0.137	0.014	-0.14	1					
S2	0.091	0.197	0.336	0.199	0.028	-0.058	1				
S7	-0.253	0.042	-0.259	-0.01	-0.14	-0.052	-0.133	1			
E6	0.14	0.176	0.27	0.355	0.103	0.177	0.167	-0.14	1		
S3	-0.02	0.383	-0.137	0.137	0.06	0.109	-0.062	0.123	-0.016	1	
A1	0.042	0.047	0.065	0.005	0.043	0.284	-0.079	-0.017	0.081	0.349	1

From the table, it could be inferred that S4 shows negative correlation with E2 and S1, while S7, E1, E2, E4, S1 S2 and S4 are negatively correlated. E6 is negatively correlated to S7, and S3 shows a negative correlation with E1, E2, S4, E6. A1 is negatively correlated to S4 and S7.

Table 117. Communalities

Sl. No.	Statements	Extraction Communalities
1	E1	.546
2	E3	.643
3	E2	.539
4	E4	.516
5	S1	.638
6	S4	.665
7	S2	.518
8	S7	.530
9	E6	.563
10	S3	.682
11	A1	.601

Extraction communalities are estimates of the variance in each variable accounted for by the factors in the factor solution. Small values indicate variables that do not fit well with the factor solution, and should be dropped from the analysis. The extraction communalities for this solution are acceptable. Here, the average value of the communalities is 0.60.

Table 118. Total Variance explained

Component	Eigenvalue	Percentage of variance	Cumulative percentage
1	**2.30**	**20.95**	**20.94**
2	**1.72**	**15.63**	**36.57**
3	**1.25**	**11.36**	**47.93**
4	**1.17**	**10.62**	**59.55**

The table shows the variance explained. Only four factors have eigenvalues greater than 1. Together, they account for almost 60% of the variability in the original variables. Thus, these four components are extracted.

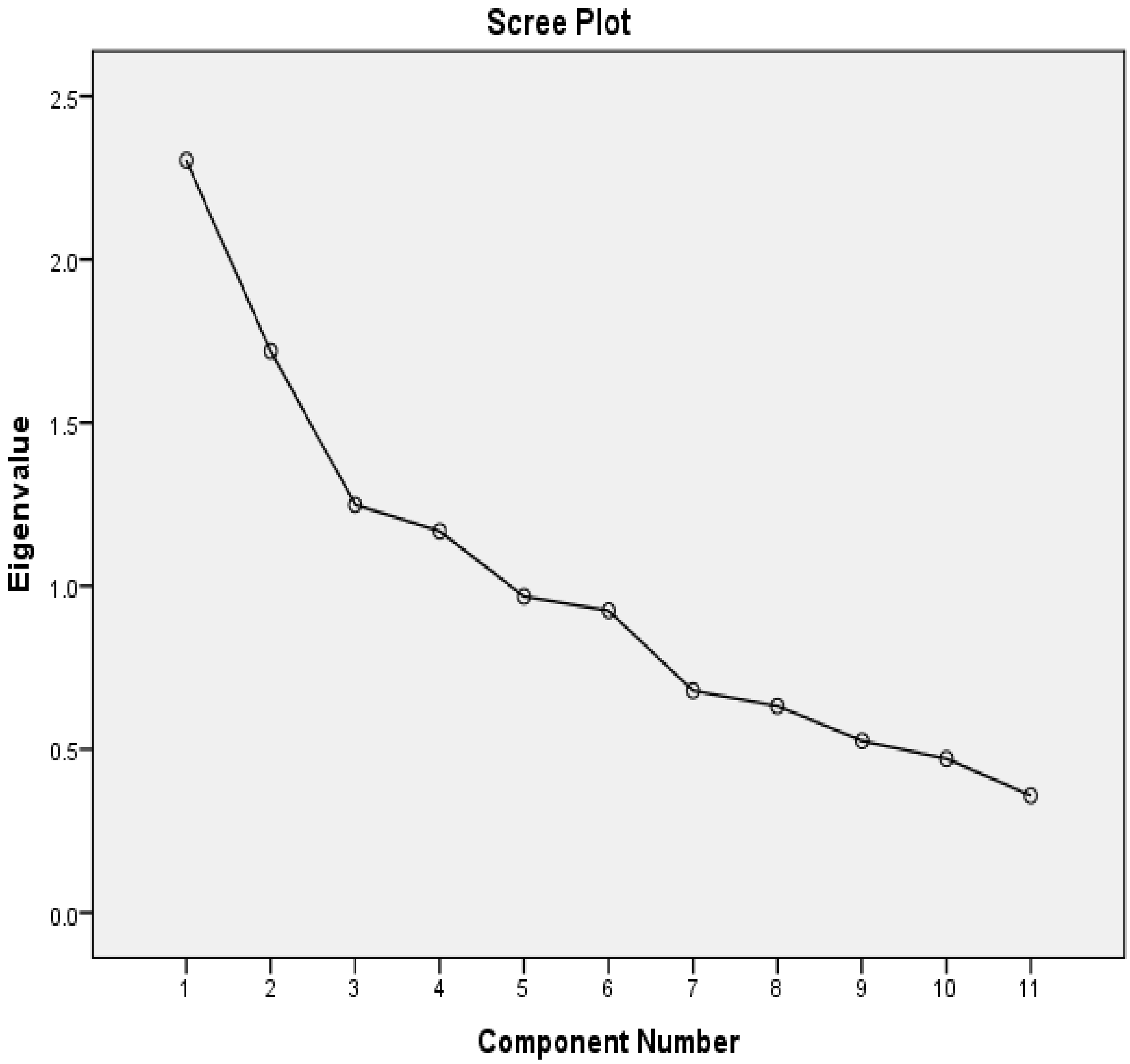


Fig. 12. Scree plot confirms the extraction of four components with Eigenvalues more than 1.

From the Scree plot it is evident that four components have an Eigenvalue of more than 1, and hence these four Principal Components are extracted.

Table 119. Rotated Component Matrix

	Components			
	1	2	3	4
E1		0.715		
E3			0.726	
E2	0.549			
E4	0.569			
S1		0.783		
S4				0.785
S2	0.695			
S7				
E6	0.68			
S3			0.751	
A1				0.724

The first rotated factor is most highly correlated with statements E2, E4, S2 and E6. These statements are not particularly correlated with the other two factors.

The second factor is most highly correlated with the statements E1 and S1.

The third factor is most highly correlated with E3 and S3

The fourth factor shows a high correlation with S4 and A1.

Thus, there are three major groupings of independent variables, as defined by the variables that are most highly correlated with the three factors.

It is evident from the above tables that the statements used to quantify the vulnerability were best described by four principal components or four dominant factors. These four components represented 60 per cent of the variance in the data. The first component including statements E2, E4, S2 and E6 represented 20.95 per cent of the data. The second component, representing 15.63 per cent of the variance, consisted of E1 and S1. The third component indicated 11.36 per cent of the variance and had the statements E3 and S3. The fourth component indicated 10.62 per cent of the variance in the data and included the statements S4 and A1.

4.6.5.1 Multi-collinearity test to determine the correlation between independent variables

Multi-collinearity is a state of very high intercorrelations among the independent variables. It is therefore a type of disturbance in the data, and if present in the data the statistical inferences made about the data may not be reliable. Multicollinearity makes it tedious to assess the relative importance of the independent variables in explaining the variation caused by the dependent variable. Multi-collinearity can also be detected with the help of tolerance and its reciprocal, called variance inflation factor (VIF). If the value of tolerance is less than 0.2 or 0.1 and the value of VIF 10 and above, then the multi-collinearity is problematic to carry out regression.

Table 120. Multi-collinearity test to determine the correlation between age and other independent variables

Variables	V1	V2	V3	V4	V5	V6	V7	V8
Age (V1)		1.031	1.574	1.56	1.17	1.09	1.14	1.34
Education (V2)	1.03		1.63	1.44	1.29	1.05	1.13	**1.12**
Experience (V3)	1.16	1.15		1.07	1.15	1.16	1.02	1.02
Area of land holding (V4)	1.13	1.06	1.15		1.70	1.02	1.71	0.13
Proximity to industrial area (V5)	1.06	1.064	1.70	1.02		2.25	1.51	1.11
Mass media contact (V6)	1.12	1.707	1.024	2.26	1.52		1.14	1.10
Water source (V7)	1.686	1.026	2.30	1.56	1.08	1.07		**1.10**
Occupation (V8)	1.759	1.091	2.29	1.62	1.12	1.15	1.19	

4.6.5.2. Multinomial Logistic Regression

4.6.5.2.1 Comparison of the perceived low vulnerability of the farming systems relative to perceived high vulnerability farming systems (Reference category)

Table 121. Parameter estimates

Effect	B	S.E.	Wald	Df	Sig.
Area of landholding	**1.8**	**0.698**	**6.643**	**1**	**0.01***
Water source used	-0.068	0.495	0.019	1	0.891
Proximity to industrial area	0.484	0.497	0.95	1	0.33
Education	-0.72	0.502	2.058	1	0.251
Mass media participation	-0.071	0.771	0.008	1	0.927
Experience in agriculture	-0.737	0.71	1.077	1	0.299
Age	**-1.123**	**0.66**	**2.893**	**1**	**0.089****
Occupation	-0.008	0.409	0	1	0.984
Note: *Significance level at 5% **Significance level at 10%					

The table describes the independent variables associated with perceived low vulnerability farming systems. The result of multinomial logistic regression shows a significant influence of the variables area of landholding (at 5 per cent significance) and age (at 10 per cent significance level) on perceived low vulnerability of farming systems.

The extent of influence of these two variables on perceived low vulnerability can be determined by odds ratio.

Table 122. Odds ratio and per cent probability

Variables	Odds ratio	Probability percentage
Area of land holding	6.049	85.81
Age	0.325	24.5

The perceived vulnerability of the farming system to pollution could be expected to decrease from high vulnerability to low by an extent of 85.81 per cent by increasing the area of land holding of the farmer by one level.

This indicated that farmers with higher land holdings are less likely to perceive their farms as vulnerable to environmental pollution, because large farmers would have the necessary resources and capital to carry out adaptive capacity measures, and more land area to diversify their crops so as to combat the detriments of environmental pollution as compared to small and marginal resource - poor farmers.

The perceived vulnerability of the farming system to pollution was seen to be reducing from high vulnerability to low vulnerability by an extent of 24.5 per cent when the age of the farmer was going down by one level.

The older farmers tended to perceive their farms more vulnerable to pollution.

This indicates that the younger farmers are either more concerned about production and profit making aspects of farming or they have lower sensitivity towards the detriments of pollution to their farm enterprises.

4.6.5.2.2 Comparison of the perceived moderate vulnerability farming systems relative to high vulnerability farming systems (Reference category)

Table 123. Parameter estimates

Effect	B	S.E.	Wald	Df	Sig.
Area of landholding	0.307	0.499	0.38	1	0.538
Water source used	0.092	0.327	0.08	1	0.778
Proximity to industrial area	0.253	0.367	0.476	1	0.49
Education	-0.286	0.366	0.611	1	0.434
Mass media participation	-0.364	0.524	0.483	1	0.487
Experience in agriculture	-0.5	0.573	0.762	1	0.383
Age	-0.215	0.449	0.229	1	0.632
Occupation	**-0.369**	**0.281**	**1.723**	**1**	**0.189***
Note: *Significance level at 20%					

The Table 4.6.5.7 describes the independent variables associated with moderately vulnerable farming systems.

The result of multinomial logistic regression shows a significant influence of the variable „occupation" at a significance level of 20 per cent.

Table 124. Odds ratio and per cent probability

Variables	Odds ratio	Probability percentage
Occupation	0.692	40.89

The perceived vulnerability of the farming system to pollution was found to reduce from high to moderate by an extent of 40.89 per cent when the occupation of the farmers went down by one level. This indicates that the respondents who only practiced farming had lower perceptions on the vulnerability to pollution, while farmers who had other occupations besides farming had higher perceptions on vulnerability. This indicates that farmers who also had alternate professions in service sector or other sectors in addition to farming are better informed about the ill effects of pollution due to higher cosmopoliteness associated with their occupation, thereby increasing the exposure and access to more resources of information, and are thus more perceptive to the detrimental effects of pollution on their farming system.

4.6.6. Relation of independent variables with vulnerability to pollution

This was interpreted by using Spearman‟s Rank Correlation and the results are shown below in Table.

Table 125. Relation of the independent variables with vulnerability to pollution

Sl. No.	Independent variable	Correlation Value (rho)
1	**Age**	**0.261****
2	Education	0.168
3	Experience	0.126
4	Area of land holding	-0.112
5	**Proximity to industrial area**	**-0.192***
6	Mass media participation	-0.023
7	Water source used	-0.053
8	Occupation	-0.1
*Significance level at 0.05% ** Significance level at 0.01 level%		

Age (10 per cent significance level) and proximity of farm to industrial area (5 per cent significance level), were found to be significantly correlated to perceived vulnerability.

4.6.6.1 Relation of age and vulnerability to pollution

The results from Table 4.6.6.1 reveal that age had a positive and significant relationship with perceived vulnerability to pollution. It has to be inferred that the older farmers perceive the vulnerability threat more, or they are more sensitive in other words. The younger persons, who generally will be more inclined towards making a profitable enterprise out of farming and who are not used to the traditional ways of farming attuned to nature, may not be perceiving this threat in its full magnitude. . They may also be unaware of the various crop adaptation and resilience farming strategies taken against pollution.

4.6.6.2 Proximity of the farm to industrial area and vulnerability

It could be inferred from Table 4.6.6.1 that proximity of the farm to industrial area had a negative but significant relationship with perceived vulnerability to pollution. If the farm is located near to an industry, its vulnerability to pollution will naturally increase. This may be due to the persistent exposure of the farming system to the industrial wastes and sludge that is often let out into the farmers‟ water source or dumped into the fields, and industrial smoke that causes air pollution, thus making the farmers more perceptive to the detriments of pollution on their farming system.

4.7. Constraints expressed by the farmers

Table 126 A list of 7 statements of constraints was scored by the 90 farmers based on importance and the constraints were ranked based on mean scores.

Sl. No.	Ranks	Constraints	Mean Rank
1	1	Inadequacy of waste disposal and recycling facilities	6.27
2	2	Increased emergence of pests and diseases	5.86
3	3	Lack of proper guidelines regarding pesticide and fertilizer application	5.79
4	4	Fluctuations in the seasons causing improper crop cultivation cycles	5.34
5	5	Unavailability of insurance for crop losses due to pollution	4.07
6	6	High cost of carrying out organic farming	2.71
7	7	Lack of access to mass media	1.44
	W	0.72	

The table shows that 'inadequacy of waste disposal and recycling facilities" was the most important constraint according to the farmers. Increased emergence of pest and diseases was the second most important constraint Lack of access to mass media was the least important constraint seen and high cost of carrying out organic farming followed it.

4.8. Suggestions and recommendations to the farmers

A list containing 11 statements pertaining to suggestions and reccommendations offered to farmers was used in the measurement.

The statements are given below in Table 142.

Table 127. Statements showing the suggestion and recommendation to the farmers

Sl. No.	Suggestions and recommendation	Indicated by
1	Pollution Act and Rules must be strictly enforced on the farms	R1
2	Farmers must make use of mass media to learn more about pollution hazards	R2
3	The farms and living surrounding must be properly sanitized	R3
4	Automobile pollution must be technologically controlled	R4
5	Increase the use of bio-pesticides	R5
6	Large scale plantation of trees must be carried out near farms	R6
7	Wastes and by-products must be recycled	R7
8	Adopt Integrated Pest Management	R8

	techniques along with insecticides	
9	Encourage more of agroforestry farming systems	R9
10	Urban and industrial waste must be recycled, managed and controlled	R10
11	Vermicompost biotechnology must be made use of	R11

4.8.2 Suggestion and recommendation to the farmers of Puzhakkal

The ranking of the suggestions and recommendations by farmers based on importance was for the farmers must make use of mass media to learn more about pollution hazards, followed by proper sanitization of farms and recycling of wastes and by-products. The least important as identified by the farmers was technological control of automobile pollution.

Table 128. Rank of the statements

Sl No.	**Statements**	**Mean Score**	**Rank**
1	R2	10.27	1
2	R3	10	2
3	R7	8.67	3
4	R1	7.33	4
5	R10	5.93	5
6	R8	5.43	6
7	R6	5.33	7
8	R5	4.73	8
9	R9	3.8	9
10	R11	2.4	10
11	R4	2.1	11

4.8. 3 Suggestion and recommendation to the farmers of Alathur

The results from Alathur Panchayath show similarities with Puzhakkal, with the suggestion considered most important by farmers being the use of mass media to learn more about pollution hazards, which was succeeded by proper sanitization of farms and recycling of wastes and by-products. The least important was identified as technological control of automobile pollution.

Table 129. The rank of statements

Sl. No.	Statements	Mean Score	Rank
1	R2	10.03	1
2	R3	10.03	2
3	R7	8.53	3
4	R1	7.1	4
5	R8	6.8	5
6	R6	5.67	6
7	R5	4.67	7
8	R10	4.6	8
9	R9	3.27	9
10	R11	3.13	10
11	R4	2.17	11

4.8.4 Suggestion and recommendation to the farmers of Puthur

Table 130. Rank of the statements

Sl. No.	Statements	Mean Score	Rank
1	R2	8.97	1
2	R3	8.7	2
3	R7	8.6	3
4	R10	8.23	4
5	R1	7.3	5

6	R5	7.03	6
7	R6	5.23	7
8	R8	4.33	8
9	R11	2.87	9
10	R9	2.77	10
11	R4	1.97	11

The results from Puthur Panchayath show similarities with Puzhakkal and Alathur, with the suggestion considered most important by farmers being the use of mass media to learn more about pollution hazards, which was succeeded by proper sanitization of farms and recycling of wastes and by-products. The least important was identified as technological control of automobile pollution.

4.8.5 Suggestion and recommendation to the farmers of Pananchery Pananchery

Table 131. Rank of statements

Sl. No.	Statements	Mean Score	Rank
1	R2	9.67	1
2	R7	8.73	2
3	R10	8.73	3
4	R3	8.53	4
5	R1	8.27	5
6	R8	5.5	6
7	R6	3.93	7
8	R5	3.63	8
9	R11	3.57	9
10	R4	2.73	10

11	R9	2.7	11

The most important suggestion and recommendation according to the farmers of Pananchery is the use of mass media to learn about pollution, succeeded by the recycling of by-products and waste and recycling, managing and controlling industrial waste. The least important was encouraging agroforestry based farming systems.

4.8.6 Suggestion and recommendation to the farmers of Nadathara

Table 132. Rank of statements

Sl. No.	Statements	Mean Score	Rank
1	R3	9.67	1
2	R2	9.43	2
3	R7	8.87	3
4	R10	8.8	4
5	R10	6.4	5
6	R8	5	6
7	R9	4.07	7
8	R5	4.03	8
9	R6	3.9	9
10	R4	3.47	10
11	R11	2.37	11

4.8.7 Suggestion and recommendation to the farmers of Madakkathara

Table 133. Rank of statements

Sl. No.	Statements	Mean Score	Rank
1	R1	5.73	1
2	R2	8.8	2
3	R3	9.23	3
4	R4	2.4	4
5	R5	5.1	5
6	R6	4.93	6
7	R7	9.7	7
8	R8	6.13	8
9	R9	3.03	9
10	R10	8.43	10
11	R11	2.5	11

Table 134. Comparison of the ranks between the 6 Panchayaths

Sl. No.	Ranks	Puzhakkal	Alathur	Puthur	Pananchery	Nadathara	Madakkathara
1	1	R2	R2	R2	R2	R3	R1
2	2	R3	R3	R3	R7	R2	R2
3	3	R7	R7	R7	R10	R7	R3
4	4	R1	R1	R10	R3	R10	R4
5	5	R10	R8	R1	R1	R10	R5

6	6	R8	R6	R5	R8	R8	R6
7	7	R6	R5	R6	R6	R9	R7
8	8	R5	R10	R8	R5	R5	R8
9	9	R9	R9	R11	R11	R6	R9
10	10	R11	R11	R9	R4	R4	R10
11	11	R4	R4	R4	R9	R11	R11
W		0.789	0.741	0.7	0.757	0.715	0.721

According to the results of the table, a conclusion was reached that, R2 was the most important suggestion considered by the farmers in the four Panchayaths of Puzhakkal, Alathur, Puthur and Pananchery.

R3 was the second most important ranked suggestion in the two Panchayaths Puzhakkal, Alathur and Puthur.

R7 was the third most important suggestion in the four Panchayaths of Puzhakkal, Alathur, Puthur and Nadathara.

R4 was the least important statement as ranked by the farmers in Puzhakkal, Alathur and Pananchery.

The W scores of the six Panchayaths indicates that there is a there is a reasonably high agreement between the farmers of each Panchayath in ranking the statements of suggestions and reccommendations.

4.9. Government schemes and legislative support to safeguard farmers from the ill effects of pollution

4.9.1 The Government of India has implemented various schemes to safeguard the environment from the detrimental effects of pollution for the year 2018-2019. The schemes are,

- **National Mission for Sustainable Agriculture (NMSA)**

The scheme has the objective of optimize the resource utilization to resource management and to expand crop coverage to achieve „more crop per drop‟.

- **Paramparagath Krishi Vikas Yojana –**

The main objectives of this scheme are, the implementation of Soil Health Card Scheme and establishment of Mobile Soil Testing Labs

- **National Biogas and Organic Manure Programme**

To reduce the environmental degradation and prevent the GHG emission into the environment.

4.9.2 The Government of Kerala has implemented various schemes to safeguard the environment from the detrimental effects of pollution for the year 2018-2019. The schemes are,

- **Soil Health Management and Productivity Improvement Scheme**

Under this scheme, soil ameliorants are provided to selected districts and awareness programmes, workshops and seminars about soil health are conducted. Panchayath level adoption of Soil Health Card was also included in this scheme.

- **Organic Farming And Good Agricultural Practices**

Farm schools and training regarding good agriculture practices and trainings must be carried out under this scheme.

4.9.3 Legislative policies to safeguard the environment from ill effects of pollution for the year 2018-19

According to the National Green Tribunal, any state failing to enforce the proper guidelines for illegal mining of coal will be considered to be conniving with the polluters.

The Central Pollution Control Board has devised a formula to calculate Environmental Compensation, to ensure that the discharge quantity of pollutants would remain within specified limits and CPCB would take penal action against defaulters.

In April, 2019, a “zero draft of Environmental Assessment Notification” was given to all states of the country to make Environmental Clearance process more efficient and decentralized.

The MoEFandCC has issued an environmental policy wherein any activity that needs Environmental Clearance from the state regulators would be appraised at Central level if it is located within 5 km from the boundaries of the 100 Critically Polluted Areas as classified by CPCB using pollution indices.

An open ended discussion was made with the stakeholders from all the six Panchayaths comprising of Agricultural Officers, development personnels, local governance members, NGO‟s and the general public regarding Government schemes and legislative support to safeguard farmers from the ill effects of pollution. All the stakeholders were aware of the soil health cards and replied in affirmative regarding the implementation. Most of the stakeholders responded in the affirmative regarding the implementation of biogas plants in households and small agro-industries. Most of the stakeholders were not aware of the environmental legislative policies implemented for the year 2019-2020.

5. SUMMARY AND CONCLUSION

"The place makes the poison" is a popular dictum by Paracelsus. But pollution is no longer a matter confined to a locality, but is now a matter of global health concern.

It is a ubiquitous catastrophe that shows its range from household wastes to the complex compounds released from industries. Health risks due to environmental pollution are more likely to occur in developing countries.

Increased prevalence of autism, cancer, blue baby syndrome and other medically inexplicable diseases are the consequences of pollution. Thus, it is of utmost importance to focus on the perspective of farmers regarding environment, as they are often the most vulnerable to the dire consequences of pollution.

The present research was conducted in Kerala Agricultural University. 90 farmers and 30 stakeholders comprising of Agricultural Officers, local governance members, development personnel, NGO's and General public were randomly selected from the six Panchaths Puzhakkal, Alathur, Puthur, Pananchery, Nadathara and Madakkathara.

Independent and dependent variables were selected after discussing with experts, major advisor and previous literature. Data was collected by using interview schedule.

The data was then scored, tabulated and presented using statistical instruments like frequency, percentage, composite index, arithmetic mean, standard deviation, non-parametric tests, factor analysis, regression and correlation.

Prominent findings of the study are

5.1 Basic details of the farmers

- A majority (38.88 per cent) farmer were younger than 40 years of age.
- A high percentage (47.77 per cent) of the farmers were graduates and above showing the high literacy among farmers.
- Majority (43.33 per cent) of the selected farmers had a farming experience of 10-20 years.
- Forty per cent of the farmers were small farmers with land holdings of 2.5-5 ha.
- Canal was the major water source used by the farmers to carry out irrigation (38.8 per cent).
- Majority (42.22 per cent) of the farmers had their farms at a distance of 1-3 km from an industrial area.
- A majority (45.5 per cent) farmer had high mass media exposure.

5.2 Type and extent of pollution in the different agricultural systems

The three major types of pollution seen in the farming systems were water pollution, air pollution and soil pollution. All the selected six Panchayaths showed moderate levels of water pollution, air pollution and soil pollution.

5.3 Ill effects of environment experienced by the stakeholders

There were high differences in the ill effects of environmental pollution due to agri-intensive cultivation, integrated farming system and threat to human health due to certain farming system practices as experienced by the six Panchayaths as perceived by all the stakeholders from the six Panchayaths using Kruskal Wallis Test. This shows the heterogeneity of perception of the stakeholders about ill effects of environmental pollution which may be a consequence of the different levels of exposure, sensitivity and adaptive capacity of the farming systems towards the hazards.

5.4 Awareness of farmers about environmental pollution

From the study, it was revealed that 60 per cent of the farmers had medium levels of awareness about the causes of environmental pollution, while a high majority (82.22 per cent) had high awareness about the effects of pollution.

5.5 Assessment of vulnerability of the farming systems

Vulnerability of a farming system to pollution depended on the exposure, sensitivity and adaptive capacity of the farming system to potential environmental pollution hazards. It was revealed from the study that Puzhakkal was the most vulnerable Panchayath to pollution with a vulnerability index of 75.35, followed by Nadathara with 74.41, Puthur with 64.95, Pananchery with 63.08 amd Madakkathara with 52.55. The least vulnerable Panchayath was Alathur at 48.88. Vulnerability increased with an increase in exposure and sensitivity, while adaptive capacity negatively influenced vulnerability.

The results of Principal Component Analysis revealed that the vulnerability of all the six Panchayaths to environmental pollution could be best explained by 4 components.

The highest total variance explained by the four components was in Pananchery at 80.20 per cent, followed by Madakkathara at 73.74 per cent, Nadathara at 72.69 per cent, Puzhakkal at 72.04 per cent, and Puthur at 70.90 per cent and Alathur at 67.33 per cent.

5.6 Odds for a farming system to attain low and moderate vulnerability

Multinomial logistic regression was used to find the probability of a farming system to attain low vulnerability and moderate vulnerability from high vulnerability.

Area of land holding and age of the farmer are found to be significant variables for attaining low vulnerability. The probability of attaining low vulnerability by increasing the area of land holding and age of the farmer by one unit was 85.81 and 24.5 per cent respectively.

None of the variables showed significance for a farming system to attain moderate vulnerability.

5.7 Relation of independent variables with vulnerability to pollution

Spearman's Correlation Coefficient was used to assess the relation of independent variables with vulnerability to pollution. It was found that age and proximity of the farm to an industrial area were the factors that showed significant correlation with vulnerability. Age was positively correlated while proximity of the farm to an industrial area was negatively correlated.

5.8 Constraints faced by the farmers

The inadequacy of waste disposal and waste recycling facilities was observed by this study to be the most important constraint in almost all the Panchayaths. High cost of carrying out organic farming was reported to be the least important constraint by the majority of farmers. The farmers also reported high resurgence of pests and diseases in their farms.

5.9 Suggestions and recommendations to the farmers

According to the study, the suggestion that the farmers must utilize more of mass media to know about environmental pollution and its detrimental effects was considered as the most important by a majority of the farmers. Improving the sanitization of the farms and living areas of the farmers was also considered an important suggestion to the farmers. The least relevant suggestion according to the farmers was the technological control of automobile pollution, as opined by the majority farmers.

5.10. Government schemes and legislative support to safeguard farmers from the ill effects of pollution

The Government of India and Government of Kerala have implemented some schemes for environmental protection for the year 2018-2019. The major schemes namely, National Mission for Sustainable Agriculture (NMSA), Paramparagath Krishi Vikas Yojana, National Biogas and Organic Manure Programme etc. have been implemented at the national level. Soil Health Management and Productivity Improvement Scheme,

Organic Farming And Good Agricultural Practices are the important environment related schemes in the state of Kerala for the year 2018-2019.

Some notable legislative policies have also come into existence for the year 2018-2019 like Environmental Compensation, Environmental Clearance and Environmental Assessment Notification.

A discussion conducted with the stakeholders from all the six Panchayaths comprising of Agricultural Officers, development personnels, local governance members, NGO's and the general public regarding Government schemes and legislative policies revealed that all the stakeholders were aware of the soil health cards and the implementation of biogas plants. Majority of the stakeholders were unaware of the environmental legislative support and policies implemented for the year 2019-2020.

PHOTOS TAKEN DURING THE SURVEY

PLATE 1. POLLUTION SEEN IN FARMERS' FIELD

Presence of water hyacinth indicating polluted water

Presence of water hyacinth indicating polluted water

Open trash dumping in the farmers' fields

Open trash dumping in the farmers' fields

PLATE 2. INTERVIEWING THE FARMERS AND OTHER STAKEHOLDERS

Interviewing the vegetable farmers of Nadathara Panchayath

Interviewing the vegetable farmers of Nadathara Panchayath

Interviewing the Agricultural Officer of Puzhakkal Krishi Bhavan

REFERENCES

Altieri, K. E., and Keen, S. L. 2006. Public health benefits of reducing exposure to ambient fine particulate matter in South Africa. *Sc. Total Environ.* 684:610-620.

Aneja, V. P., Schlesinger, W. H., and Erisman, J. W. 2008. Farming pollution. *Nature Geoscience*, *1*(7): 409-411.

Anith, K. N., Soumya, V. G., Sreekumar, A., Raj, R. A., and Radhakrishnan, N. V. (2014). A cheap and farmer-friendly method for mass multiplication of Pseudomonas fluorescens. *J. Tropical Agrl.*, 52(2):145-148.

Anitha, B. (2004). A study on entrepreneurial behaviour and market participation of farm women in Bangalore rural district of Karnataka (Doctoral dissertation, University of Agricultural Sciences, GKVK).

Arbaugh, W. A., Fithen, W. L., and McHugh, J. 2000. Windows of vulnerability: A case study analysis. Computer, 33(12):52-59.

Badhe, D. K. (2012). Farmers'perception Regarding Environmental Risk In Use Of Pesticides In Anand District Of Gujarat State (Doctoral Dissertation, AAU, Anand).

Behere, G. T. (2019). Bio-pesticide applications may impair the pollination services and survival of foragers of honey bee, Apis cerana Fabricius in oilseed brassica. *Environ. Pollution*, *249*:598-609.

Bell, S. and Laura, S. (2017). Outdoor Air Pollution and Human Health.

Bergstra, A. D., Brunekreef, B., and Burdorf, A. (2018). The effect of industry-related air pollution on lung function and respiratory symptoms in school children. *Environ. Health*, *17*(1):30.

Bicalho, S. T., Langenbach, T., R-odrigues, R. R., Correia, F. V., Hagler, A. N., Matallo, M. B., and Luchini, L. C. (2010). Herbicide distribution in soils of a riparian forest and neighboring sugar cane field. *Geoderma*, 158(3-4):392-397.

Bord, R. J., and O'Connor, R. E. (1997). The gender gap in environmental attitudes: The case of perceived vulnerability to risk. *Soc. Sci.*, 830-840.

Briguglio, L., Cordina, G., Farrugia, N., and Vella, S. 2009. Economic vulnerability and resilience: concepts and measurements. Oxford development studies, 37(3):229-247.

Casler, S. D., and Blair, P. D. (1997). Economic structure, fuel combustion, and pollution emissions. *Ecol. Econ.*, 22(1):19-27.

Chigozie,. C. G. (2019). Consequences of Environmental Pollution on Agricultural Productivity in Developing Countries: A Case of Nigeria. *Int. J. Agril. Food Res.*, 5(3).

Choudhury, T. U. R., (2016, June). Analysis of optimum crop cultivation using fuzzy system. In 2016 IEEE/ACIS 15th International Conference on Computer and Information Science (ICIS). pp. 1-6.

Cole, M. A. (2004). Trade, the pollution haven hypothesis and the environmental Kuznets curve: examining the linkages. *Ecol. Econ.*, 48(1):71-81.

Cui, Y., Zhang, Z. F., Froines, J., Zhao, J., Wang, H., Yu, S. Z., and Detels, R. (2003). Air pollution and case fatality of SARS in the People's Republic of China: an ecologic study. *Environ. Health*, *2*(1):1-5.

Devi, P. I., Sunil, K. M., Solomon, S. S., and Seenath, P. (2014). Vulnerability mapping for water stress in Kerala. *J. Resources, Energy Development*, 11(1): 41-54.

Dongre, M. M. (1976). Effects of pollutants on photosynthesis in Clerodendrum inerme Gaertn.

Dyer, J. A., Vergé, X. P. C., Desjardins, R. L., Worth, D. E., and McConkey, B. G. (2010). The impact of increased biodiesel production on the greenhouse gas emissions from field crops in Canada. *Energy for Sustainable Development*, *14*(2):73-82.

Fatemi, F., Ardalan, A., Aguirre, B., Mansouri, N., and Mohammadfam, I. (2017). Social vulnerability indicators in disasters: Findings from a systematic review. *Int. J. Disaster Risk Reduction*, 22:219-227.

Folke, C., Carpenter, S. R., Walker, B., Scheffer, M., Chapin, T., and Rockström, J. (2010). Resilience thinking: integrating resilience, adaptability and transformability.

Füssel, H. M. 2007. Vulnerability: A generally applicable conceptual framework for climate change research. *Global Environmental Change*, 17(2):155-167.

Graff Zivin, J., and Neidell, M. (2012). The impact of pollution on worker productivity. *American Economic Review*, *102*(7):3652-73.

Gallopín, G. C. (2006). Linkages between vulnerability, resilience, and adaptive capacity. *Global Environ. Change*, 16(3):293-303.

Gbetibouo G A and Ringler C. 2009. Mapping South African

Farming Sector Vulnerability to Climate Change and

Variability. A Subnational Assessment. IFPRI Discussion Paper

00885. Washington, DC: International Food Policy Research

Institute (IFPRI).

Gerber, P., Opio, C., and Steinfeld, H. (2007). Poultry production and the environment—a review. *Animal production and health division, Food and Agriculture Organization of the United Nations, Viale delle Terme di Caracalla*, *153*.

Gurr, S. J. (2016). Tackling emerging fungal threats to animal health, food security and ecosystem resilience.cology and society, 15(4).

Hall, J. V. (1996). Assessing health effects of air pollution. Atmospheric Environment, 30(5):743-746.

Holling, C. S. (1996). Engineering resilience versus ecological resilience. Engineering within ecological constraints, 31(1996):32.

Hou, J., Liu, F., Tong, Y., Guo, K., Ma, L., and Li, D. (2020). Numerical simulation for runoff regulation in rain garden using 2D hydrodynamic Model. *Ecol. Eng.*, *153*, 105794.

Hribar, C. (2010). Understanding concentrated animal feeding operations and their impact on communities.

Ikerd, J. E. (1999, May). Environmental Risks Facing Farmers. In *Tri-State Conference for Risk Management Education, Pocono Manor, Pennsylvania* (pp. 5-6).

Islam, M. S., Alam, M. J., Khan, S. I., and Huq, A. (1994). Faecal pollution of freshwater environments in Bangladesh. *Int. J. Environ. Studies*, 46(2-3):161-165.

K., Gibson, and Kim, J. (2013). Examining the links between air quality, climate change and respiratory health in Qatar. Avicenna, 2013(1): 9.

Kalarani, M. K., Raja, D., Sivachandran, R., and Premavathi, R. (2009). Effective way of transfer of technology to boost the groundnut yield under rainfed condition through frontline demonstration in Salem, Tamil Nadu.

Kumar, M. (2017). *Emotion, agency and access to healthcare: Women's experiences of reproduction in Jaipur* (Vol. 1, pp. 27-51). Berghahn Books.

Lakshmi, S. R., Devi, I. B., and Naidu, G. M. Forecasting Prices Of Chilli (Dry) In Major Markets Of Andhra Pradesh And Telangana.

Lesschen, J. P., Van den Berg, M., Westhoek, H. J., Witzke, H. P., and Oenema, O. (2011). Greenhouse gas emission profiles of European livestock sectors. *Animal Feed Science and Technol.*, *166*:16-28.

Lipiec, J., and Hatano, R. 2003. Quantification of compaction effects on soil physical properties and crop growth. *Geoderma*, *116*(1-2), 107-136.

Wang HL, Han ZM, Yuan YF. The Black River pollution on pregnancy outcomes of women. Chin J Modern Prev Med. 2008;35(24):4791–4793.

Li, Y. W., Wu, X. L., Mo, C. H., Tai, Y. P., Huang, X. P., and Xiang, L. (2011). Investigation of sulfonamide, tetracycline, and quinolone antibiotics in vegetable farmland soil in the Pearl River Delta area, southern China. Journal of agricultural and food chemistry, 59(13):7268-7276.

Liverman, D. M. (1999). Vulnerability and adaptation to drought in Mexico. *Nat. Resources J.*, 39:99.

Lovelock, J. E. (1971). Air pollution and climatic change. *Atm. Environ. (1967)*, *5*(6): 403-411.

Manizheh Dadbakhsh, Narges Khanjani, Abbas Bahrampour. Death from Respiratory Diseases and Air Pollutants in Shiraz, Iran (2006-2012). *J. Environ. Pollution and Human Health.* 2015: 3(1):4-11. doi: 10.12691/jephh-3-1-2.

Maqsood, M. A., Hussain, S., Aziz, T., and Ashraf, M. (2013). Sustainable agriculture through integrated soil fertility management on degraded lands. In *Developments in Soil Salinity Assessment and Reclamation* (pp. 759-768). Springer, Dordrecht.

Miller, F., Osbahr, H., Boyd, E., Thomalla, F., Bharwani, S., Ziervogel, G., and Hinkel, J. 2010. Resilience and vulnerability: complementary or conflicting concepts?. *Ecol. Society*, 15(3).

Mohapathra and Rath, M. 1997.Thesis. Dimensions of pollutions as perceived by the farmers. Orissa University of Agricultural Sciences, Bhubaneshwar, 33-150 pp .

Nagajyoti, P. C., Lee, K. D., and Sreekanth, T. V. M. (2010). Heavy metals, occurrence and toxicity for plants: a review. Environmental chemistry letters, 8(3):199-216.

Nguyen, N. H., Smith, D., Peay, K., and Kennedy, P. (2015). Parsing ecological signal from noise in next generation amplicon sequencing. *New Phytol., 205*(4):1389-1393.

Oliver-Smith, A. (2013). Theorizing vulnerability in a globalized world: a political ecological perspective. In Mapping vulnerability (pp. 29-43). Routledge.

Kanae, S., Oki, T., 2011. Assessment of global nitrogen pollution in rivers using an integrated biogeochemical modeling framework. *Water Res.*, 45(8):2573-2586.

Ongley, E. D. (1996). *Control of water pollution from agriculture* (Vol. 55). Food and Agriculture Org..

Papageorgiou, C. (2005, June). Turbines and generators for floating solar chimney power stations. In *IASTED Proceedings of Power and Energy Systems, EuroPES conference Benalmadena, Spain..*

Pharate, D. N., Shinde, S. B., and Sonawane, H. P. (2010). Training needs and participation of farmers in dairy management. Agriculture Update, 5(3/4):271-273.

Pimentel, D., Whitecraft, M., Scott, Z. R., Zhao, L., Satkiewicz, P., Scott, T. J., ... and Moe, T. L. (2010). Will limited land, water, and energy control human population numbers in the future?. *Human Ecology*, *38*(5): 599-611.

Ponti, L., Altieri, M. A., and Gutierrez, A. P. (2007). Effects of crop diversification levels and fertilization regimes on abundance of Brevicoryne brassicae (L.) and its parasitization by Diaeretiella rapae (M'Intosh) in broccoli. *Agric. Forest Entomol.*, 9(3):209-214.

Ram, D. (2015). Awareness Level of Poultry Husbandry Practices by the Poultry Farmers in Imphal West District of Manipur. *Indian J. Ext. Edn.*, 51(3):172-174.

Rathod, P. K., Nikam, T. R., Sariput, L., and Amit, H. (2012). Entrepreneurial behaviour of dairy farmers in Western Maharashtra, India. *Int. J. Commerce Business Management*, *5*(2):115-121.

Raghunath, R. (2014). An elephantine challenge: human–elephant conflict distribution in the largest Asian elephant population, southern India. *Biodiversity And Conservation*, 23(3):633-647.

Reiff, J., and Velds, C. A. (1979). The use of a trajectory model for studying interregional transport of air pollution.

Reynolds, P., Von Behren, J., Gunier, R. B., Goldberg, D. E., Hertz, A., and Smith, D. F. (2003). Childhood cancer incidence rates and hazardous air pollutants in California: an exploratory analysis. *Environ. Health Perspectives*, *111*(4):663-668.

Ricker-Gilbert, J., Jayne, T., and Shively, G. (2013). Addressing the ―wicked problem‖ of input subsidy programs in Africa. *Applied Economic Perspectives and Policy*, *35*(2):322-340.

Sabale, T. D., Chauhan, D. S., and Jagdale, V. Y. (2018). Studies on feeding and management practices adopted in livestock fodder camps during drought in Wadwani and Dharur Tahsil of Beed district. *IJCS*, *6*(4):2403-2409.

Saha, J. K., Selladurai, R., Coumar, M. V., Dotaniya, M. L., Kundu, S., and Patra, A. K. (2017). *Soil pollution-an emerging threat to agriculture* (Vol. 10). Springer.

Sandin, S. (2005). Present and future methane emissions from rice fields in DôngNga. c commune. *Hanoi, Vietnam, Göteborg University, Department of Physical Geography*, *41*.

Savci, S. (2012). Investigation of effect of chemical fertilizers on environment.

Apcbee Procedia, *1*:287-292.

Scharen, A. L., and Krupinsky, J. M. (1970). Cultural and inoculation studies of Septorianodorum, cause of glume blotch of wheat. Phytopathology. 60:1480-85.

Sharma, N., Arya, S., Kadian, M. S., and Singh, B. P. (2013). Seed potato utilization pattern and its impact on farmers' profitability in Karnataka. *Indian J. Agric. Res*, 47(6):488-495.

Singh, R. (2017). Problems and prospects of women entrepreneurship with special reference to MSMEs in the state of Gujarat. *Unpublished doctoral thesis). Gujarat Technological University, Gujarat, India. Retrieved from https://www. gtu. ac. in/uploads/Thesis129990992024. pd f.*

Singh, P. K., Deshbhratar, P. B., and Ramteke, D. S. (2012). Effects of sewage wastewater irrigation on soil properties, crop yield and environment. *Agric. Water Mgt.*, 103: 100-104.

Singh J. B. (2006). Constraints encountered by dairy farmers in adoption of improved dairy farming practices. *J. Dairying, Foods and Home Sciences,* 25(1):47-50.

Swathi Lekshmi, P. S., and Annamalai, R. (2010). Awareness of farmers about social forestry programme-An analysis. *Ind. Res. J. Ext. Ed.*, *10*(2):85-88.

Sun, F., Koemle, D. B., and Yu, X. (2017). Air pollution and food prices: evidence from China. *Aus. J. Agric. Res. Econ.*, *61*(2):195-210.

Tamilselvi, G., and Sudhakar, G. (2010). Entrepreneurial behaviour of vegetable growers of Tamil Nadu. *Mysore J. Agric. Sci.*, 44(3):590-593.

Tekale, V., Jalit, N., and Gaikwad, C. Adoption Of Recommended Chilli Cultivation Practices By The Farmers. *Seed*, 29(19):19-00.

The World Bank and the environment : fiscal 1992 (English). Washington, D.C. : World Bank Group. http://documents.worldbank.org/curated/en/728631468766240119/The-World-Bank-and-the-environment-fiscal-1992

Tilman, D., Fargione, J., Wolff, B., D'Antonio, C., Dobson, A., Howarth, R., ... and Swackhamer, D. (2001). Forecasting agriculturally driven global environmental change. *science*, *292*(5515):281-284.

Turner, B. L., Kasperson, R. E., Matson, P. A., McCarthy, J. J., Corell, R. W., Christensen, L., and Polsky, C. 2003. A framework for vulnerability analysis in sustainability science. Proceedings of the national academy of sciences, 100(14): 8074-8079.

Van Maele-Fabry, G., Libotte, V., Willems, J., and Lison, D. (2006). Review and meta-analysis of risk estimates for prostate cancer in pesticide manufacturing workers. Cancer Causes and Control, 17(4):353-373.

Vanni, M. J., Arend, K. K., Bremigan, M. T., Bunnell, D. B., Garvey, J. E., Gonzalez, M. J., ... and Stein, R. A. (2005). Linking landscapes and food webs: effects of omnivorous fish and watersheds on reservoir ecosystems. *BioScience*, *55*(2): 155-167.

Vanos, J. K., Cakmak, S., Kalkstein, L. S., and Yagouti, A. (2015). Association of weather and air pollution interactions on daily mortality in 12 Canadian cities. *Air Quality, Atmosphere and Health*, *8*(3): 307-320.

Vasava, J. (2005). Knowledge And Adoption Of Recommended Pigeonpea Production Technology By Pigeonpea Growers (Doctoral Dissertation, Aau, Anand).

Venkatraman, N. and Koh J. 1991. Joint venture formations and stock market reactions: An assessment in the information technology sector. *Academy of management Journal*, *34*(4):869-892.

Weber, C. L., and Matthews, H. S. (2008). Food-miles and the relative climate impacts of food choices in the United States.

Williams, S. E., Shoo, L. P., Isaac, J. L., Hoffmann, A. A., and Langham, G. 2008. Towards an integrated framework for assessing the vulnerability of species to climate change. PLoS Biol, 6(12):325.

Wiréhn, L., Danielsson, Å., and Neset, T. S. S. (2015). Assessment of composite index methods for agricultural vulnerability to climate change. *J. Environ.Mgt.*, 156: 70-80.

Wallach, L., and Sforza, M. (2019). Whose trade organization: Corporate globalization and the erosion of democracy: An assessment of the World Trade Organization. Public Citizen.

Xiong, Y., Li, X., and He, P. (2016). Farmers' adoption of pollution-free vegetable farming in China: Economic, informational, or moral motivation?. Cogent Food and Agriculture, 2(1): 1240022.

Yang, J., McBride, J., Zhou, J., and Sun, Z. (2005). The urban forest in Beijing and its role in air pollution reduction. *Urban Forestry And Urban Greening*, 3(2), 65-78.

Zhang, K., Su, J., Xiong, X., Wu, X., Wu, C., and Liu, J. (2016). Microplastic pollution of lakeshore sediments from remote lakes in Tibet plateau, China. *Environ. Pollution*, *219*:450-455.

Zhuang, Q., Melack, J. M., Zimov, S., Walter, K. M., Butenhoff, C. L., and Khalil, M. A. K. (2009). Global methane emissions from wetlands, rice paddies, and lakes. *Eos, Transactions American Geophys. Union*, *90*(5): 37-38.

ENVIRONMENTAL POLLUTION EXPERIENCED BY AGRICULTURAL SYSTEMS: A STAKEHOLDER PERSPECTIVE

By

LAKSHMI MURALIKRISHNA

(2018-11-063)

ABSTRACT OF THE THESIS

Submitted in partial fulfilment of the

requirement for the degree of

Master of Science in Agriculture

Faculty of Agriculture

Kerala Agricultural University, Thrissur

DEPARTMENT OF AGRICULTURAL EXTENSION

COLLEGE OF HORTICULTURE

VELLANIKKARA, THRISSUR – 680656

KERALA, INDIA

2020

ABSTRACT

"The place makes the poison" is a popular dictum by Paracelsus. But pollution is no longer a matter confined to a locality, but is now a matter of global health concern.

It is a ubiquitous catastrophe that shows its range from household wastes to the complex compounds released from industries. Health risks due to environmental pollution are more likely to occur in developing countries. Increased prevalence of autism, cancer, blue baby syndrome and other medically inexplicable diseases are the consequences of pollution. Thus, it is of utmost importance to focus on the perspective of farmers regarding environment, as they are often the most vulnerable to the dire consequences of pollution.

The present research was conducted in Kerala Agricultural University. 90 farmers and 30 stakeholders comprising of Agricultural Officers, local governance members, development personnel, NGO's and General public were randomly selected from the six Panchaths Puzhakkal, Alathur, Puthur, Pananchery, Nadathara and Madakkathara. Independent and dependent variables were selected after discussing with experts, major advisor and previous literature. Data was collected by using interview schedule.

The data was then scored, tabulated and presented using statistical instruments like frequency, percentage, composite index, arithmetic mean, standard deviation, non-parametric tests, factor analysis, regression and correlation.

A majority (38.88 per cent) farmer were younger than 40 years of age and high percentage (47.77 per cent) of the farmers were graduates and above showing the high literacy among farmers. Majority (43.33 per cent) of the selected farmers had a farming experience of 10-20 years and forty per cent of the farmers were small farmers with land holdings of 2.5-5 ha. Canal was the major water source used by the farmers to carry out irrigation (38.8 per cent) and majority (42.22 per cent) of the farmers had their farms at a distance of 1-3 km from an industrial area. A majority (45.5 per cent) farmer had high mass media exposure.

The three major types of pollution seen in the farming systems were water pollution, air pollution and soil pollution. All the selected six Panchayaths showed moderate levels of water pollution, air pollution and soil pollution based on the scores of the statements.

There were high differences in the ill effects of environmental pollution due to agri-intensive cultivation, integrated farming system and threat to human health due to certain farming system practices as experienced by the six Panchayaths as perceived by all the stakeholders from the six Panchayaths using Kruskal Wallis Test. This shows the heterogeneity of perception of the stakeholders about ill effects of environmental pollution which may be a consequence of the different levels of exposure, sensitivity and adaptive capacity of the farming systems towards the hazards.

From the study, it was revealed that 60 per cent of the farmers had medium levels of awareness about the causes of environmental pollution, while a high majority (82.22 per cent) had high awareness about the effects of pollution.

Vulnerability of a farming system to pollution depended on the exposure, sensitivity and adaptive capacity of the farming system to potential environmental pollution hazards. It was revealed from the study that Puzhakkal was the most vulnerable Panchayath to pollution with a vulnerability index of 75.35, followed by Nadathara with 74.41, Puthur with 64.95, Pananchery with 63.08 amd Madakkathara with 52.55. The least vulnerable Panchayath was Alathur at 48.88. Vulnerability increased with an increase in exposure and sensitivity, while adaptive capacity negatively influenced vulnerability.

The results of Principal Component Analysis revealed that the vulnerability of all the six Panchayaths to environmental pollution could be best explained by 4 components.The highest total variance explained by the four components was in Pananchery at 80.20 per cent, followed by Madakkathara at 73.74 per cent, Nadathara at 72.69 per cent, Puzhakkal at 72.04 per cent, and Puthur at 70.90 per cent and Alathur at 67.33 per cent.

Spearman's Correlation Coefficient was used to assess the relation of independent variables with vulnerability to pollution. It was found that age and proximity of the farm to an industrial area were the factors that showed significant correlation with vulnerability. Age was positively correlated while proximity of the farm to an industrial area was negatively correlated.

Multinomial logistic regression was used to find the probability of a farming system to attain low vulnerability and moderate vulnerability from high vulnerability. Area of land holding and age of the farmer are found to be significant variables for attaining low vulnerability. The probability of attaining low vulnerability by increasing the area of land holding and age of the farmer by one unit was 85.81 and 24.5 per cent respectively.None of the variables showed significance for a farming system to attain moderate vulnerability.

The inadequacy of waste disposal and waste recycling facilities was observed by this study to be the most important constraint all the Panchayaths. Lack of mass media contact and high cost of carrying out organic farming was reported to be the least important constraint by the majority of farmers. The farmers also reported high resurgence of pests and diseases in their farms.

According to the study, the suggestion that the farmers must utilize more of mass media to know about environmental pollution and its detrimental effects was considered as the most important by a majority of the farmers. Improving the sanitization of the farms and living areas of the farmers was also considered an important suggestion to the farmers. The least relevant suggestion according to the farmers was the technological control of automobile pollution, as opined by the majority farmers.

A discussion conducted with the stakeholders from all the six Panchayaths comprising of Agricultural Officers, development personnels, local governance members, NGO's and the general public regarding Government schemes and legislative policies revealed that all the stakeholders were aware of the soil health cards and the implementation of biogas plants. Majority of the stakeholders were unaware of the environmental legislative support and policies implemented for the year 2019-2020.

APPENDICES

Interview schedule for the farmers

Basic details of the farms and farmers

Name of the farmer:

Panchayath:

Phone Number:

Age:

Sl. No.	Categories	
1	Up to 40 years	
2	41-50 years	
3	51-60 years	
4	>60 years	

3.4.2 Education

Sl. No.	Categories	
1	Illiterate	
2	Primary	
3	High school	
4	Higher secondary	
5	Graduation and above	

3.4.3 Experience of farming

Score	Categories	
0	<5 years	

1	5-10 years	
2	10-20 years	
3	20-30 years	
4	30-40 years	
5	>40 years	

3.4.4 Size of land holding

Score	Category	
1	Marginal (< 1 ha)	
2	Small (1-2 ha)	
3	Medium (2-10 ha)	
4	Large (>10 ha)	

3.4.5 Occupation

Score	**Occupation**	
1	Agriculture	
2	Business	
3	Service	
4	Other	
5	Agriculture allied	

3.4.6 Water source used by the farmer

Score	**Water source**	
1	Rain water	
2	Well	
3	Canal	
4	Stream	
5	Tube well	

3.4.7 Proximity to industrial area

Score	Distance from industrial area	
0	<1 km	
1	1-3 km	
2	3-6 Km	
3	>6 km	

3.4.8. Mass media contact

Score	Category	
3	Regularly	
2	Frequently	
1	Occasionally	
0	Never	

On the arbitery basis, the respondents were categorized into the following four categories based on frequency of using different mass media

Score	Category	Category classification	
0	No mass media contact	0	
1	Low mass media contact	1-7	
2	Medium mass media contact	7-9	

3	High mass media contact	>9	

1. Types and extent of environmental pollution faced in different agricultural systems

a. Water pollution

Sl. No.	Statement	Highly agree	Agree	Undecided	Disagree	Highly disagree
1	Water is polluted by the excess use of pesticide in crop					
2	Water is polluted due to bathing of man and animals in water bodies					
3	There is water pollution due to the dumping of faecal matter of man and animal into the water bodies					

4	The quality of water is affected due to the use of detergents					
5	Water is polluted due to the let-out of industrial effluents					
6	Water is polluted due to excess use of chemical fertilizers					
7	Water is polluted due to untreated sewage					
8	Water is polluted due release of garbage/plastic to water bodies					
9	Water quality is affected due to fish excrement as a result of pisciculture					

a. Soil pollution

Sl. No.	**Statement**	**Highly agree**	**Agree**	**Undecided**	**Disagree**	**Hig disa**
1	Soil is polluted due to excess use of chemical					

	fertilizers					
2	Soil is polluted by soil borne pathogens					
3	Soil is polluted due to sewage material					
9	Soil is polluted due to occurrence of heavy wind and flood					

a. Air pollution

Sl. No.	Statement	Highly agree	Agree	Undecided	Disagree	Highly disagree
1	There is air pollution due to decomposition of animal carcasses					
2	There is air pollution due to burning crop residues cause air pollution					
3	There is air pollution due to trash and domestic waste burning					
4	There is air pollution by the noises from heavy vehicles					

5	There is air pollution due to automobile emissions					
6	There is air pollution due to fumigant pesticide/fertilizers					
7	There is air pollution due to emission from industries					
8	There is air pollution due to excess use of nitrogenous fertilizers					
9	There is air pollution due to exhaust fumes from agriculture machinery					

2. **Ill effects of pollution as perceived by the stakeholders**

   a. **Statements showing the ill effects due to agri-intensive cultivation**

Sl. No.	**Due to agri-intensive cultivation**	**Highly agree**	**Agree**	**Undecided**	**Disagree**	
1	Water quality is hampered due to frequent use of pesticides					
2	Water quality is affected by					

	chemical fertilizers					
3	Beneficial soil microbes are destroyed by chemical fertilizers					
4	Debris from plastic mulching causes soil pollution					
5	Use of fumigant pesticides cause air pollution					
6	Residual toxicity is seen due to pesticide use					
7	Soil pollution is caused due to indiscriminate pesticide use					
8	Natural predators of pests are killed due to indiscriminate pesticide use					
9	Air pollution is caused due to increased application of N and P fertilizers					
10	Air pollution is caused due to the burning of agricultural by-products					

11	There is a pest resistance and resurgence due to pesticide application				
12	Respiratory diseases are caused due to the usage of power threshers				

a. Due to IFS with livestock

Sl. No.	Statements	Highly agree	Agree	Undecided	Disagree	H d
1	Water pollution is caused due to livestock manure					
2	Air pollution occurs due to noxious odour and methane from livestock waste					
3	Environment is polluted due to poultry litter containing ammonia					
4	Outbreaks and epidemics in human beings are caused due to uncleaned litter					
5	Water is polluted due to application of					

	fish feed					
6	Water is polluted due to fish waste and debris					
7	Soil pollution is caused due to repeated use of dairy waste in crops					

a. Due to threats to human health due to farming system practices

Sl. No.	**Statements**	**Highly agree**	**Agree**	**Undecided**	**Disagree**	**Highly disagr**
1	Fluorosis is caused due to contaminated water					
2	Blue baby syndrome due to water pollution is seen					
3	Neurological disorders due to air and noise pollution is witnessed					
4	Sterility disorders in crops are caused due to pollution					
5	Automobile					

	exhaust causes plant damage				
6	Cardiovascular diseases are caused due to pollution				
7	Bronchitis and asthma are caused due to pollution				
8	Food poisoning and diarrhoea occur due to pollution				
9	Overall unpleasantness in lifestyle as a consequence of pollution				

1. **Statements on the awareness of the farmers about the causes of pollution faced by agricultural systems**

Sl. No	**Statement**	**Unaware**	**Aware by friends**	**Aware by mass media**	**Aware by experience**
1	The industrial sludge let into water bodies cause				

	environmental pollution				
2	Water quality is hampered due to fish wastes and uneaten feed from aquaculture practice				
3	The plastic/domestic wastes dumped by civilians into water bodies causes pollution				
4	The recurrent occurrence of wind and flood causes soil erosion				
5	The improper burying of biomedical waste causes groundwater pollution				
6	Disposal of the chemical pesticide and fertilizer containers near the field or water bodies pollutes them				
7	The dumping of domestic wastes in and around the field pollutes the soil				
8	The debris left behind from fishing activities pollute the water and destroy aquatic ecosystem				

1. **Statements on the awareness of the farmers about the effects of pollution faced by agricultural systems**

Sl. No	**Statement**	**Unaware**	**Aware by friends**	**Aware by mass media**	**Aware by experience**

1	Poor crop stand and yield is as a result of pollution				
2	Presence of dead aquatic animals is a consequence of pollution				
3	Respiratory diseases occur in the farmer and his family due to prolonged air pollution				
4	Death of livestock and other farm animals occur due to pollution				
5	Difficulty in carrying out agricultural operations in the field occurs due to pollution				
6	Trash dumped around the field is the breeding ground for pests and diseases				
7	Dead aquatic creatures are seen in water bodies due to leftover debris from fishing activities				
8	Blue baby syndrome in infants is a consequence of water pollution				

1. Exposure of the farming systems as perceived by farmers

Sl. No.	Exposure					
1	Agriculture sector has become more vulnerable due to environmental pollution					
2	There is an occurrence of pollution caused by both natural changes in environment and human activities					
3	Air, water and soil pollution affect the farming practices					
4	Pollution has emerged as a major problem in agriculture nowadays					
5	There is climate change due to pollution					
6	There is an uncertainty in rainfall as an indirect consequence of pollution					
7	Extreme weather events in the last few years have affected the adaptation and mitigation practices					
8	Biodiversity is threatened as a result of pollution					

9	There are dry spells associated with pollution					

1. **Sensitivity of the farming systems as perceived by farmers**

Sl. No.	**Sensitivity**					
1	There is an increased incidence of weeds and insect pest attacks than earlier times					
2	There is a decrease in production due to pollution					
3	There is increased deforestation as a consequence of pollution					
4	There is an increase in soil erosion					
5	There is extinction of plant and animal species due to pollution					
6	Livestock rearing has become vulnerable because of pollution					
7	Productive capacity of livestock is adversely affected due to extreme pollution					

1. **Adaptive capacity as perceived by farmers**

Sl. No.	Adaptive capacity					
1	Farmers resort to change in cropping pattern and cropping seasons					
2	Farmers change their livelihood pattern					
3	Farmers change their crop choice and crop cycle					
4	Farmers change their land use pattern					

1. **Constraints expressed by farmers**

Sl. No	Constraints	Unimportant	Least important	Less important	Important	More	Most important
1	Inadequacy of waste disposal and recycling facilities						
2	Increased emergence of pests and diseases						
3	Lack of proper guidelines regarding pesticide and						

	fertilizer application						
4	Fluctuations in the seasons causing improper crop cultivation cycles						
5	Unavailability of insurance for crop losses due to pollution						

Interview schedule for the other stakeholders

Name:

Phone No.

Panchayath:

Position held:

1. **Ill effects of pollution as perceived by the stakeholders**

   a. **Statements showing the ill effects due to agri-intensive cultivation**

Sl. No.	Due to agri-intensive cultivation	Highly agree	Agree	Undecided	Disagree	Highly disagree
1	Water quality is hampered due to frequent use of pesticides					
2	Water quality is affected by					

	chemical fertilizers					
3	Beneficial soil microbes are destroyed by chemical fertilizers					
4	Debris from plastic mulching causes soil pollution					
5	Use of fumigant pesticides cause air pollution					
6	Residual toxicity is seen due to pesticide use					
7	Soil pollution is caused due to indiscriminate pesticide use					
8	Natural predators of pests are killed due to indiscriminate pesticide use					
9	Air pollution is caused due to increased application of N and P fertilizers					
10	Air pollution is caused due to the burning of agricultural by-products					
11	There is a pest resistance and resurgence due to pesticide application					
12	Respiratory diseases are caused due to the usage of power threshers					

a. Due to IFS with livestock

Sl. No.	Statements	Highly agree	Agree	Undecided	Disagree	Highly disagree
1	Water pollution is caused due to livestock manure					
2	Air pollution occurs due to noxious odour and methane from livestock waste					
3	Environment is polluted due to poultry litter containing ammonia					
4	Outbreaks and epidemics in human beings are caused due to uncleaned litter					
5	Water is polluted due to application of fish feed					
6	Water is polluted due to fish waste and debris					
7	Soil pollution is caused due to repeated use of dairy waste in crops					

a. Due to threats to human health due to farming system practices

Sl. No.	Statements	Highly agree	Agree	Undecided	Disagree	Highly disagree
1	Fluorosis is caused due to contaminated water					
2	Blue baby syndrome due to water pollution is seen					
3	Neurological disorders due to air and noise pollution is witnessed					
4	Sterility disorders in crops are caused due to pollution					
5	Automobile exhaust causes plant damage					
6	Cardiovascular diseases are caused due to					

	pollution					
7	Bronchitis and asthma are caused due to pollution					
8	Food poisoning and diarrhoea occur due to pollution					
9	Overall unpleasantness in lifestyle as a consequence of pollution					

Sl. No	Constraints	Unimportant	Least important	Less important	Important	More	Most important
1	Pollution Act and Rules must be strictly enforced on the farms						
2	Farmers must make use of mass media to learn more about pollution hazards						
3	The farms and living surrounding must be properly sanitized						
4	Automobile pollution must be technologically controlled						
5	Increase the use of bio-pesticides						
6	Large scale plantation of trees must be carried out near farms						
7	Wastes and by-products must be recycled						
	Adopt Integrated Pest Management techniques along with insecticides						
	Encourage more of agroforestry farming systems						
	Urban and industrial waste must be recycled, managed and controlled						
	Vermicomp. must be made use of						