Agricultural Risks Management through Collective Actions

Managing Editors

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Foreword

The digital age has its preferences. The reading time has been encroached upon by a watching time. The access to information is easy and a plenty where Wikipedia has emerged as the most powerful encyclopedia ever. Yet, a book is a book! We wish to promote the habit of reading books. Finding books is not difficult or expensive (www.pdfdrive.com) but a local context and indigenous experiences could be missing.

The University of Agriculture, Faisalabad (UAF) has achieved global rankings of its flagship programs and acceptance as a leader in the field of agriculture and allied sciences. A competent faculty, the stimulating ecosystem and its learning environment have attracted increasing attention. Publication of books is an important KPI for any institution of higher learning. Hence, UAF has embarked upon an ambitious 'books project' to provide reference texts and to occupy our space as a knowledge powerhouse. It is intended that the UAF books shall be made available in both paper and electronic versions for a wider reach and affordability.

UAF offers more than 160 degree programs where agriculture remains our priority. There are about 20 institutions other than UAF who are also offering similar degree programs. Yet, there is no strong history of indigenously produced text/reference books that students and scholars could access. The last major effort dates back to the early 1990's when a USAID funded TIPAN project produced a few multiauthor text books. Those books are now obsoleted but still in demand because of lack of alternatives. The knowledge explosion simply demands that we undertake and expand the process anew.

Considering the significance of this project, I have personally overseen the entire process of short listing of the topics, assemblage of authors, review of contents and editorial work of 29 books being written in the first phase of this project. Each book has editor(s) who worked with a group of authors writing chapters of their choice and expertise. The draft texts were peer reviewed and language corrected as much as possible. There was a considerable consultation and revision undertaken before the final drafts were accepted for formatting and printing process.

This series of books cover a very broad range of subjects from theoretical physics and electronic image processing to hard core agricultural subjects and public policy. It is my considered opinion that the books produced here will find a wide acceptance across the country and overseas. That will serve a very important purpose of improving quality of teaching and learning. The reference texts will also be equally valued by the researchers and enthusiastic practitioners. Hopefully, this is a beginning of unleashing the knowledge potential of UAF which shall be continued. It is my dream to open a bookshop at UAF like the ones that we find in highly ranked universities across the globe.

The farming community is facing a robust push towards the abysmal misery. In this arena of various risks, getting triumph over the situation is the real challenge. In this book, various risks factors and their management through collective action in various realms of agriculture have been discussed.

Before concluding, I wish to record my appreciation for my coworker Dr. Muhammad Farooq who worked skillfully and tirelessly towards achieving a daunting task. Equally important was the contribution of the authors and editors of this book. I also acknowledge the financial support for this project provided by the USDA endowment fund available to UAF.

Iqrar Ahmad Khan

Preface

Risks and uncertainties create perplexed and skeptical situations. Uncertainties and risks thrust the farming community towards the certainty of failure. In agricultural sector, mostly there is confrontation of farming community with uncertainties. The risk has a connotation of uncertainty. Agricultural sector is full of risks and uncertainties starting from production till marking and even after marketing. This sector is totally exposed towards climatic changes and more vulnerable towards various hazards transforming this important sector more uncertain and full of risks. The natural catastrophic impacts are very much drastic, and the repercussions have their perpetual impacts.

There are various types of risks pertinent to agriculture. The agricultural risks having prominent realms in production, marketing, financial, institutional and human etc. The success of agricultural sector and the farming community is interlinked in a reciprocal way. The negative trend in any aspect of agriculture would put negative impacts on the farming community. Any wrong agricultural policy would result in augmentation of various risks for farming community. Any illogical or irrational decision would deteriorate the situation for the farming community. Moreover, small famers with meager resources are more vulnerable and exposed to hazards as compared to the landlords with plenty of resources. The agricultural risks are interlinked.

There are a number of other publications and literature available on these crucial issues and challenges. However, it seems logical to present such a book that can reflect various pictures with single comprehensive sight. The book is a strive to make a contribution by giving a nudge for stirring the mind towards multifaceted dimensions to zoom in and out the challenges for salvation form the distressed and dejected position. It can open the horizons for pragmatic vision of a paradigm shift from oblivious towards the awareness light. The explicitly can pave the way to comprehend the rigorous transitions.

The book is a venture to encompass the diversified domains of risks in the sphere of agriculture. There are seven chapters in the book as detailed below:

- Chapter 1 reflects the agronomic practices and the risks involved in this perspective.
- Chapter 2 is an effort by the authors to envisage various risks with the perspective of plant protection approaches. There are glimpses of risks pertinent to various types of pests/diseases.
- Chapter 3 is an attempt to encompass agricultural risks with respect to farm machine management.

- Chapter 4 describes agricultural risks under climate change are reflected which is a gigantic challenge at present and in the coming years.
- Chapter 5 highlights the vital importance of livestock and livestock related threats are manifested.
- Chapter 6 discusses agricultural marketing and risk management.
- Chapter 7 covers crucial dimensions of economics of risk management.

This book a joint endeavor of on the part of various authors from different pertinent realms having national and international exposure. We are highly indebted all of them for their valuable contribution. We hope the book would be reflections of various scenarios on a single locus and would contribute to quench the thirst of knowledge.

Muhammad Iftikhar

Ghazanfar Ali Khan

Contents

Chapter 1

Agronomic Practices: Risks involved and their Management

Muhammad Farrukh Saleem and Muhammad Shahid*

Abstract

Accomplishment of yield potential following agronomic practices often acquaints with serious impairments in sustainability of agro-ecosystem. This chapter deals with jeopardies caused by agronomic practices and stratagems that can prove helpful to alleviate the adverse impacts induced by these faulty agronomic practices. Ramifications of agronomic practices include poor soil physiochemical and biological attributes, inefficient genotypic and environmental interactions, declined nutrients, water and pesticide use efficiency, polluted soil, air and water, and reduced profit margins at farmer level. Moreover, living organisms (humans, aquatic and terrestrial animals and birds) are highly prone to disproportions in agro-ecosystem since agricultural pollutant finds way to food webs of these organisms. Following soil conservation practices during soil preparation reduces soil compaction, erosion, nutrient imbalances, salinity, water logging and other damages. While, genotypic × environment interaction can be optimized using biochemical and physiological markers that depict strong association with morphological attributes. Moreover, soil and plant analysis based site specific application of nutrients increases nutrient use efficiencies. Most importantly, enhancement of organic matter in soil diminishes the leakage of nutrients from system and improves water holding capacity of soil. Water losses can be minimized through proper scheduling of irrigation, application of water at moisture sensitive stages of crops and optimization of water application methods in different crops. While, combination of biological, mechanical, physical and chemical methods in an integrated manner reduces risks associated with application

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of herbicides. Post-harvest damages in crops can be minimized using cares during seed harvesting, transport, seed enhancements and storage. Conclusively, sustainability of agronomic practices is highly shaky and should be negotiated to attain natural balance. In this perspective, considering the soil as living entity and not only a physical substrate during soil preparation, working within a closed system during nutrient management using organic sources of nutrients and minimizing the use synthetic fertilizers during fertilizer applications, monitoring of soil and plant moisture status and crop stages during irrigation, utilizing natural predators of weeds and integrated approaches usually reduce risks caused by agronomic practices to the sustainability of environment.

1.1. Risks during Soil Preparation and Tillage

Tillage has been an indispensable component of antiquate agriculture. It is mechanical manipulation of soil to prepare seedbed for sowing of new crops, to burry stubbles of previous crops, weeds eradication, mix soil amendments and conserve water. Numerous tools ranging from digging stick to modern ploughs and cultivators have progressed through time. However, numerous implications of tillage have been observed as tilling soil interferes with natural ecosystem.

1.1.1. Reduced soil biodiversity

Nature comprises of biodiversity and soil is also of no exception. Hence, soil comprises of diverse living organisms (Sheibani and Ahangar 2013). In the context of soil as living entity, one gram soil contains several thousands of bacteria, 1500000 fungi and mycorrhizae (Romero-Olivares et al. 2017). While, millions of fungal species are yet unexplored and only a few fungal pathogens have been revealed so far. Regarding soil fauna, 100000 protozoans, 500000 species of nematodes (West and Blader 2015) and 3000 species of earthworms exist in soil (Martinkosky et al. 2017). Besides these organisms, numerous invertebrates e.g. ants, termites, beetles, spiders etc. also inhabit soil (Renaud et al. 2017). All soil dwelling organisms are adversely affected under enhanced soil disturbance.

1.1.1.1. Earthworm population and tillage

Earthworms are of supreme importance regarding soil texture since these are considered as the most critical engineers of soil ecosystem (Chachina et al. 2016). Enhancing tillage intensity poses direct threat to population of earthworms (Schaik et al. 2016). Soil inversion during tillage leaves earthworms exposed to predators and enhances injuries to earthworm biomass under the varying microclimate of soil (Roger-Estrade et al. 2010). Earthworm population reduces under the intensive tillage while augments in conservation and no tillage in sandy loam and loamy textures soil (Capelle et al. 2012). Moreover, earthworm population also responds distinctly to tillage systems under dissimilar soil textures. With the increment of tillage intensity, reduction in earthworm population is more in sandy soils than in clayey type soils (Yvan et al. 2012). Furthermore, response of population of earthworms depends on soil stratification and body masses (Moos et al. 2016).

Earthworm species inhabiting near surface depict higher injuries than the species localized deeper in soil. Likewise, injuries aggravate with enhancing body size and masses (Singh et al. 2016). Moreover, epigean species of earthworms are lesser sensitive to soil disturbance than endogean species under the same tillage intensity, tillage system and soil texture (Mirmonsef et al. 2017).

1.1.1.2. Bacterial colonies and tillage

Regarding bacterial colonies in soil, rhizobia are the most important as these synthesize root nodules and fix atmospheric nitrogen (Dogan et al. 2011). Number of nodules is reliant on soil preparation method and tillage intensity (Chetan et al. 2016). Conventional tillage with burnt stubbles manifests 36 nodules per plant on an average. Whereas, no tillage with heavy disks used for addition of residues exhibited 56 and no tillage with direct seeding manifested up to 96 nodules per plant (Ceja-Navarro et al. 2010). Burning of crop might adversely affect bacterial populations. Burning of crop residues enhance soil temperature, diminishes nutrient availability and burns soil organic matter (Wang et al. 2012). Ultimately, bacterial populations are declined. Furthermore, nodule weight diminishes with enhancing soil disturbance (Valentine et al. 2017). Average weight of nodule under heavy disking and no tillage was 3.06 and 3.92 mg per nodule, respectively (Dogan et al. 2011).

Likewise, number of nodules decreases with enhancing tillage intensity and depth. However, average density of bacteria in soil strongly depends on crop residues availability (Sheibani and Ahangar 2013). In the presence of residues, bacterial population is more in tilled soils than no till. Relatively lower bacterial activities in no tillage soil are ascribed to anaerobic conditions in soil (Kumar et al. 2017). Addition of crop residues in no tilled soil aggravates the ratio of monounsaturated to saturated fatty acids that often leads to hypoxic conditions. Thus, deficiency of oxygen in the presence of stubbles causes declined bacterial activities (Dikgwatlhe et al. 2014). Still, bacterial activities are more in no tillage with residues than without residue additions. Hence, it proposes that bacterial populations entail stubbles together with nutrient availability specifically nitrogen and oxygen for multiplication. Mofeover, adding residues of crops enhance gram positive to gram negative ratio in soil (Jian et al. 2016).

1.1.1.3. Fungal growth and tillage

Soil conditions are usually not suitable for growth of fungi. Hence fungi are localized as dormant propagules in rhizospheres. Numerous dormant forms of propagules encompass conidia, sclerotia and thick walled chlamydospores. Afterwards dormant fungal propagules are triggered from signals through seed or plant roots growing towards fungi. Response of fungi is chemotactic towards stimulation from plant. Enhancing soil disturbance normally decreases fungal growth while adding organic residues usually stimulates fungal growth. Hence, fungal growth is more under zero or no till conditions than conventional tillage. While, addition of crop residues often enhances the fungal growth under all tillage systems over no addition of organic residues and thus aggravates soil sickness.

From agricultural point of view, arbuscular mychorrhizae (AM) are of primary concern. Arbuscular mychorrhizae constitute an important fraction of soil ecosystem while proportion of AM is direct indicator of physically protected organic carbon in soil. Glomalin biosynthesis of AM declines with enhancing frequency and intensity of conventional tillage. Therefore, soil particles aggregate stability and carbon sequestration are reduced in conventional tillage system. Likewise, hyphal growth capability to enclose macro-aggregates of soil also declines under conventional tillage systems. Moreover, there also exist a significant positive association of AM with soil microbial biomass and total nitrogen. Thus, nitrogen accessibility and microbial growth would be diminished under enhanced soil disturbance (Wang et al. 2012). Decrease of mycorrhizal growth under enhanced tillage can be attributed to alterations in moisture regimes and disruption of hyphal network. Distribution density of AM depends on nature of vegetation and soil disturbance. So, hyphae are highly dense in grassland and non-tilled soils, moderately dense in organically managed non-disturbed fields while lowest in conventionally tilled soils (Verbruggen et al. 2010).

1.1.1.4. Soil nematodes

Soil nematodes' biomass, body length and weight are important indicators of soil health. Moreover, nematodes' position in lower trophic levels in food chain further enhances its importance in soil ecosystem. Enhancing soil disturbance usually declines nematode population while addition of crop residues triggers nematode multiplication. Conventional tillage practices diminish trophic diversity and enrichment index while enhance activity in shallow channels. While, specific response of nematodes to tillage intensity and frequency is dependent on genera. Some genera are tillage sensitive while others are crop residue sensitive. All genera are sensitive to tillage except Acrobeloides and Dorylaimellus which depend on residue-tillage driven soil dynamics. Furthermore, intensive tillage declines biomass and number of nematodes while decrease in residue addition reduces abundance of nematodes per unit soil mass. Organic matter addition increases diversity index and generic richness. Nematodes population, diversity and genera distribution are strongly correlated with ecosystem processes and other biotic groups. Basal index of nematodes is also higher under conservation tillage over conventional tillage. Conventional tillage might seal soil surface to produce constricted air spaces in soil. Whereas, nematodes are present immediately above bacteria and fungi (bacteria and fungi eaters) in food chain of soil ecosystem. Therefore, any soil conditions that adversely affect bacteria and fungi also reduce nematode population.

1.1.1.5. Soil sickness

(i) Glycosidase enzyme

Its activity is usually enhanced under tillage operations however, intensive tillage might aggravate loss of organic carbon from soil ecosystem.

(ii) Microbial biomass carbon changes (MBCC)

It specifies ecosystem health under the dynamic management practices. Higher MBCC designate good health of ecosystem. Intensive tillage declines MBCC.

(iii) Monounsaturated fatty acids (MUFA) / saturated fatty acids (SFA)

Ratio of MUFA to SFA elucidates aeration and aggregation of soil. Higher is the MUFA/SFA, poor will be capability of soil to support oxygen passage. Conventional tillage enhances MUFA/SFA while conservation tillage practices decline MUFA/SFA.

(iv) Basal and substrate induced respiration (IR)

It is indicator of soil microbial respirational activities and decomposition rate of organic residues. Conventional tillage improves basal and substrate IR of soil microbes.

(v) Total biomass and abundance of earthworms

Tillage practices usually reduce earthworm abundance.

(vi) Microbial biomass C: N ratio

It depicts relative proportion of fungi and bacteria in soil. If bacteria are more then C: N becomes narrow while in case of more fungal growth C: N ratio becomes wider. Moreover, tillage mediated decline in fungal hyphae is much larger than that of bacterial activities in in non-tilled soil.

(vii) Bio-indicators

Bio-indicators comprise earthworms, mites, nematodes, collembolans and enchytraeids. These are important components of soil ecosystem in temperate climate. Activities of bio-indicators diminish under conventional tillage over conservation tillage.

(viii) Gram positive / gram negative

Ratio of gram positive and gram-negative bacteria is an indicator of soil starvation stress. If rate of loss of organic carbon is faster than decomposition of organic matter, then gram positive/ gram negative ratio will decline and there will be higher starvation. Conventional tillage decreases gram positive/ gram negative ratio.

(ix) Nematodes

Nematodes designate important components as these plays important role in food web after bacteria and fungi. Conventional tillage generally declines nematode body weight, abundance and distribution at all soil depths.

1.1.2. Imbalanced nutrients uptake

Nutrient uptake is modified under tillage since it alters physical, chemical and biological properties of soil. Nitrogen losses are lesser in reduced tillage systems than those in conventional tillage systems. Nitrate nitrogen levels are much higher in intensive tillage systems over zero or no tillage. Improved aggregation of soil under minimum soil disturbance downregulates nitrification and thus reduces nitrogen leakage from agro-ecosystem. Ultimately, nitrogen use efficiency enhances as nitrate leaching and denitrification losses are alleviated under stable aggregation.

Conversely, more nitrogenous fertilizer would be required to accomplish nitrogen use efficiency same as in reduced tillage system. Consequences of nutrient loss include imbalanced availability of nutrients and deficiency of micronutrients.

1.1.3. Enhanced decomposition of organic matter

Intensive tillage practices aggravate decomposition of organic matter, organic carbon and nutrient loss from ecosystem. Lesser soil organic matter results in poor soil structure. Puddling in rice fields also degrades soil physiochemical and biological attributes. Consequently, poor physical conditions of soil result into poor stand establishment.

1.1.4. Soil compaction

Excessive tillage leads to compaction of soil. Soil compaction is microscopic rearrangement of soil particles in response to applied pressure which reduces the distance between soil particles and enhances soil bulk density. In quantitative terms, it is the ratio of actual bulk density to the bulk density reached after application of 200 k Pa pressure on a wet soil. Negative implications of compaction comprise augmented shear strength, reduced soil air and disrupted soil structure.

Soil strength is influenced by its moisture contents, texture, structure, organic matter, axle load (weight of tractor) and axle pressure (axle load per unit area of surface with unit k Pa). Axle load is dependent on number, dimension, velocity of tyres and interaction of tyres with soil. Tractor with more axle load causes more compaction during tillage and land preparation operations. While, enhancing the frequency of tillage operations augments bulk density and cone index of soil. Most of total compaction caused by tractor comes about during first passage or early passage. While, continuous 10 passages can block soil pore spaces up to a depth of 50 cm (Hamza and Anderson 2005).

1.1.5. Reduced aeration

Reduced aeration is a consequence of tillage mediated compaction. It accompanied by highly reduced conditions, more negative reduction potential, blocked air spaces, poor microbial activities and mineralization. Frequent tillage promotes compactions, deprives the soil of oxygen and aggravates waterlogging simultaneously. Therefore, plant water uptake is also downregulated. Moreover, reduced conditions trigger synthesis of Fe^{+2}-oxides and hydroxides. Schnurr-Putz et al. 2006 recorded 15-30% increment in Fe^{+2} in soil solution above 30 cm soil because of tillage mediated compaction. Besides, compaction also promoted water logging conditions. Moreover, soil compaction mediated reduction in oxygen availability favors the growth of anaerobic methanogen bacteria leading to higher efflux of methane.

1.1.6. Environmental impacts

Tillage enhances fuel consumption which threatens environment sustainability through release of greenhouse gases into atmosphere. Tillage triggered soil compaction enhances release of greenhouse gases such as CO_2, NO_2, CH_4 etc. Therefore, climatic skepticism may cause complete crop failure, shifting cropping patterns, species dominance and distribution and failure of current genotypes of crops (Singh et al. 2015).

1.1.7. Erosion

Declined soil fertility and organic matter are some major consequences of tillage specifically in highly weathered soils. Since, nutrients and most of the organic matter are localized in upper few centimeters of soil layers. Loss of soil fertility under tillage mediated accelerated erosion can be ascribed to escalated nutrient loss along runoff water and transportation of solid soil colloids to other sites. Consequently, enrichment ratio inclines since eroded sediments depict higher nutrients contents than the bulk of soil. As, most of minerals nutrients are adsorbed on soil colloids, hence tillage induced decline in density and settling velocity further aggravates nutrient loss.

Tillage mediated disruption of soil texture diminishes aggregate stability of soil. Consequently, available soil water contents are diminished and susceptibility to drought aggravates. Water runoff declines under no tillage over conventional tillage. Runoff was declined from 29.9% in conventional tillage to 0.8% in no till over the years (Lal 1996).

Tillage mediated increment in erosion declines aggregate stability, infiltration capacity and mineralizable nitrogen while enhances crusting and compaction. Escalated erosion usually enhances Fe contents of soil which ultimately augments soil shear force. Moreover, tillage mediated alterations in soil quality comprises enhanced soil bulk density, declined permanent wilting point, hydraulic conductivity, field capacity moisture contents, available water contents and soil organic carbon (Busari and Salako 2015).

1.1.8. Increased operational costs

Tillage being a necessary evil enhances crop establishment and reduces soil born diseases. However, only tillage constitutes 25% cost of the total inputs of crops, Therefore, net profit abolishes under intensive tillage at the cost of environmental pollution. In conservation tillage, total operations required to prepare field are reduced. Moreover, lesser time is required for field preparation that results in timely/early sowing. Labor force prerequisites are also more in conventional tillage over conservation practices. Similarly, fuel usage is significantly higher in conventional tillage over conservation tillage. Higher fuel burning in conventional tillage also aggravates the emission of greenhouse gases into atmosphere.

Conventional tillage consumed 60 L ha^{-1} more fuel than zero tillage (Laxmi et al. 2007).

1.1.9. Low water use efficiency

Water use efficiency usually declines under conventional tillage. Lower water use efficiency can be attributed to disrupted soil aggregate stability under conventional tillage. Furthermore, escalated decomposition of organic matter under intensive tillage is another reason for poor water use efficiency in conventional tillage. Aggravated water wastage in conventional tillage also accompanies waterlogging and salinity problems. Overexploitation of ground water compounded by poor management declines ground water table depth and aggravates pumping cost. Evapotranspiration losses were significantly more in conventionally sown wheat after rice than zero tilled wheat (Jehangir et al. 2007).

1.1.10. More weeds growth

Growth of weeds is usually more under conventional tillage system over conservation tillage. Since seed are exposed to environment during soil inversion hence, dormancy period usually ends for many buried seeds which ultimately compete with crop. Lesser infestation under conservation tillage is a result of consequence of moisture preservation, mulching effect of crop residues and lesser disturbance to weeds seed bank in soil.

1.1.11. Lesser economic yield

Economic yield is also negatively impacted by excessive tillage practices and soil disturbance. Yield usually declines as a consequence of poor nutrient availability, organic matter contents, soil compaction, poor microbial activities and aeration. Moreover, late sown triggered synchronization of terminal stages with high temperature prevalence further diminished yield.

1.1.12. Aggravated costs

Chief factors deterrent to higher profits in intensive tillage practices are lesser yield and aggravated production cost (Erenstein et al. 2007).

1.1.13. Impacts on root growth

Tillage induced compaction can alter roots morphologically, biologically and chemically. Tillage mediated compaction concentrates root growth in upper soil layers with a corresponding decrease in root density in subsoil layers. Lesser root growth is consequence of mechanical impedance experienced by roots.

Consequently, cytokinins biosynthesis at root tips diminishes and cell division and chlorophyll biosynthesis is reduced. Tillage mediated compaction also declines number, biomass and distribution of root nodules in legumes.

1.2. Management Options

1.2.1. Reduce the soil compaction

1. Reduce the passage of traffic and other machineries to 20-30% of total field area by developing lanes; it reduces soil compaction by 70-80%
2. Decrease the axle load of tractor; it can be achieved through engineering the shape of tyres. Enhancing surface area of tyres reduces axle load on per unit soil area, therefore compaction reduces to remarkable extent.
3. Avoid execution of mechanical operations on wet soil. Soil containing moisture more than field capacity is highly prone to compaction.
4. Include deep rooted crops in cropping
5. Enhance organic matter contents of soils through addition of animal manures, green manures, natural mulches etc.

1.2.2. Promote conservation tillage

Conservation tillage is an umbrella term that encompasses any type of tillage that minimizes soil disturbance and leaves residues of previous crops on soil surface as mulch taking account into soil health. It can be divided into zero tillage or direct seeding and reduced or minimum tillage. No tillage or zero tillage is direct sowing of new crop in stubbles of previous crops without any tillage operation, e.g. sowing of wheat in stubbles of cotton. While, reduced or minimum tillage means reducing the number of total tillage operations to a level that required to prepare soil for sowing of crop. Benefits of conservation tillage comprises

1.2.3. Improvement in soil physical attributes

Conservation tillage improves soil physical health in the long run. Soil porosity improved under conservation tillage, it enhances infiltration capacity as well as saturated and unsaturated hydraulic conductivity of soil. Role of stubble retention in this regard is also evident. Resultant improved aggregate stability and caused decline in its bulk density. While, light texture soils containing low organic matter depict more promising results under conservation tillage than in conventional tillage. Minimum tillage for a period of 40 years enhanced aggregation, infiltration, soil organic carbon contents and nitrogen availability over the conventional tillage (Jacobs et al. 2009). Moreover, augmented porosity of soil improves eater holding capacity and available water contents to plant roots. Water transmitting as well as storage pores are enhanced remarkably under enhanced aggregation in no tillage system. Consequently, roots can penetrate deeper soil layers than conventional tillage.

1.2.4. Improvement in soil chemical properties

No tillage enhances cationic exchange capacity, available nitrogen and phosphorous. Organic matter contents are also improved under conservation tillage particularly in upper 10-15 cm layer. Owing to organic matter content, pH of soil becomes low under the influence of carbonic acid. Exchangeable potassium, magnesium, sulfur, boron and zinc are also increased under no tillage over excessive tillage.

1.2.5. Biological properties

Activities of earthworms are enhanced under no tillage over conventional tillage. Hence, soil aeration and infiltration increase remarkably. Owing to organic matter, bacterial activities, earthworms' and nematodes' biomass are improved under conservation tillage.

1.2.6. Improvement in yield

Conservation tillage mediated increment in length, diameter and biomass of roots leads to enhanced nutrient and water use efficiencies. Consequently, susceptibility to drought declines as roots become able to penetrate deeper layers.

1.2.7. Environmental sustainability

Conservation tillage techniques reduce the process of denitrification by enhancing oxygen availability and improving aggregate stability. While, tillage mediated increment in soil surface area enhances ion exchange capacity of soil colloids and diminishes nitrate leaching into ground water. Thus, contamination of ground water is also eliminated. Moreover, it enhances environmental sustainability by reducing the efflux of greenhouse gases into atmosphere directly. Indirectly, this reduces fuel consumption of mechanical machineries. Conservation tillage mediated increase in water and nutrients' use efficiencies means reduced release of these elements into air and underground water.

1.2.8. Soil organic carbon (SOC) contents

It increases soil organic matter which is considered as an index of soil health. It not only controls biological activities but is also a good indicator of physical and chemical characteristics of soil. So, significantly lesser organic matter contents were observed with chisel and mold board plough (Ussiri and Lal 2009). While, organic matter was 38% more in no till farming over intensive tillage practices (Verhulst et al. 2010).

1.2.9. Increased nutrient availability

Conservation tillage improves nutrient use efficiencies in the long run. Although, mineralization reduces at the initiation of conservation agriculture and it accompanies the application at higher rates. However, with time, nitrogen immobilization is declined and its availability is enhanced. Rapid immobilization at initial stages occurs due to higher microbial activities in conservational tillage over conventional tillage. More microbial activities escalate degradation of carbon rich residues and nitrogen released is utilized by microbes to synthesize proteins of their bodies. After some time, nitrogen released becomes more than microbial requirements and thus mineralization starts. Although, nitrogen availability is severely reduced at the initiation of conservation agriculture, however it has been recorded that nitrogen losses are enhanced in conventional tillage while declined under no till farming over the years. No and conventional tillage depicted 24.6% and 11% improvement in nitrogen use efficiency after 16 years (Wang 2008).

Phosphorous fixation declines under conservation tillage practices in upper soil layers. Tillage practices convert the soil to smaller particles that enhance surface area of soil particles. Consequently, more fixation is caused by smaller sized particles of soil. Moreover, improvement of organic matter of soil escalates mineralization process and hence phosphorous availability is enhanced.

Improved aggregate stability, organic matter contents, infiltration capacity and microbial activities lead to more potassium use efficiencies under conservation tillage over intensive tillage practices. Therefore, roots penetrate to deeper soil layers under reduced soil compaction in no tillage system. Moreover, zero tillage with residues left on soil surface depicted 3.5% more potassium uptake over conventional tillage in 0-5 cm depth (Govaerts et al. 2007). Higher potassium uptake is also ascribed to lesser leaching in no tillage. Shoved stubbles left on soil surface might decline loss of nutrients through leaching which is more likely to happen with the buried stubbles in conventional tillage.

1.3. Risks Involved in Genotype Selection

Selection of genotypes using morphological and agronomic attributes has been an outmoded tactic to boost the productivity. On basis of agronomic tactics, group of genotypes are mapped and linked using desirable and undesirable morphological attributes. Therefore, selection of genotype depends on physically discernable traits under field conditions. There are numerous reasons for which agronomic selection of genotypes is dubious. First, morphological attributes of crops and their performance is highly dependent on environmental conditions. Often, the environmental aspects alter the expression of agronomic traits and thus lead to faulty inferences about genotypes. Second, morphological traits are associated with undesirable attributes such as dwarfism or albinism. Third, the distribution of loci throughout genome for the focused trait is not taken into consideration during agronomic selection which further declines selection efficacy. Fourth, various phenomenon such pleiotropic effects, epistasis and dominance also decline the reliability of agronomic and morphological traits as selection tool. Lastly, agronomic based selections of genotypes are time and resource consumptive since repetition over time, seasons and years is often demanded to enhance the reliability of selected genotypes.

Qualitative traits cannot be measured while selecting genotypes of different crops using agronomic traits. Moreover, reliability of agronomic selection becomes even more ambiguous when selection is done at terminal stages using sex-linked attributes of crops. Physiological restrictions to growth and yield cannot be addressed genetically when promising alleles are less frequent. Thus, gene pool cannot be improved for a trait to be improved on agronomic basis. Likewise, agronomic selection for traits that exhibit low heritability proves ineffective and time consuming. Moreover, opportunities to pyramid promising alleles from diverse parental genetic pool are totally ignored while selecting genotypes agronomically.

All these factors contribute towards poor efficacy of agronomic genotype selection. Abiotic stress tolerance in crop is highly correlated with physiochemical attributes such as antioxidant activities and maintenance of turgor by accumulation of osmotic substances. Osmotic substances accumulated by crops to accomplish abiotic stress tolerance are amino acids (proline, arginine), non-protein amino acids (γ amino butyric acid, 3-di methyl sulfonio propionate), secondary metabolites (glutamate, glutrate), osmolytes (potassium, calcium) and osmo-protectants (proline, glycine betaine). Antioxidants and osmotic substances often depict strong positive association with morphological attributes and therefore induce abiotic stress tolerance. While, these attributes are taken into consideration during the field evaluation of varieties selection and thus efficacy of selection is reduced.

Genotypes selected under glass house conditions using morphological traits are also not demonstrative of diverse field conditions. Consequences of selection results into poor and stagnant yield in marginal areas and reduced genetic diversity. While, selection of varieties in isolation without considering other plant species disrupts ecological balance. Specific problems allied to different field crops while selecting a cultivar on agronomic standards are discussed here.

1.3.1. Wheat

Allohexaploid ploidy level of wheat complicates the selection of wheat genotypes on agronomic grounds. Selection of wheat genotypes on morphological and agronomic traits for numerous production, abiotic, biotic stresses and nutrient use efficiencies depicts lower efficacy over contemporary techniques. Presence of numerous quantitative loci for a single morphological trait complicates selection process (Mwadzingeni et al. 2016). Since, numerous loci interact differently under varying environments to constitute a dissimilar phenotype. Furthermore, agronomic attributes (tillers, thousand grains weight, number of grains per spike and grain yield) based selection manifests varying grain protein, gluten and glutenin contents. Moreover, baking features of wheat comprise grain protein contents, starch contents, dough development, water absorption, dough departure time and dough stability. These are not taken into consideration while selecting genotypes on agronomic basis which declines end use quality. Hence, selecting wheat genotypes using agronomic traits makes the wheat indecorous for industrial processing (Sanchez-Garcia et al. 2015).

Selection for a single trait for stress tolerance engenders segregation when genotype interacts with environment since most of the traits are polygenic. Stress tolerance is mutagenic trait in wheat and expression of a trait in an environment relies on silencing of and expression of different genes. Moreover, these traits rely on multifarious environment and their expression is resultant of signaling transduction, transcription and expression of stress proteins. Selection on the basis of agronomic traits thus reduces efficacy and leads to faulty conclusions about the varying genotypes under stresses. Moreover, selection of wheat genotypes under stress exhibit substantial impacts on physiochemical processes. These physiochemical processes often depict strong association with agronomic and morphological traits. Stress tolerance is an integrated function of boosting of these processes. These physiochemical attributes are ignored during agronomic selection while repetitive loci in hexaploidy genome exhibit segregation of agronomic attributes. Likewise, seedling vigor in wheat and other cereals is highly associated with embryo size and specific leaf area. While, overlooking of these traits using agronomic techniques decreases the efficacy of genotype selection for vigor. Moreover, early vigor of wheat genotypes is a consequence of gene additive effect which varies with the environment (Zhang et al. 2015).

1.3.2. Rice

Selection of rice genotypes based on agronomic and morphological traits declines efficacy of selection. Selecting segregating populations morphologically might accompany undesired loci for a trait being evaluated in selection. Consideration of genetic variations in varying genotypes is an important components of genotype selection which remains abandoned in agronomic selection. Rice genotypes should be genetically divergent to enhance efficacy of selection while this aspect is neglected during agronomic selection. Consequences of genetic homozygosity in rice results aggravated predisposition to numerous biotic and abiotic stresses. While, overlooking of genetic diversity during selection poses serious threats to sustainability of rice based cropping systems. Moreover, polygenic traits and narrow genetic diversity for abiotic stress tolerance further aggravate complications in agronomic selection of rice genotypes.

Selection of rice on basis of panicle length has often demonstrated efficacy. However, varieties with larger sink capacities often fail to accomplish higher yield in field conditions due to limited inputs (Jian et al. 2016). Most importantly, such genotypes attain smaller leaf area, impediments in carbohydrate translocation to sink due to nutrient deficiencies, poor growth rate of endospermic cells and disrupted balance of plant growth substances (Li et al. 2013). Moreover, moderate soil dryness at grain filling aggravates oxidative stress, escalates grain filling rate, abscisic acid biosynthesis and grain shriveling (Meng et al. 2016). Ultimately, panicle length is diminished and variety becomes incapable to express its potential and often abandoned on agronomic basis. Genetic linkage maps are ignored during selection of genotypes on agronomic basis. These linkage maps encompass incalculable loci for numerous quality, production and stress related attributes. Saturation region of desirable gene is not given due consideration during morphological selection.

Biosynthesis of amylose and gel consistency are important attributes regarding quality. Amylose contents and consistency in rice grains is mediated by a microsatellite sequence of genes which cannot be selected using agronomic approaches. While, aroma of rice is developed by the biosynthesis of formaldehydes and formaldehyde biosynthesis is controlled by RG28 in rice genome. Agronomic selection will not be a viable practice to improve aroma of rice for selection among diverse genetic pools. Likewise, myoinositol-hexakisphospahte (storage house of phosphorous) constitutes major portion of rice grain phytate contents and decrease bioavailability of iron and zinc. Agronomic selection of genotypes does not provide a satisfactory selection for low phytate contents rice grains. Abiotic stress tolerance in rice genotypes is highly associated with accumulation of solutes and secondary metabolites to sustain water potential. Moreover, antioxidant activities overcome reactive oxygen species and thus trigger abiotic stress tolerance. These physiochemical attributes are usually overlooked in most of field trials of genotype selection and ultimately probability of faulty inferences aggravates. Attributes that impart abiotic stress tolerance are quantitative and polygenic which are highly dependent on environmental factors. Measurement of quantitative trait loci is also not possible while selecting genotypes on agronomic basis.

Tolerance against biotic stresses is triggered in rice by closely linked multigene families. Besides, these are clustered on a region of genome and cannot be selected using agronomic techniques. While comparing phenotypic and biochemical markers assisted selection of rice genotypes for blast resistance, more efficacy of marker assisted selection is obvious over phenotypic selection. Moreover, biochemical markers dependent selection also promotes the pyramiding of blast resistant genes to consequence into more reliable blast resistance over phenotypic selection. Likewise, resistance against brown planthopper is dependent on 5 loci of genomic region of chromosome-12 which is devoid of polymorphism. Agronomic selection does not account for these loci to concentrate in selected genotypes and consequence are disease epidemics under field conditions (Akhtar et al. 2010).

1.3.3. Maize

Maize depicts broad genetic diversity, morphological variations and polymorphism owing to open pollination. Higher genetic diversity enhances the probabilities of numerous traits to interact with environment over the crops having limited diversity. Effect of recessive alleles remains neglected in agronomic selection. Genome containing smaller portions of genes of a trait is also not discernable during selection of maize based on agronomic parameters. Moreover, large number of biotic and abiotic stress related traits in maize are quantitative and polygenic in nature. Indirect selection for stress tolerance using antioxidants, secondary metabolites and osmo-protectants are of enormous importance for selection when heritability estimate is higher than those primary traits. Selection on the basis of agronomic approaches does not deal with heritability estimates of target traits. Likewise, association of secondary traits also influences expression of phenotypes under stressed environments. Knowledge allied to kind and magnitude of correlation among biochemical markers and morphological traits affects selection of genotypes. This aspect is also overlooked in agronomic selection of genotypes (Iqbal et al. 2011).

Numerous problems confronted during agronomic selection of maize are due to broader genetic diversity of maize. Heterogeneity in genetic makeup in maize genotypes often depicts a varying phenotype after interaction with environmental factors. While, there is also likelihood that recessive alleles might interact with environment to produce a phenotype. Environmental factors might produce similar phenotypes for genotypes that are distinct at loci for a trait and their genetic similarity is beyond threshold levels. Therefore, physically and agronomical noticeable traits might not be proportional to genetic makeup in maize. Moreover, broad genetic diversity in maize often induces polymorphism and pleiotropic effects. Improper control of pollination can contaminate seeds, it might change expression of an agronomic trait and results in incongruities in genotype selection (Prasanna and Hoisington 2003).

Allelic variations in genes controlling a trait are not assessed while selecting genotypes on agronomic basis. Numerous traits in maize depict proportion to variations in genes; such traits are called metric traits. Utilization of metric traits is effective approach to determine genetic similarity and distinctness since these traits predict dependability of phenotype for a target trait. While, metric traits cannot be studied using agronomic approaches and result in faulty conclusions. Agronomic approaches do not deal with the genetic variances during the selection of genotypes based on morphological attributes (Poudel and Poudel 2016).

Information about the pedigree in genotypes of maize and other allogamous crops helps in deriving information about the genetic makeup. This aspect is also neglected during genotype selection. Grain yield and yield components are quantitative and regulated phylogenetically. Regarding quantitative traits, expression of recessive alleles is masked and expresses at terminal stages of plant. Moreover, quality related traits, grain yield and environmental stresses are regulated by QTLs. Linkage drag of one gene with the selection of another gene during agronomic selection reduces efficacy of selection. Genetic gains usually double in maize with marker assisted selection over agronomic selection (Crosbie et al. 2006). Hence agronomic based selection of maize cultivars neither reliable nor operative to make an explicit differentiation of diverse genotypes (Anley et al. 2013).

1.3.4. Cotton

Broad genetic diversity of any crop is an indication of sustainability and numerous genetic manipulations. While most of the genetic studies on cultivars of cotton (Gossypium hirsutum L. and Gossypium barbadense L.) exhibit low polymorphism, narrow genetic base and allotetraploid ploidy level. Allotetraploid signifies that single loci will essentially exist in cotton genome in the form of two unlinked loci on the related sub genomes. Allotetraploid ploidy level and narrow genetic basis especially in elite cultivars are leading bottleneck in selection of cotton genotypes agronomically. Moreover, quality and yield traits of cotton fiber are physiochemically complex and genome size is 2702-2246 Mb (Rafiq et al. 2015). Hostile growing conditions in conditions might also distort a locus and thus change phenotypic expression of agronomic traits. Lesser genetic diversity further aggravates complexities to distinct numerous genetic pools and varieties.

Moreover, expression of quantitative traits is also linked to recombination of genes hence it would not be efficient selection for quantitative traits using agronomic tools as selection standards. Prevalence of soma clonal variations in cotton genotypes necessitates perceptions of genetic structure of cotton. Soma clonal variations in diverse genotypes of cotton poses serious threats to efficient selection of target traits in cotton. Similarly, mapping of fiber quality traits and associated quantitative traits are not considered during agronomic selection of cotton. Quantitative traits exist as cluster while also perform innumerable functions to accomplish deficiencies during cotton growth. Moreover, environmental factors can induce mutation in fiber quality by affecting primary and secondary cell wall biogenesis, cellulose metabolism, organization, structure and ethylene biosynthesis. Therefore, quantitative traits cannot be associated on morphological basis.

Phytochrome red and far red is regulated by phytochrome gene family in cotton. Phytochrome gene family regulate the expression of numerous processes such flowering initiation, boll development, architecture of plant, days taken to maturity, abiotic stress (heat, drought, salinity and chilling/freezing) and biotic stress (fungal diseases) tolerances. Agronomic selection can neither control nor provides any indicator to quantify phytochrome gene family. Likewise, genetic recombination together with polyploidy nature might change the expression of agronomic traits even if a gene for the selected trait is recessive. Therefore, resulted heterochromatin can comprise of larger portion of recombinant type. This will aggravate genetic distance while other portions will contain smaller proportion of recombinant genes. Both cases will result in wide ranges of phenotypes of the target traits and enhance incongruities in targeted traits (Preetha and Raveendren 2008).

Morphological selection causes transfer of undesirable genes through linkage drag. Thus, no control over linkage drag might introduce undesirable phenotype in cotton. Numerous qualitative attributes such as leaf shape, pubescence, leaf brackets, fiber color and boll shape undergo mutations when interact with environment. Qualitative traits cannot be selected precisely on basis of morphological observations (Rafiq et al. 2015).

1.3.5. Sugarcane

Saccharum officinarum L. is octoploid (x = 10, 80 chromosomes) while Saccharum spontaneum L. comprises numerous ploidy levels from 5 to 16 ploidies (x = 8). High and complex ploidy levels complicate agronomic selection of sugarcane cultivars. Low heritability of biotic and abiotic stress tolerance related attributes aggravates incongruities in phenotypic selection also. Cytogenetic complications of sugarcane genotypes encompass varying number of chromosomes, complex recombination of genes and larger genome size. Genome size of sugarcane is about 6 pg and it is six times larger than rice genome. Moreover, prevalence of aneuploidy in modern cultivars further aggravates complexities if selected based on morphological observations. Therefore, selection for more than one traits often enhances ambiguities and is time consuming if based only on agronomic approaches (Mirajkar et al. 2017).

Sucrose contents regulating genes are quantitative in nature hence sucrose contents would not be improved until QTLs are employed in selection process. Moreover, sucrose controlling alleles might contain a negative allele and therefore decline sucrose contents. Presence of negative alleles can be ascribed to quantitative nature of sucrose contents (controlled by multiple alleles). Consequently, gene recombination and transgressive plants will prevail, and agronomic selection would not distinguish genotypes containing negative alleles for sucrose contents. Moreover, sucrose synthase catalyzes the conversion of glucose and fructose to sucrose. Alleles regulating biosynthesis of sucrose depict both negative and positive association with sucrose contents. Contrasting consequence can also be ascribed to negative alleles in varying genotypes (Singh et al. 2013). Likewise, genotypes of sugarcane selected on agronomic basis using sucrose contents as screening tool result into narrow polarization in cane juice of selected genotypes. Hence, agronomic selection of genotypes does not consider negative alleles for sucrose biosynthesis (Silva and Bressiani 2005).

Selection of agronomically stress tolerant genotypes usually depicts stress tolerance in field. However, time and resource consumption makes it tedious to select genotypes using agronomic approaches. Additionally, polygenic and quantitative nature of stress related attributes reduces reliability of agronomic selection. Prevalence of soma clonal variability and genotypic mutagenesis cannot be distinguished by selecting genotypes on morphological basis. Gene transfer rate by selecting genotypes morphologically is lagging far behind than that of selection through markers. Numerous traits such as salinity, heat, drought, nutrient stress tolerance, viral infection resistance, lignin biosynthesis, herbicide resistance, nutraceuticals and bio-pigments exhibit poor transfer rate over marker assisted selection when selected based on physically detectable differences. While, mutagenesis associated to biotic and abiotic stress tolerance further aggravates irrationalities in agronomic selection (Khan et al. 2017).

1.3.6. Fodders

Selection of genotypes of forage species is tedious task using agronomic approaches since most of the traits are polygenic, quantitative and expression is highly reliant on environmental factors. Moreover, intraspecific interactions complicate process for selection of quantitative traits. Estimation of expression of traits before actual expression in field and transfer of desirable traits has low success rate over marker assisted selection. Selection of a specific allele in gene controlling the expression of traits often leads to faulty conclusions since allele interacts with environment and a phenotype is a resultant of environment and allele interaction. Inbreeding depression is most observable in tetraploids during selection on morphological basis. Inbreeding depression can be avoided selecting partially inbred genotypes containing favorable alleles for the target trait. It necessitates the use of marker assisted selection of fodders since recombination of alleles cannot be explored agronomically.

1.3.6.1. Alfalfa

Major species of alfalfa are *sativa* and *caerulea*. It exists as diploid (2n = 2x = 16) and tetraploid (2n = 4x = 32) with a genome size of 800-1000 Mbp. Cross pollination of innumerable ploidy levels in alfalfa declines efficacy of selection on agronomic basis. Presence of unreduced gametes in diploid populations of alfalfa alters ploidy level which is not detectable physically. Chief bottlenecks during selection of alfalfa genotypes are unreduced gametes induced polyploidization, gene sequences and genes flow (Han et al. 2011).

Mixing of diploid and tetraploid genotypes promote introgression and constitute the chief deterrent to selection on morphological basis. Agronomic selection in genotypes of alfalfa is also associated with constraints such as genotype × environment interaction, low inheritance of traits and multiple harvests over time and space, gene linkage problems and small improvements in biomass yield. Pooling of alleles by mixed growing of numerous genotypes is proposed as solution to low gains in biomass yield. However, it reduces considerations about the single allele for the targeted trait. Regarding gene linkage drag, tetraploid genotypes contain four homologous chromosomes with the varying saturation. Moreover, small linkage maps cannot be controlled by selecting genotypes on agronomic basis. Similarly, biotic and abiotic stress tolerance inducing quantitative alleles cannot be controlled using agronomic tactics. Specific problems faced in alfalfa selection on morphological/agronomic basis are i) enhancement of leaf to stem ratio and multi-foliate traits depict unpredictable expression ii) impossibility to make selection for an individual quality trait iii) impossibility to make downregulation of lignin biosynthesis (Li and Brummer 2012).

1.3.6.2. Egyptian clover

Egyptian clover is diploid (2n = 16), it most genotypes are synthetic in nature and differences among genotypes are not discernable through agronomic approaches. Allogamous nature complicates section on morphological basis through gene recombination. Moreover, karyotype genotypes depict differences in morphology of chromosomes. Biotic and abiotic stress related genes have not been explored yet. However, characterization of genotypes on agronomic traits exhibit variations in phenotype expression. Alteration in phenotype expression can be ascribed to varying gene frequencies for the targeted traits. Hence, agronomic selection of genotypes is not efficient owing to cross pollination, morphological differences in chromosomes and gene recombination (Zayed 2013).

1.3.6.3. Red clover

Red clover is also allogamous in pollination with sufficient inbreeding depression. Most of the cultivars are synthetic and developed through pooling of numerous genotypes. Varying genotypic populations are intercrossed with a subsequent open pollination. Even in narrow genetic based synthetic cultivar development, more than

10 cultivars are intercrossed. Consequences are heterogeneous genetic makeup for physically observable traits. Even if narrow synthetic cultivars are chosen based on agronomic selection, it limits enough genetic diversity in red clover genotypes to resist against biotic and abiotic stresses (Annicchiarico et al. 2015).

1.3.6.4. Persian clover

Persian clover being allogamous depicts alterations in physically detectable traits similarly to red clover. Recombinant types are not detectable morphologically since linkage instability of loci and gene also alter phenotypic expression in fodders. While, inbreeding depression is most common prevalence during agronomic selection of Persian clover genotypes (Annicchiarico et al. 2015).

1.3.6.5. Sesbania

Being cross pollinated, gene recombination alters phenotypic expression of traits. Moreover, leaf to stem ratio improvement, cellulose and lignin downregulation to ease decomposition after burying in soil, protein contents, crude fiber contents, biomass and dietary proteins cannot be augmented by agronomic selection. Moreover, drag linkage of genes introduces undesirable traits during agronomic based selection.

1.3.6.6. Fodder sorghum

Basic chromosome number in sorghum is 10 while polyploidization has evolved tetraploid sorghum ($2n = 4x = 40$). Starch, proteins, leucine, threonine contents and biomass yield are important attributes regrading polyploidization and agronomic selection of sorghum genotypes. Prevalence of polyploidy and soma-clonal variations often leads to faulty inferences during agronomic section. Environmental factor induced mutations depict strong impacts on nutrient uptake and plant height (Dahlberg et al. 2011).

Moreover, inheritance of varying traits is complex since some traits are highly heritable while others exhibit low heritability. Time taken to maturity, color of seeds and plant height are highly heritable and can be selected to some extent agronomically provided environment is suitable for expression. While, drought, heat, disease and insect resistance depict low inheritance and are polygenic, quantitative and non-uniform on phenotypic basis. Consistent correlation of single trait with biotic and abiotic stress tolerance does not prevail even under similar conditions which further aggravates incongruities in agronomic selection. Similarly, photoperiod sensitivity cannot be controlled in agronomic selection of sorghum and thus leads to poor quality inferences. Highly heritable traits selected agronomically do not depict stability for the targeted traits and not repeatable. Polyploidization and environmental interactions complicate selection of genotypes for these traits while using agronomic strategies as selection tool (Girijashankar and Swathisree 2009).

1.3.6.7. Pearl millet

Genetic improvement in pearl millet using agronomic tactics is a complex function of innumerable interacting factors. Inheritance of some traits is more than others and screening techniques are not time, labor and technically efficient to improve productivity. Broader genetic diversity of pearl millet complicates process of genotype selection for the focused trait. Inheritance pattern of most of traits is complex and gene recombination is not considered during agronomic approaches. Moreover, pearl millet lacks genetic diversity sufficient for developing biotic and abiotic stress resistance. Likewise, phenotypically selected genotypes using agronomic traits depict segregation for the targeted and heterozygous traits. Moreover, traits depicting high heritability are not associated to biomass and grain yield (Izge and Song 2013).

Close relationship of millet with other cereals in phylogeny aggravates the introgression of alleles and genes. It enhances incongruities in agronomic selection of stress related attributes owing to multigenetic and quantitative nature of these traits. Complications regarding phenotypic selection can be reduced by appraisal of genetic diversity. Numerous enzymes such as kinases, oxidases and transferases depict strong association with grain yield and trigger abiotic stress tolerance. Likewise, quality attributes of stover either under normal or stressed conditions cannot be improved using agronomic strategies (Hash et al. 2003). Thus, agronomic based selection of cultivars would not improve these enzymatic activities and ultimately yield would not improve under stress.

1.3.7. Pulses

Rate of genetic gains are lagging far behind despite substantial selection of grain legumes on agronomic basis. Chief constraints confronted during selection are quantitative traits and stress tolerance, interplay of external factors in expression of genetic makeup and low stability of grain yield. Yield components depict high instability if selected and improved on physically noticeable basis. Phenotypically selected genotypes exhibit high environmental interactions. Influence of environment for the quantitative traits is about 80% while influence of genetic makeup is only 1.5-7% if selected on agronomic basis (Kumar and Ali 2006).

Agronomic approaches seldom enhance the frequency of desirable alleles for single trait. However, a complex of drought, heat, salinity, asco-chyta blight, powdery mildew and waterlogging endanger yield stability under field conditions. Improvement of stress resistance for single pathogen or abiotic stress results into prevalence of new and resistant biotypes which endanger ecosystem sustainability. Pyramiding of multiple genes regulating the expression of quality traits and stress tolerance is a time and resource wasting process. Since, agronomic based selection needs to be repeated over time and spaces to enhance the consistency of expression of targeted traits (Millan et al. 2010).

1.3.8. Oilseed crops

Selection of genotypes on agronomic basis depict lower efficacy for introgression of a trait in oilseed crops. Whereas, oilseeds exhibit poor genetic diversity for stress tolerance which further complicate the selection of genotypes. While, biotic and abiotic stress tolerance, seed yield and oil contents are quantitative in nature. Phenotype for these quantitative traits is resultant of complex interaction of genotype and environment. Agronomic based selection of segregates necessitates specific requirements of environmental factors for selection. Provision of environmental growing factors is not possible on economic scale for large number of genotypes. Crop specific problems during agronomic selection are described here.

1.3.8.1. Rapeseed and mustard

Most of brassica species are diploid while *Brassica napus, Brassica juncea* and *Brassica carinata* are allo-tetraploid in nature. Rapeseed and mustard depict low genetic diversity for physically observable traits. Biotic stress tolerance for Alternaria blight, Sclertinea rot and bug resistance are quantitative in nature hence selection on phenotypic basis would not improve these traits. Similarly, seed yield is multifaceted interplay of agronomic practices and environmental conditions. Hence, phenotypically observed grain yield is not true demonstrative for its genotype. Conclusively, pyramiding of genes to improve biotic and abiotic stress tolerance, seed yield and seed oil contents is not advantageous when genotypes are selected using agronomic traits (Dong-Hui et al. 2016).

1.3.8.2. Soybean

Soybean is diploid having 40 (2n) chromosomes and depict sufficient genetic diversity. However, agronomic based selection is not effective for photoperiod sensitivity, maturity and resistance to stresses. Moreover, efficient transfer of pollens in soybean is the chief deterrent to select genotypes based on physically noticeable traits. Oil contents and quality attributes are quantitative in nature; hence expression of these traits is product of genotype × environment interaction. Likewise, agronomically assorted genes do not provide any mean to exploit negative association of seed size with seed germination in soybean (Santana et al. 2014).

1.3.8.3. Sunflower

Diploid ploidy level of sunflower ($2n = 34$) and narrow genetic diversity are major bottlenecks during selection of sunflower genotypes. Stress tolerance is quantitative and polygenic in nature and agronomic selection does not offer reasonable selection for these traits. Consequences are instability in yield of selected genotypes. Moreover, open pollination often develops new recombinants and confine the success of agronomic selection (Chigeza et al. 2012).

1.3.8.4. Groundnut

Groundnut is diploid ($2n = 40$) regarding the ploidy levels. Selection for biotic, abiotic stress tolerance on agronomic basis is not appropriate since these traits are polygenic, quantitative and phenotype expression is complex interplay of innumerable environmental factors and genes. Moreover, selection for maturity is regulated by phytochrome genes, hence selection of genotypes on maturity basis introduces incongruities in selection (Yol et al. 2014).

1.3.8.5. Sesame

Constraints associated to agronomic selection of sesame genotypes are seed yield and stress tolerance. Quantitative nature hinders phenotypic selection as influence of environmental factors reduces efficacy of selection. Moreover, agronomic based selection for plant architecture also does not depict viable results. Selection to reduce the free fatty acid contents is also not viable using agronomic approaches (Uzun and Yol 2013).

1.3.8.6. Linseed

Narrow genetic diversity and quantitative nature of biotic and abiotic stress tolerance, seed yield and seed oil contents are the chief deterrents in selection of linseed genotypes while using morphological parameters (Chandrawati et al. 2014).

1.3.9. Management Options

Various modernistic methods have been revealed to renovate agronomic selection and enhance the efficacy of genotype selection.

1.3.9.1. Biochemical marker assisted selection

Numerous isozymes have been and determined to improve efficiency of genotype selection. Isozyme is any group of enzymes that perform similar functions in plant cell but are chemically distinct from each other. Indicator isozymes for focused traits are independent of environmental factors and often depict strong association with morphological attributes. Biochemical markers are genetically analogous and do not cause polymorphism to greater extent in the primary structure of the protein. Despite biochemical markers still alter the protein expression and thus morphological attributes are also improved with protein expression (Zhang et al. 2008).

1.3.9.2. Molecular marker assisted selection

Molecular markers are vital concerning the genetic dissection of diverse genotypes of a species. These are morphologically neutral, innumerable in number and dispense a landmark to each genotype in highly diverse and impenetrable chromosomes of a species. Certain cares should be taken during utilization of molecular markers to select genotypes. Molecular markers should exhibit polymorphism, randomly and uniformly distributed in genome, easy to use, economically feasible and repeatable (Ellur et al. 2016).

1.3.9.3. Selection for polygenic traits

Most of the agronomic, particularly stress related traits, are polygenic in nature and selection under field conditions using morphological markers leads to faulty inferences hence quantitative trait loci (QTLs) are recommended to select genotypes. Number of genotypes, heritability of focused attribute and probability of wrong selection (type-I error) should be taken into consideration while selecting genotypes using QTLs. If heritability of the target trait is high then same importance should be given to morphological and QTLs. Efficacy of selection decreases with enhancing of QTLs while increases when a single QTL explicates large portion of genome. Moreover, efficacy of selection enhances with the increase of population size. Likewise, QTLs enable the pyramiding of genes regulating the expression of numerous proteins at early stages of plant growth.

1.4. Risks Assoscited with Crop Nutrition

A failure is like fertilizer; it stinks to be sure, but it makes things grow faster in the future. Applications of fertilizers boost efficiency of other inputs and consequence in better quality of agricultural outputs. As a discipline, crop nutrition possesses two legs, one leg is affixed to plant physiology where it elucidates mineralization, uptake, partitioning and assimilation of nutrients to different parts of plants that help the plant to accomplish higher productivity and complete its life cycle. While, other leg is deeply entrenched in soil where nutrient exchange between soil colloids and solution sustains nutrients balance.

Perturbation in nutrient addition and removal in soil ecosystem escalate nutrient losses, aggravate nutrient fixation, pollution, costs and ecosystem vulnerability. Innumerable damages associated with imbalanced nutrition are demarcated in this section.

1.4.1. Residual effects of fertilizers

Total amount of fertilizer added in soil is not available for plant uptake. Fate of remaining fertilizer is vital regarding the long-term impacts of fertilizers in soil. Three conceivable fates of the fertilizers are i) Fertilizer converts into nutrients that are available for plant uptake in soil solution or they are trapped by soil colloids but become part of soil solution after some time and again accessible for plant roots ii) Released nutrients move down below the soil root zone area and ultimately find its way to ground water table iii) Nutrients can undergo chemical reactions to volatilize into atmosphere. The relative contribution of these processes depends on environmental condition and physio-chemical attributes of soil (Savei 2012).

1.4.1.1. Nitrogenous fertilizers

Commercially available nitrogenous fertilizers are urea, ammonia, salts of nitrate, nitrite and ammonium. Any of these fertilizers after adding in soil rapidly converts to nitrates ions (NO_3^{-1}) provided soil is well porous to allow oxygen to penetrate in its pores. Nitrates being negatively charged are leached down.

During injection of anhydrous ammonia, all ammonia is not absorbed by soil and plant roots but outflows to atmosphere and hence causes pollution. Addition of urea in soil having pH more than 6 often leads to the leakage of ammonia to environment. Urea [$(NH_2)_2CO$] hydrolyzes to form ammonium carbonate [$(NH_4)_2CO_3$] after addition in soil. Hereafter, ammonium carbonate under reduction synthesizes ammonium (NH_4^+), carbon dioxides (escapes to air) and water. Ammonium ions react with hydroxyl ions (OH^{-1}) to synthesize ammonia (NH_3) which volatilizes and pollute environment.

$$(NH_2)_2CO + 2H_2O \xrightarrow{\text{Urease}} (NH_4)_2CO_3$$

$$(NH_4)_2CO_3 + 2H^+ \rightarrow 2NH_4{}^+ + CO_2 + H_2O$$

$$2NH_4{}^+ + OH^- \rightarrow NH_3 + H_2O$$

The same loss is observed when ammonium sulfate is applied under calcareous soil conditions. Nitrate from fertilizers is destined to four fates i) absorption from plant roots ii) become integral part of microbial proteins iii) volatilization iv) denitrification as nitrous oxide to atmosphere (Sun et al. 2017).

1.4.1.2. Primary and secondary orthophosphates

Any kind of phosphatic fertilizer added in soil is not immediately available for uptake plant since phosphorous is tremendously immobile nutrient in soil medium. Owing to immobility, concentration near a pellet is about 120 g L^{-1} while it’s just 30-300 µg L^{-1} of soil solution few centimeters away from pellet. Moreover, under alkaline calcareous soil conditions, calcium binds phosphorous to synthesize calcium minerals. While, under acidic soil conditions, iron, aluminum and manganese cause phosphorous fixation. Owing to these reasons, crops harvest only 20% of added phosphorous after addition of phosphatic fertilizer. Phosphorous availability to plant declines and thus puts question on the recommended rates of phosphorous fertilizer. While, enhancing rate of application aggravate fixation and depict antagonistic effect for another nutrient as well.

1.4.1.3. Potassium

Potassium is absorbed by plant roots as cation K^+. Being positively charged, leaching losses in K^+ are negligible. However, K^+ adsorbs on soil colloids with a strength much lesser than the phosphate fixation. Moreover, same number of other cations are displaced in soil solution when K^+ ions fix on clay minerals. These cations are magnesium and calcium mostly. Consequently, nutrient concentration in soil solution is less despite adding potash fertilizers. Moreover, adding more potassium fertilizer further aggravates fixation and potassium concentration in solution does not improve remarkably. Therefore, recommendations based on potassium contents often leads to faulty inferences.

1.4.1.4. Calcium and magnesium

Most of the nitrate losses take place in the form of salts of calcium and magnesium. Thus, addition of nitrogen might imbalance the availability of calcium and magnesium. Hence, non-calcareous soil will be deficient in calcium and magnesium if liming is not done at continuous intervals.

1.4.2. Surface water contamination

Water is 'natural gold liquid', 'universal solvent' and indispensable for innumerable biochemical reactions in living organisms. Currently, 70% of water resources have become polluted (Joseph and Claramma 2010). Regarding nitrogenous fertilizers, 90% of added fertilizer immediately converts to nitrate form that is prone to leach down to find its way to ground water. Under the ideal conditions, 50% of the applied nitrogenous fertilizers are absorbed by plants while 2-20% escapes to atmosphere in the form of nitrous oxide. Moreover, 15-25% reacts with complex organic substances and 2-10% leaches to underground water (Savci 2012). Aftermaths of polluted water are

1.4.2.1. Reduced biological/biochemical oxygen demand

Biological/biochemical oxygen demand (BOD) is amount of oxygen required by living organisms to decompose complex organic substances at a temperature over a period. Only 40% of applied nitrogenous fertilizers are taken up by plants while remaining finds its way to water bodies. Availability of nitrates causes excessive growth of plants which depletes the water bodies of oxygen. Consequences are turbidity of water, reduced light for photosynthesis of micro flora in water and death of animals in water owing to oxygen deficiency.

1.4.2.2. Chemical oxygen demand

Chemical oxygen demand (COD) is the total oxygen (g m^{-3} of water) required for the oxidation of complex organic substances in water to simpler substances. Disproportionate applied of nitrates ultimately deposit in water bodies and decline COD. Depletion of COD causes dominance of nuisance species such as carp and aggravates anoxic conditions (Pasternak et al. 2017).

1.4.2.3. Sudden changes in pH

Excessive application of nutrients causes their leakage from ecosystem and drains them into water bodies. It escalates pH changes of water and causes cause migration or death of aquatic life. Moreover, solubility of heavy metals and other toxic substances increases with changes in pH. Favorable pH for majority of aquatic biota is 6.5-9. Undesirable species of planktons also dominate as pH approaches 5. Mosses start to grow aggressively as pH drops below zero and water becomes totally devoid of fish life. Fall in pH also escalates the release of Al^{+3} from minerals causing more mucus biosynthesis and plethora of Al^{+3} stifles gills. Aluminum ions trigger suffocation, decline weight of fish and decrease the probability for completion of life cycle (Divya and Belgali 2012).

1.4.2.4. Temperature changes

Excessive addition of nutrients causes increase in temperature of water bodies that further declines the solubility of oxygen in water. This boost in metabolic reactions further enhances the demand for oxygen availability in hypoxic environment.

1.4.2.5. Eutrophication

Runoff from fertilized fields accompanies excessive nitrates and phosphates which ultimately drains into water bodies. Accumulation of excessive nitrogenous and phosphatic ions in water causes excessive algal growth and scum on water. It depletes the water of oxygen, causes turbidity, enhances COD, BOD and prevents the penetration of light in water and thus photosynthesis in phytoplanktons is inhibited. Rapid algal growth has been observed with nitrogen and phosphorous concentrations of 0.3 ppm and 10 ppb, respectively. Likewise, dislodging of sediments from nutrient enriched soil and addition of organic manures in water also trigger eutrophication (Huang et al. 2017).

1.4.3. Risks to human health

Innumerable biological, physical and chemical factors determine suitability of water for drinking purposes. Physio-chemical and biological features suitable for one segment of ecosystem might be unsuitable for another segment. Permissible limit of nitrates + nitrites in water is 10 ppm according to WHO. Nitrates also undergo reduction to synthesize nitrites in humans while nitrites are more fatal than nitrates.

Moreover, leaf vegetables (spinach, celery, lettuce) tend to uptake greater amounts of nitrates from soil and thus nitrates find way to human food chain.

Leaching of nitrogen enhances concentration of nitrates in drinking water. Maximum contaminant limit for nitrate-nitrogen is 10 mg L^{-1} while 1 mg L^{-1} for nitrite nitrogen (Water research Center 2017). Higher nitrate concentrations cause methemoglobinemia in children and stomach cancer in adults. Nitrites and nitrates react with haemoglobin and diminish its oxygen binding capability. Nitrates are accumulated in kidneys and gastro-intestinal tracts within 4-12 hours of drinking contaminated water. Drinking water containing NO^{-3} ions more than 50 mg L^{-1} affect bowl movement and causes inflammation in urinary and gastro-intestinal tracts. Moreover, tertiary amines, tertiary nitrites, alkyl amines and nitroso-amines are highly carcinogenic for human body.

1.4.4. Soil deterioration

Soil structure is the arrangement of soil particles into units “aggregates”. These aggregates can be distinguished into granular, crumby, blocky, sub-angular blocky, platy, columnar and prismatic on the basis of arrangement of soil separates. Excessive and imbalanced application of fertilizer degrades soil structure. Regarding this, intensive use of KCI, K_2SO_4, $NaNO_3$, NH_4NO_3 and NH_4Cl are highly hazardous to degrade soil aggregate stability.

Excessive sodium ions replace calcium from soil colloids and thus dislodge soil particles from aggregate and clog soil pore spaces. Likewise, continuous use of fertilizers with basic pH aggravates the alkalinity in soil. Moreover, excessive application of some fertilizers deprives the soil solution capability to supply other nutrients through antagonistic effect. Excessive application of potassium declines the calcium and magnesium in soil solution. Similarly, excessive calcium decreases the availability of magnesium and potassium. While, higher phosphatic fertilizers decline the availability of zinc. Disruption of nutrients balance also accompanies disturbed soil biota activities e.g. excessive application of nitrogen fertilizer diminishes the activities of rhizobia, azotobacter and azospirillum. Nitrogenous fertilizers add excessive nitrate which might compete for uptake of molybdate ions and reduce the co-factor availability for nitrogenase and nitrate reductase and thus downregulate nitrogen fixation (Tetteh 2015).

1.4.5. Degraded air quality

Application of fertilizers without considering plant and soil analysis often leads to the emission of nitrous oxide (N_2O), nitric oxide (NO), nitrogen dioxide (NO_2) and hydrogen sulfide. Moreover, release of other greenhouse gases (methane and chloro-fluoro carbons) also pollutes air. Emission of N_2O is rising at 0.2-0.3% per annum. Excessive nitrogenous fertilizers also cause emission of ammonia (NH_3) from soil ecosystem into air. Emission of NH_3 is usually proportionate to the added concentration in soil. Released NH_3 returns to soil as acid rain and acts as corrosive agent for plants and aquatic life and thus deleteriously impacts plant life (Sun et al. 2016).

1.4.6. Ground water contamination

Numerous nutrients carrying negative charges leach below the root zone and eventually contaminate underground water. Most protuberant contaminants are nitrates, sulfates and heavy metals (Lema et al. 2014).

1.4.7. Heavy metals

Excessive fertilizer use boosts the concentration of heavy metals in soil solution. Henceforth, heavy metals are taken up and assimilated by plants and thus these enter in food chain. Though, plants require certain heavy metals for growth and development since theis acts as important co-factor of enzymatic activities (Sardar et al. 2013). However, non-desirable metal nutrients are also absorbed during uptake of essential metal nutrients. Supra-optimal concentrations impose heavy metal stress as most of crop plants do not have developed mechanisms for partitioning of heavy metals (Chibuike and Obiora 2014).

1.4.8. Complications regarding the recommendations of nitrogenous fertilizers

Regarding the fates and determination of nitrogen, innumerable technical issues are confronted. Firstly, practically it is impossible to measure either removed nitrates have leached or denitrified under field conditions. Secondly, smaller fractions of nitrates in soil solution are derived from recently added nitrogenous fertilizers while most of nitrate are derived from previously added organic matter in soil. Thirdly, concentration of nitrates in soil is usually lesser than the organic fraction of nitrogen in that soil. Lastly, change in nitrogen concentration of soil over different seasons is impossible to govern since changes over the seasons are smaller than the variations and errors confronted during sampling under field conditions.

Complications regarding nitrogen determination increase if farm contains leguminous crops in rotation. Organic nitrogen from leguminous crop rapidly changes to nitrates than other fractions of soil organic nitrogen. Hence, a portion of nitrates present in soil solution might also be derived from atmospheric nitrogen. Owing to these complications, scientists are not able to estimate how much nitrates in water are contributed from synthetic fertilizers added in soil (Abdullahi 2015).

Likewise, little knowledge is available regarding the measurement of denitrification losses under field conditions. Lysimetric experiments that depict that at least one third of the added fertilizer is lost through denitrification losses. Although denitrification losses are measured correctly based on contemporary biochemical processes in lysimeters. Contrarily, field conditions are expected to contain innumerable small patches of soil, compacted by tractor during tillage operations and totally devoid of oxygen. Denitrification process actively takes place with interludes under field conditions. Moreover, denitrification losses vary with varying moisture contents of soil. Hence, lysimetric studies are likely to under estimate the denitrification losses by neglecting small compact pockets of soil that are wholly devoid of oxygen.

1.4.9. Damage to crops

Fertilizers also depict harmful impact on growth and yield. Excessive application of nitrogenous fertilizers declines cellulose accumulation in culm of cereals and causes lodging. It also declines accumulation of sugar by declining conversion of glucose and fructose into sucrose. Moreover, excessive accumulation of nitrogen enhances succulence and thus makes plant more susceptible to insect and disease attacks. In non-calcareous soils having neutral pH, excessive nitrogen induced low pH damages the emerging seedlings through acidifying actions. Excessive micro nutrients such as Fe and Zn bind phosphorous and decline its solubility. Regarding this, ‘Liebig’s Law of Minimum’ can also be elucidated as ‘Law of Maximum’. Any amount of fertilizer added above the recommended amount is likely to cause damages both based on quality and quantity.

1.4.9.1. Impact on soil biota

Fertilizer salts and anhydrous ammonia are highly toxic for earthworms. However, larger portion of earthworm population is not in direct contact with added fertilizers and not affected directly. Negative relation of excessive nitrogenous fertilizer and rhizobium activities is obvious in agro-ecosystems. Excessive addition of nitrogenous fertilizers also slows down the process of nitrification from native soil organic matter. Contrarily, deficient Ca, N and P induces mineralization from native soil organic matter (Geisseler and Scow 2014).

1.4.10. Management Options

Numerous agronomic options improve use efficiency of fertilizers and thus associated negative impacts of fertilizers can be minimized. Application of fertilizer amount, time and method is further complicated by weather conditions.

1.4.10.1. Nutrient management

1. Rate of fertilizer

During the recommendation of rate of fertilizer, species of crop, genotype and stage of application should be considered. Moreover, amount of fertilizer should base on soil and plant analysis. While, often residual nitrogen is not considered during recommendation of fertilizer amount. Growing of representative plots in different area in small patches before the extensive sowing of crop can also produce better estimates regarding fertilizer rate in crops.

II. Time of application

Side dressing enhances use efficiency remarkably if it is applied along with the crop sowing. Ammonium forms of nitrogen convert slowly to nitrates if applied during fall or winter. Thus, nitrogen losses are lesser than spring or summer application. Moreover, establishment of root system is of prime importance regarding nitrogen uptake. An active root system often depicts more use efficiency over basal applications since leaching, denitrification, volatilization and fixation losses are minimized. Moreover, splitting of total amount into smaller sub parts reduces leakage of nutrients from ecosystem.

III. Fertilizer placement

In surface application urea rapidly hydrolyzes to synthesize ammonia which volatilizes to atmosphere. Sometimes losses can reach to 100% provided soil moisture is not enough. Placement of fertilizers in soil deprives the added fertilizers of oxygen and nitrification slows down. Hence, important considerations during placement are root accessibility to nutrients and appropriate moisture to reduce excessive oxygen availability for oxidation. Similarly, surface application of directly available form should be depressed since it has potential to loss through runoff and can also volatilize to synthesize ammonia. Likewise, cares should be taken during injection of anhydrous ammonia in soil that volume being diffused should not reach at surface. Otherwise, it'll be lost immediately through volatilization. Injection should also be circumvented when soil is enormously dry or moist since it clogs injecting slots. Moreover, balance should also be maintained between shank spacing, injection volume and soil cation exchange capacity during injection of anhydrous ammonia in soil (Nkebiwe et al. 2016).

IV. Nitrogen carriers

Each nitrogen carrier would have its own restrictions and utilizations depending on soil type, its time of application with respect to crop species and genotypes, soil moisture, economics and numerous other factors.

Ammoniacal forms of nitrogen are usually more efficient for application in flooded rice. Nitrates form is not apposite for application under submerged conditions. Efficacy of nitrate form for immediate supply of nitrogen is more useful than ammonium forms. Therefore, it is usually recommended to apply at booting or flowering stage in cereals since rapid available nitrogen improves grain protein contents in cereals. While application of ammonium sulfate is suggested in tropical climate owing to its lesser deliquescence and remarkable storage capabilities in soil. In this regard, all other sources are not recommended provided these are coated with some substance that can lower the process of nitrification. Moreover, sulfur in ammonium sulfate declines pH in alkaline soil and enhances nutrient availability. Process of decrease in pH escalates if soil have low cation exchange capacity. Hence, ammonium sulfate is not suitable option for tropical soils with low pH unless lime is applied to counterbalance the acidifying impacts of ammonium sulfate. Likewise, ammonical sources produce more promising results than sources containing nitrates if nitrogen is to apply prior to commencement of rains in rainfed areas. While, more promising results are realized if nitrogenous fertilizers are applied in proper moisture conditions that do not let enough oxygen to infiltrate and roots have access to nitrogen (Zhang et al. 2016).

V. Water management to improve nitrogen use efficiency (NUE)

Nitrogen and irrigation water interact to improve crop productivity. Incessant replenishment of moisture in upper soil layers keeps the nutrients' zone always moist and relatively lesser oxygen availability slow down the nitrification and losses. It has been noticed that increasing nitrogen application under water deficiency elongates vegetative growth and ultimately declines economical yield (Nkebiwe et al. 2016).

VI. Crop management to maximize NUE

Handling different crops in rotation and cropping systems that enhance productivity and economic yield also augment NUE. Selection of nitrogen efficient genotypes also improves NUE significantly. Similarly, growing of deep tap rooted crops in rotation with small grain crops keeps sub soil moisten and slows down nitrification and nitrogen losses. While leaving the soil fallow in intensive cropping sequence for a season improves soil aggregate stability, cation exchange capacity and ultimately nitrates retaining capacity (Zheng et al. 2017).

VII. Use of nitrification inhibitors

Nitrification inhibitors are synthetic substances that retard the activities of nitrifying bacteria and thus slow down the reduction of ammonium ions to nitrates in soil. Commercially available nitrification inhibitors are 2-chloro-6-(trichloromethyl)-

pyridine (Nitrapyrin), 3,4-dimethylpyrazole phosphate (DMPP) and dicycandiamide (DCD). Regarding this, biological nitrification inhibition can also be manipulated. Biological nitrification inhibition is plant rhizosphere mediated process in which root exudates slowdown the nitrification.

VIII. Coated fertilizers

Fertilizers are coated with synthetic substances that slow down the release of nitrates. The combination of urea and aldehydes enhances the NUE slowing down the nitrification process. Commercially coated fertilizers available are isobuytylidene diurea, crotonylidene di-urea, urea-form, pyrimidine, pyridine and dicyandiamide.

IX. Recycling of organic wastes

Organic wastes of farm comprise crop residues, livestock manure, urine, poultry manure and feed remnants. Organic wastes release nutrients slowly which remain available throughout growing cycle of crop and losses are minimum.

Mixing of organic wastes in soil in waterlogged conditions increases the loss of nutrients in manures. Denitrification, leaching and volatilization losses of nitrogen also aggravate under waterlogged conditions. Moreover, provision of dry conditions reduces mineralization while ideal moisture for mineralization of organic substances is field capacity moisture. Regarding the addition of industrial and home effluents, care should be taken for heavy metal contamination (Li et al. 2017).

1.4.10.2. Integrated nutrient management (INM) strategies

Integrated nutrient management strategies deal with the optimization of nutrient benefits form all possible sources of nutrients in such a way that nutrient us efficiency is improved, and minimum nutrients leak out of agriculture ecosystem. Components of INM are

I. Organic manures

Organic manures enhance nutrient use efficiency and physical, chemical and biological traits of soil. These comprise organic manures of plant and animal origin. Any green manure crop (sesbania, Egyptian clover, red clover, alfalfa, Indian clover etc.) can be grown and added in soil when reaches at flowering stage. Similarly, organic manures of animal origin which are rich in nutrients are poultry and livestock manures. Moreover, crop residues, tree wastes, urban and rural wastes and agro-industry byproducts are also important sources of nutrients (Das et al. 2014).

II. Biofertilizers

These are living cells or microbes that are capable to mobilize or convert non-available form of nutrients to available form. Numerous bacterial species that fix atmospheric nitrogen are rhizobia, azotobacter, azospirilium and blue green algae. While, phosphorous mobilizers include bacteria and absorbers are mycorrhizae. Moreover, sulfur solubilizers, organic matter decomposers and plat growth promoting rhizobacteria are also available as commercial biofertilizers that improve nutrient use efficiency.

III. Inorganic fertilizers

Application of synthetic fertilizers in integration with organic sources is proposed to improve nutrient use efficiency.

IV. Vermicomposting

Organic matter is collected in a heap and inoculated with earthworm population that enhances mineralization. Application of vermi-compost in combination with synthetic fertilizer is also an important strategy to improve fertilizer use efficiency.

V. Non-conventional sources of nutrients

Non-conventional sources comprise night soil, sewage sludge, oilcakes and meals. Numerous objectionable substances are converted to less toxic forms after treatment and applied as important nutrient sources (Garai et al. 2014).

1.5. Risks Associated with Irrigation Practices

1.5.1. Risks associated with runoff water used for irrigation

Runoff water is often collected and crops are irrigated with collected runoff. It increases water productivity but poses numerous challenges to sustainability of soil. For example, potential threat of biosolids (manures) cannot be neglected during use of runoff water. Salmonella was extracted from 68% samples of runoff water. Persistence of such pathogens was about 28 days after application of runoff water (Becerra-Castro et al. 2015).

1.5.2. Risks in use of reclaimed water

Despite strict filtration and treatments, reclaimed water still offers problems for crops. Fecal coliforms often find way in food web if crops are irrigated with treated water. Specifically, leaf vegetables act as transfer medium for pathogens in animals and humans. Ultimate results are infections in humans consuming leafy vegetables. Exogenous application of treated water in horticultural crops deteriorates quality and perishability while increase and insect and disease attack. Persistence of pathogens is complex interaction of temperature, species of pathogen, plant anatomy, sunlight interception and pesticide concentration applied. Hence, food crops produced using treated water pose serious complications for consumers (Suslow et al. 2003).

1.5.3. Microbial contamination from irrigation water

Microbial contamination of agricultural produce is also common from irrigating water. It varies with species of microbe, crop species and contaminant load of irrigation water. Use of fecal contaminated water and addition of organic matter in soil further worsen the conditions. Viruses and bacteria are common contaminants with more persistence in viruses than bacteria.

1.5.4. Effects of irrigation on physical characteristics of soil

Numerous physical disorders of soils owing to application of irrigation are demarcated in this section.

1.5.4.1. Soil structure

It is distribution and arrangement of soil particles to form collective unit called aggregate. Irrigation applied for different crops vary from a few milliliters to 10 mega liters per hectare. Water converts soil into a hard mass that is impermeable to water. Soil that depict instability in structure undergoes hard setting and collapses structurally to synthesize impermeable mass. Such mass converts to dry clods and requires huge shear force for breakdown. Consequences are increased bulk density, blocked pore spaces, poor mineralization and infiltration. Structural changes in soil might also be consequence of raised water table and associated salinity.

1.5.4.2. Soil strength

It is magnitude of plough shear stress that can be sustained by a soil. It is function of shear resistance and cementation of soil aggregates. Soil strength declines with enhancing frequency of irrigation water and becomes more susceptible to structural damages than dry soil. Decreased strength can be attributed to diminished cohesion and attractive forces between soil colloids. While, if runoff speed is more it also damages aggregate stability (Murray and Grant 2007).

1.5.4.3. Soil consistency

It is strength with which soil aggregates are held together or it is resistance offered by soil during shearing action of plough. It alters under influence of irrigating water. Tillage makes the dry soil pulverized while application of water decreases soil consistency. Greater proportion of clay contents causes development of cracks. Rapid wetting escalates swellings in clay colloids and develops a friable state to depict consistency that is most apposite for tillage operation. At the same time, soil also becomes more vulnerable to compaction if mechanical operations are performed in friable state.

Higher moisture than friable state tends to cause soil plastic which is easily smeared and molded into compact mass. Structure of soil that disrupt in presence of excess moisture can gain state of liquid and disperse. Interconversion and persistence time of brittleness, friable, liquid and dispersion states of consistency rely on soil texture and amount of irrigation water applied. Moreover, persistence time of these states is inversely related to size of colloids. Hence, clay soil exhibits long persistence time for each of these stages while sandy soil depicts no persistence at all. Higher persistence of clay soil can also be ascribed to its water holding capacity. Furthermore, declined soil consistency under influence of irrigation water aggravates soil susceptibility to dispersion under shearing action of rainfall droplet. Consequences are clogged soil pore spaces and declined infiltration (Valdes-Abellan et al. 2017).

1.5.4.4. Slaking

Transfer of larger soil aggregates into smaller aggregates during the rapid wetting of dry soil is called slaking. For, slaking rate of wetting is more important than subsequent wetting and shearing. More rapid is wetting greater will be slaking and disruption in soil aggregates. Slaking can be ascribed to rapid entry of water in pore spaces and ultimately air traps and squeezes soil particle erratically. Thus, air in pore spaces causes uneven wetting of soil aggregates. Slaking is most destructive and takes place rapidly in coarse textured soils than fine textured soils. Rapid entry of water in sandy soils escalates slaking while slow entry in clay soil weakens soil consistency. Although slaking mediated structural damages are less pronounced in fine textured soil still it reduces consistency considerably. Moreover, drip and sprinkler irrigation cause less slaking in aggregates than all the surface irrigation application methods (Jiang et al. 2017).

1.5.4.5. Soil dispersion

It is separation of smaller soil particles (< 10 µm) from other associated particles spontaneously under the influence of shearing force of irrigation water or rainfall droplets. Consequences of dispersion are clogging of pore spaces, deficiency of oxygen for soil biota, reduced mineralization, promotion of reducing condition in sub soil layers and ultimately decreased crops productivity. Despite a good soil aggregate stability in sub soil layers, disruption of structure at surface confines crop productivity remarkably. Since dispersion hinders gaseous exchange and root respiration (Nave et al. 2017).

1.5.4.6. Hard setting soil

It is collapsing of soil aggregates under the weight of clods of soils own self on application of irrigation to develop an impermeable soil mass that depicts no or little porosity but becomes soften again on application of water. Texture of surface soil collapses under the influence of irrigation and tillage actions. On drying, soil strength aggravates which ultimately confines emergence attributes of crops. While, tillage operations develop dusty and cloddy tilth of soil particles and promote hard setting of soil (Dexter 2004).

1.5.4.7. Coalescence

It is progressive hardening of raised beds without any trafficking or mechanical pressure under the influence of irrigation water. It diverges from hard setting since it occurs slowly while hard setting takes place rapidly. Macro pores remain operative in coalescence hence infiltration remains continue while microspores are blocked which confines root growth. Persistence of coalescence conditions changes to hard setting eventually and soil becomes vulnerable to hard setting induced damages (Rillig et al. 2015).

1.5.4.8. Soil compaction

Soil compaction is closed packing of soil particles as a consequence of applied pressure from mechanical operations that ultimately declines aeration, enhances bulk density and makes the soil non-workable. Soil becomes more susceptible to compaction under excessive moisture.

1.5.5. Effect of poor quality water on chemical properties of soil

Damaging impacts of poor quality irrigation water on soil chemical attributes are defined in this portion.

1.5.5.1. Salinity

More concentration of total soluble salts in irrigation water continually deposits salts in soil. Threshold concentration of total dissolved salts for irrigation water is < 450 mg L^{-1} and EC should be < 0.7 dS m^{-1}. Application of water containing excess salts replaces cations from exchange sites of soil and disrupts cation exchange. Mostly, sodium occupies exchange sites and causes dispersion in soil (Becerra-Castro et al. 2015).

1.5.5.2. Sodium adsorption ratio (SAR)

Recommended SAR for irrigation water is < 0.7 and at a specific level of SAR, infiltration increases with increase of salinity of water. Under normal conditions, calcium, magnesium and potassium occupy most of exchangeable sites of clay colloids, while poor quality irrigation water replaces these cations with sodium and causes deflocculatiion of soil aggregates. Thus, irrigation water with SAR more than threshold level converts normal soil to sodic soil. Buffering capacity of soil against high SAR of irrigation water depends on cation exchange capacity and texture of soil. Fine texture soil usually depicts more buffering against higher SAR irrigation water than coarse textured soils (Elgallal et al. 2016).

1.5.5.3. Carbonate-bicarbonate ratio

Threshold level of bicarbonates in irrigation water is < 1.5 mmol L^{-1}. Bicarbonates are always present in equilibrium with irrigation water carbonates, pH and environmental carbon dioxide. Most of carbonates and bicarbonates are soluble in irrigation water except the calcium carbonate. Applying irrigation water containing carbonates more than permissible limits tend to remove calcium from soil solution and synthesize calcium carbonate. Consequently, sodium occupies exchange sites and thus soil converts to sodic soil. In sub surface soil, CO_2 concentration is 100 times more than in atmosphere owing to microbial respiration. Higher CO_2 in sub soil layers lower the carbonates-bicarbonates ratio while at soil surface excess of carbonates are present. Moreover, higher pH and carbonate concentration develop salinity as well as sodicity and impair nutrient availability (Martinez-Alvarez et al. 2016).

1.5.6. Effect on biological properties of soil

1.5.6.1. Organic matter

Application of irrigation water deprives the pore spaces of oxygens and slows down the decomposition of organic matter. Moreover, microbial mediated decomposition of organic matter also depends on iron or ferrous sulfate that act as electron acceptor in microbes. Under the oxygen deficiency, ferric hydroxides act as electron acceptors in microbes and result into reduced efficacy of organic matter decomposition. Biological nitrogen fixation and humus biosynthesis are also reduced and organic matter accumulates in soil.

1.5.6.2. Soil microbial activities

Soil microbial activities are affected when irrigation water is applied. Deficiency of oxygen declines activities of rhizobia, azotobacter, azosprilium and denitrifying bacteria. Moreover, population of gram positive bacteria enhances under anaerobic conditions since these are less sensitive to oxygen deficiency. Moreover, fungal growth also improves under irrigation because fungi require low redox potential than other soil biota.

1.5.6.3. Substrate availability for microbes and enzymatic activity

Frequent irrigations deplete pore spaces of oxygen and alter substrate availability for microbes and microbial enzymatic activities. Rate of catabolism of organic substances is impaired under limited oxygen availability. Breakdown of macro molecules such as lignin and cellulose depends on geometry, structure, order of molecules and surface characteristics of complex organic substances. Application of water alters these attributes which result into impairment of substrate availably and therefore microbial activity is declined. Moreover, microbial biosynthesized enzymatic activities are also affected by solid-liquid interface of soil. Extracellular enzymes such as cellulases, hemicellulases, lipases, pectinases and proteases undergo structural and surface area changes in moist soils. Consequences are accumulation of complex organic substances and reduced mineralization (Widmer et al. 2006).

1.6. Risks Associated with use of Household Water

Waste water from household use is proposed an important source of irrigation and remains available during the whole year. However innumerable problems associated with the use of waste water are discussed in this section.

1.6.1. Excessive salts

Waste water contains significantly more total dissolved salts and ions. Thus, electrical conductivity is also higher than that of fresh water. Source of excessive salts and ions are detergents and soaps. Hence application of this water might convert a normal soil to saline soil. Application of 1000 mm waste water containing 500 mg

L^{-1} total dissolved salts caused the accumulation of 5 t ha^{-1} salts in a year (Muyen et al. 2011).

1.6.2. Heavy metals

Heavy metal load in waste water is detrimental for crops and humans as well. Untreated waste water contains heavy load of lead, cadmium, copper, arsenic and mercury. Cadmium is the most common amongst all in household waste water while other heavy metals also become part of waste water on mixing of effluents in household water. Aluminum and iron can limit the availability of other nutrients if applied in acidic soil. Particularly phosphorous availability is hampered under acidic soil conditions. All other heavy metals are strongly adsorbed on soil colloids and enter in soil solution with the passage of time (Khan et al. 2013).

1.6.3. Nutrients

Enough nutrients such as nitrogen, phosphorous and potassium are motive force for utilization of waste water for irrigation purposes. However, excessive nitrogen and phosphorous can aggravate nutrients leakage from agro-ecosystem and contaminate surface and ground water. Specifically, excessive nitrogen limits the catabolic activities of microbes and ultimately biodegradation of recalcitrant organic substances is hampered (Ramirez et al. 2012).

1.6.4. Microbial load

Waste water is also rich in microbial loads so when applied it induces significant changes in human food chain. Most common are Escherichia, Bacillus, Aeromonas, Shigella and Legionella species (Qin et al. 2015).

1.6.5. Management Options

Risks associated with the use of waste and fresh water can be minimized practicing various agronomic measures.

1.6.5.1. Management of waste water

I. Salinity and sodicity management

Drainage: Soil drainage is an important management strategy to drain excessive salts. After water drains salts below soil root zone area, it is followed by application of fresh water.

Selection of crops: Salt tolerant crops can uptake salts and partition these to vacuoles. Regarding this, moderately salt sensitive crops are corn, peanut and alfalfa while moderately tolerant are sorghum, soybean, wheat and olive. High salt tolerant crops are oat, barley and cotton.

Alternate use of fresh and waste water: Most of the crops are sensitive to salts at earlier stages of seedling establishment. Therefore, one or two fresh water irrigations can be used to irrigate crops at earlier stages. Likewise, mixing of fresh and waste water is also proposed however it is not recommended since benefits that be gained through fresh water lost by mixing.

Heavy metal alleviation in wastewater: Load of heavy metals can be alleviated using numerous treatments. Although these treatments are costly but can prove useful to enhance water availability. Chemical treatment encompasses ion exchange, coagulation, adsorption, precipitation, membrane filtration and reverse osmosis. Biological strategies comprise growing of accumulators' plants on heavy metal contaminated soils. Commercial crops that can be grown include flax and cotton while other crops are red canary grass and salix tress (Ninerola et al. 2017).

II. Methods of water application

Water use efficiency can be improved using numerous agronomic strategies which minimize the loss of water from evapotranspiration and maximize the use of water by crops and thus enhance productivity ultimately. Water application methods are specified for different crops.

Basin irrigation method is usually recommended for puddled rice, alfalfa, Egyptian clover, Indian clover and leaching of salts (Pereira and Marques 2017). Furrow irrigation is used where crops are sown on ridges. While, border irrigation reduces the lodging of crops allowing the deep penetration of roots in soil and enhances water uptake also. Sprinkler irrigation is recommended for small grain crops and orchards and is not recommended for soils that develop crust on application of water. Use of drip or trickle reduces evapotranspiration and localized application of water limits growth of weeds. Moreover, it also makes possible the localized application of fertilizers in dissolved form in water. Water use efficiency improves by 30-40% and irrigation associated damages to soil are minimized (Chandra et al. 2007).

III. Critical growth stages of crops

Lack of moisture at sensitive stages of crops declines productivity remarkably. Moisture sensitive stages in wheat are crown root initiation, tillering, jointing, booting, flowering and grain filling if six irrigations are available. While, if 5 irrigations are available then irrigation at jointing stage can be escaped. Whereas, irrigations are recommended to apply at crown root initiation, booting, flowering and milking stage if 4 irrigations are available.

Irrigations in rice are recommended to apply from transplanting to maximum tillering, at panicle initiation, flowering and grain formation. Mazie should be essentially irrigated at seedling establishment, knee height, tasseling, silking and dough stage. While, squaring, flowering and boll formation are moisture sensitive stages in cotton. In sugarcane, water is recommended to apply from seedling establishment to the completion of maximum vegetative growth. Flowering and grain formation are moisture sensitive stages in sorghum.

In mung bean, chickpea, mash bean and peas, critical stages regarding irrigation are early vegetative stages, branching, flowering and pod development. Groundnut is sensitive to water shortage at early vegetative growth, flowering, pegging and pod development. Similarly, water is recommended to apply from blooming to maturity in sesame crop. While rapeseed and mustard are sensitive to water deficits at vegetative stage, branch development and siliqua formation and must be irrigated at these stages. In sunflower, water is recommended to apply at vegetative stage, disc formation and grain filling.

IV. Irrigation practices for different soil characteristics

Soil comprises of three major components i) solids ii) liquids iii) gases. Solid portion comprises of minerals and organic matters and is highly influential regarding different irrigation practices. Gaseous and liquid portions consist of macro and micro pores and are filled with water and air. While, gaseous and liquid states vary continually according to soil moisture holding capacity. Whereas, soil pore spaces undergo little changes during irrigation practices and alter only with tillage and soil compaction. Numerous soil characteristics that influence irrigation practices, intensity and frequency are discussed in this section.

Soil depth: It refers to the thickness of soil portion responsible for anchorage, provision of nutrients and water to plants. Coarse textured soils are deep and contain remarkably lesser gravels at depth of 50 cm. Moreover, these soils are often rich in calcium carbonate. Higher calcium carbonates and gravels depict significant effects on decisions of irrigation application time, frequency and intensity. Hence, deeper soil requires more frequent and less intense irrigations than fine soils to maintain moisture in soil root zone area.

Soil texture: Relative distribution of soil particles of different sizes in a soil mass is called soil texture. Soil particles with diameter of 0.05-1 mm are called sand and any soil mass containing > 50% of soil particles with diameter 0.05-1 mm are sandy soils. With the increase in coarser fraction of soil particles in a soil mass, infiltration and soil bulk density usually enhance. Hence water percolates rapidly across soil profile and leaches out of rhizosphere. Resultantly, sandy soils require more frequent and lesser intensity irrigations. Similarly, surface application methods often depict lower water use efficacy in coarse textured soils. Since, soil is also prone to loss through runoff using surface methods. Therefore, sprinkler or drip irrigations methods are proposed for sandy soils.

Available water is water held by soil pore spaces that is extractable by soil roots. It is measured by difference of field capacity and permanent wilting point. Available soil moisture declines with enhancing coarse soil particles in a soil mass. Available water in fine sandy soil, sandy loam, loamy sands, fine sands and coarse sand has been recorded 150-170, 90-130, 65-110, 60-85 and 20-65 mm m^{-1}, respectively.

Soil infiltration: Coarse textured soils depict high bulk density over fine textured soils and rich in macro pores. Larger pore spaces increase the velocity of water in coarse texture soil. Hence, 4-25 cm h^{-1} has been observed in sandy clay to sandy loam soils. While, infiltration increases to 100-400 cm h^{-1} with the decrease of clay contents. Application of water more than infiltration capacity enhances runoff and erosion.

V. Important information before application of irrigation

Net amount of water that can be applied per unit time on a given area of soil using a specific irrigation system is important for decision making. It is usually estimated from gross water applied and different types of water efficiencies using an irrigation system. Moreover, uniformity of irrigation system that can be accomplished for repetitive irrigations over time should also be considered during application of water.

In addition to critical growth stage, other crop information like leaf area, plant height, plant population etc. should also be known during application of irrigation. As for example, application of heavy irrigation in wheat crop at booting having dense plant population might result in lodging of crop. Similarly, frequent application of water at terminal stages in sugarcane often result into reduction of sucrose contents in cane juice. While, excessive water application during vegetative growth of crops (wheat, rice, maize and cotton) might cause expansion of vegetative stage and delay in the onset of reproductive stage. Similarly, frequent application of water escalates rotting in root crops such as sugar beet. Considering these factors can improve water use efficiency and save water as well.

Climatic elements (temperature, probability of rainfall, relative humidity, wind speed and sunshine hours) help in decisions about irrigation time and intensity. Application of irrigation with subsequent rainfall in cotton causes water logging. Aftermaths of water logging encompass diminishment in opening of bolls and poor lint quality. While, adverse impacts of sudden temperature changes of soil owing to frost can be alleviated by application of irrigation when sky is clear, low speed breeze is blowing and temperature is low. Similarly, more frequent irrigations are recommended in case of higher temperature to enable the crops to fulfill evapotranspiration needs.

Environmental conditions also depict remarkable effects on irrigation application practices. Under heat stress, application of water decreases the sensitivity of crop towards heat. While, under salinity a pre-sowing heavy irrigation (flooding)is recommended thereafter crops are sown on ridges and water is applied in furrows to decrease the exposure of roots to salts. Similarly, nutrient availability under application of water in low fertile soil improves under the application of irrigation.

IV. Methods to schedule irrigation

Observe for the critical stage of crop for water application and determine crop condition through visual observation. Drooping of leaves and wilting are common indicators for irrigation requirement.

Moisture meters can be used to determine moisture status of soil and crops. For determination of soil moisture, tensiometer, gypsum bocks, granular matrix and capacitance probes can be used.

Smart irrigation practices can be aided by information about evapotranspiration, coefficients of crops for actual evapotranspiration and estimation of time after which soil depletes of water considering weather elements.

Modern techniques of irrigation scheduling include use of infrared thermometer and remote sensing technology. Infrared thermometer simultaneously measures canopy and air temperature and if canopy temperature exceeds air temperature, it is indicator of water deficit for plants. Similarly, reflectance is measured using sensors in remote sensing. Reflectance spectrum from soil containing sufficient moisture differs from soil experiencing water deficit. Moreover, it also gives information about soil texture as fine texture soil holds more water than coarse textured soil and thus produces different spectrum in remote sensing.

VII. Key points

i. Crops are generally highly sensitive to water deficit or drought at flowering and fruit setting stages

ii. Most of the crops require irrigation when soil moisture falls below 50% of the field capacity

iii. Small seeded crops sown on beds or ridges generally require more frequent and light irrigations and water is recommended to apply each time when half of the bed or ridge surface is dried and visually observable from discoloration

iv. Large seeded crops sown on ridges or beds usually require heavy and less frequent irrigations and water is recommended to apply each time when moisture in soil adjacent to planted seed has fallen below the 50% of field capacity moisture

v. Root crops (sugar beet, potatoes) usually require variation in soil moisture from 50-100% field capacity at the planting and maturity stages. Initiation of tuber and expansion of tubers is most favored if soil contains moisture between 75-100% of field capacity moisture.

vi. Growth of green leafy vegetables, beans and peas is most favored if soil moisture is maintained at 50% of field capacity moisture throughout growing season

vii. It is advised to irrigate once the crops of Cruciferae family near the harvesting to reduce shattering and ease harvesting and post-harvest operations

1.7. Risks Associted with Crop Protection

1.7.1. Risks associated with allelopathy

Allelopathy is a type of plant interaction whereby secondary metabolites/ chemical substances/ products of metabolism called allelochemicals are released into environment. Allelochemicals might inhibit or promote the growth of other plant with which they interact. Numerous risks are associated with studies of allelochemicals which are often neglected during experimental work (Inderjit et al. 2005). These risks are:

1.7.1.1. Complexities in allelopathic interferences

Allelopathic interferences are made using a single allelochemical. It is not valid approach ecologically. Discussing allelopathic potential of species in isolation neglecting its interactions with other species is not suitable approach from ecologists' point of view. Different species in an ecosystem release different chemicals; any of these chemicals might be toxic or beneficial for another species. Furthermore, allelochemicals can also affect a species in vicinity directly, indirectly and after degradation or decomposition.

Complete overlooking of dynamic interactions of agroecosystems during defining allelopathic potential of a species introduces innumerable obscurities. Moreover, poor interpretation of modes of release of allelochemicals and soil characteristics increase vagueness in allelopathic interactions. Use of poor methodology for extraction of allelochemicals and absence of bioassay to measure allelochemicals mediated changes under field conditions are highly dubious. Owing to these ambiguities, it has limited acceptance by ecologists and must be focused to enhance ecological viability of allelopathic studies.

1.7.1.2. Inhibition zones and allelopathy

Numerous species in an ecosystem are aggressors which release certain chemicals in environment and rhizosphere to inhibit growth of other species. As consequence of these chemicals, aggressors develop inhibition zones in an ecosystem. Yet, it's not easy to discern allelopathic interactions from inhibition zones developed by aggressor species in an ecosystem.

1.7.1.3. Allelopathy on the basis of single bioactive compounds

Allelopathic studies hinge on toxicities induced by single chemical released by a species in an ecosystem. While, phyto-toxicity cannot be ascribed to single chemical compound which decreases viability of allelopathy ecologically. Moreover, phytotoxic chemical constitutes a small fraction of total chemical released by allelopathic species. While, secondary metabolites constitute large fraction of exudates released by plants into environment and not considered during description of allelopathic interactions. Exudation of secondary metabolites in conjunction of allelochemicals are not considered in allelopathic interactions

Likewise, median effective dose (ED_{50}) and 90% effective (ED_{90}) are concentrations of an allelochemical that infect 50% and 90% of population of targeted species, respectively. Effective doses of allelochemical are neglected during preparation of equimolar concentrations of numerous allelochemicals in allelopathic studies. Likewise, for experimental purposes, allelochemicals with same modes of action are usually mixed. Contrarily, plants exudate a complex of chemicals with dissimilar impacts on plants in vicinity under natural conditions.

1.7.1.4. Mode of release of allelochemicals

Allelochemicals can be released into environment through root exudates and in the form of volatiles from leaves. More focus on root exudates have outshined the importance of volatile allelochemicals from leaves. Numerous weeds possess glands on abaxial surface of leaves that release allelochemical in environment. Foliar released chemicals might inhibit growth and germination. Furthermore, movements and transformations of allelochemicals in wind are not explored yet. No methodology has been developed so far to study foliar released allelochemicals while these are easily observable on a bright sunny day.

1.7.1.5. Allelochemicals in soil

Effects of allelochemicals on soil physiochemical and biological attributes have not been extensively studied yet. Moreover, abandonment of time of degradation, transformation, residence time in soil, qualitative and quantitative differences among allelochemicals are not considered while making recommendations using allelopathy. Furthermore, transformations and degradations of allelochemicals and possible fates are also poorly understood yet. Hence, ambiguities associated with bioavailability of allelochemical to promote or inhibit the growth of adjoining plants decrease the reliability of allelopathy. Moreover, presence of sinks of allelochemicals in soil, complex mixture of allelochemicals and root interactions in soil cause elusiveness in allelopathy.

1.7.2. Risks to human health

Human health is exposed to risks owing to application of pesticides since these depict long half-life and residual toxicity. Numerous health risks that aggravate with use of pesticides have been described here.

1.7.2.1. Cancerous cell growth

Application of pesticides is highly correlated with cancer in human body. Application of imidazoline herbicides causes cancerous cell growth in bladder (Koutros et al. 2015). While, chlorpyriphos toxicities caused imbalance in redox balance of breast cells in humans which alters the antioxidant defensive mechanism and causes cancerous growth. It can be ascribed to excessive biosynthesis of H_2O_2 in breast cells (Ventura et al. 2015). Likewise, organo-chlorines mediated cancerous growth is attributed to increased biosynthesis of serum (Arrebola et al. 2015). Similarly, application of imidacloprid causes genotoxic effects and develops two nuclei in growing cells and consequently results in cancerous growth. Women exposed to spray drift depicted aggravated chances of cancerous cell growth. Comparative risk of cancer was enhanced by 1.74 and 2.84% using acetochlor alone and acetochlor + atrazine, respectively. While, strong association between spray drift and cancer risks was recorded (Lerro et al. 2015).

1.7.2.2. Asthma

Pesticides damage the respiratory system of humans by increasing bronchial hyper re-activity. Pesticides mediated damages encompass bronchial irritation, inflammation, nasal congestion, sneezing, immunosuppression and endocrine disruption. Consequently, susceptibility of ocular-nasal and damages in bronchial mucosa are enhanced (Raanan et al. 2015).

1.7.2.3. Diabetes

Exposure to pesticides increase human susceptibility to diabetes mellitus type 2. Organochlorines are highly damaging in this regard. Aggravated susceptibility of diabetes can be ascribed to enhanced serum concentration of oxychlordane, hexachlorobenzene and dibenzofurans. Moreover, pesticides mediated upregulations in HbA1c (blood glucose regulator) enhance the susceptibility for diabetes. Humans exposed to pesticides depicted 61.1% abnormal glucose regulation while it was only 7.9% in those humans which were not exposed to pesticides (Hansen et al. 2014). Similarly, risk of gestational diabetes mellitus in women was increased by 3.3% during pregnancy owing to pesticide pollution (Saldana et al. 2007).

1.7.2.4. Parkinson's disease

Parkinson's disease causes abnormal biosynthesis of dopamine at nerve endings of human's brain. Associated comorbidities encompass muscular rigidity, tremor, and abnormalities in gait, speech, writing and bradykinesia. Specifically, organophosphates, pyrethroids, cyprodinil and fenhexamid increase the risk of Parkinson's disease. Susceptibility to Parkinson can be attributed to aggravated levels of α-synuclein accumulation which ultimately enhance dopamine release at nerve endings (Chorfa et al. 2016).

1.7.2.5. Leukemia

Exposure to pesticides increases the risk of leukemia particularly in new born babies. Pesticides exposure is positively associated to lymphoblastic leukemia in early childhood if women is exposed to pesticide drift (Maryam et al. 2015).

1.7.2.6. Cognitive disorders

Pollution caused by pesticides escalates risks allied to cognitive disorders in humans. It causes dementia, amnesia, alzhemier's disease, delirium and paratonia. Most dangerous pesticides regarding cognitive disorders are hexachlorobenzene and trans-nonachlor. Lower IQ level, poor working memory and perceptual reasoning are most pronouncing effects of pesticides in children (Kim et al. 2015).

1.7.3. Contamination of surface water

Pesticides can find its way to rivers and streams through surface runoff and contaminate surface water. However, bioavailability of pesticides is highly dependent on desorbed pesticide contents and soluble fraction in water. Pesticides mediated damages for aquatic organisms have been described here (Grung et al. 2015).

1.7.3.1. Risks to aquatic invertebrates

Pesticide contaminated water affects biological activities of aquatic organisms. Decline in burrowing activity of Chironomus riparius was evident under pesticide pollution over control. Aquatic invertebrates like Daphnia magna and Hyalella azteca are 200 times more sensitive to chlorpyriphos pollution than fishes. Pesticide concentration of 5 µg L^{-1} alters taxonomic distribution and composition, decreases invertebrate grazing pressure and enhances periphyton and algal growth. Moreover, delay in emergence of larvae and reductions in length of wings of adult midges are other complications that aquatic life faces due to pesticide pollution. Likewise, parathion and malathion concentration of 1 µg L^{-1} causes premature death of stonefly, mayfly and caddis fly (Murthy et al. 2013).

1.7.3.2. Additive toxicity of pesticides and aquatic invertebrates

Some pesticides are nontoxic for aquatic life when applied alone while become lethal in mixture. Additive toxicity of combinations of pesticides can be ascribed to enhanced penetration in cuticular and pectinaceous material of midges and larvae of aquatic organisms. Moreover, one pesticide can elicit biotransformation in other pesticide to convert it in more bioavailable and toxic form. Likewise, alone atrazine is not toxic for Chironomus tentans midges even at higher concentrations of 20,000 µg L^{-1}. However, mixture of atrazine with any organophosphate pesticides (malathion, methyl parathion and trichlorfon) cause death of forth instar of Chironomus tentans midges. Aggravated additive toxicity of atrazine + organophosphate pesticides were due to atrazine mediated alterations in organophosphate pesticides that rendered toxicity to organophosphate (Murthy et al. 2013).

1.7.3.3. Toxicity for fish

Pesticides also pose serious threats to fish by affecting reproduction and swimming behavior. Atrazine concentration of 5 µg L^{-1} induces abnormalities in reproductive system of zebra fish. Schooling and feeding behavior also alter under pesticides pollution, however interventions in human food chain through pesticides affected fish have been infrequent for most of instances. Atrazine at concentration of 0.04 µg L^{-1} impairs priming effect of milt and subsequent regulations of plasma sex steroid (Murthy et al. 2013).

1.7.4. Toxicity in food commodities

Pesticides affect human food web by contaminating food items and thus constitute a permanent source of cancerous growth in humans. Most common pesticides that have been in human food chain encompass acephate, chlorpyriphos, chlorpyriphos-methyl, dithio-carbamates, methamidophos, iprodione and chlorothalonil.

1.7.5. Impact on soil physio-chemical attributes

Pesticides affect numerous soil traits directly or indirectly through synthesis of other products that accumulate in soil. Most problematic pesticides are those which accumulate in soil biota, have longer half-life and hydrophobic in nature. Organochlorines, endrin, endosulfan, lindane, heptachlor and their transformation products are most dangerous contaminants for soil. Transformation in persistent pesticides can be ascribed to hydrolysis, cleavage and and methylation. Transformations in persistent pesticides release toxic phenolics in soil. Consequently, innumerable soil physical, biological and chemical processes are affected. Most persuasive soil trait concerning the persistence of pesticides is soil organic matter. Generally, if higher is organic matter greater is persistence of pesticides in soil. While, some pesticides being positively charged (paraquat) occupy soil colloids and only strong acids are capable to cause desorption of these pesticides from exchange sites. Moreover, sorption of pesticides highly depends on soil pH; sorption of ionizable pesticides (picloram, atrazine, 2,4-D and 2,4,5-T) enhances with the fall in soil pH (Centofanti et al. 2016).

1.7.6. Risks to soil biology

Greater concentrations of pesticides might prove advantageous earlier however, poses serious threats to the sustainability of soil biota. Triclopyr impairs nitrifying bacteria by preventing fixation of atmospheric nitrogen and oxidation of ammonia to nitrates. Likewise, 2,4-D impairs activities of bean nitrifying bacteria and glyphosate elicits impairment in activities of free living azotobacter, azospirulum and sulfur solubilizing bacteria. Glyphosate, trifluralin and oryzalin hinder the growth and activities of mycorrhizae (Aktar et al. 2009).

1.7.7. Impacts on birds

Pesticide mediated pollution is also injurious for health and activities birds. Pesticides elicited damages to bird health are discussed in this section (Mitra et al. 2011).

1.7.7.1. Neuromuscular disorders

Organochlorines triggered toxicity impairs the muscular movements of birds by delaying the closure of sodium channels at the axon endings of nerves. Moreover, activities of calcium-ATPases are inhibited in egg shell glands of avian birds and shell thickness is diminished. While, endosulfan changes electrophysical regulations of nerve cells and membrane transportation of potassium and decreases the biosynthesis of gamma amino butyric acid. It results into numerous neuromuscular disorders.

1.7.7.2. Behavioral changes

Pesticides pollution also induces behavioral changes in birds e.g. with organochlorines toxicity overlook territorial restrictions while flying, depict lesser focus to young birds and decrease the trajectory from nest.

1.7.7.3. Abnormalities in development

Organochlorines toxicity causes ailments in development of birds. Malformed beaks, fluid retention in heart cavities, sex determination and abnormal skeleton development are damages associated with organochlorines toxicity. While, toxicity caused by organophosphates induces feather growth and congenital abnormalities in avian birds and leads to death ultimately.

1.7.7.4. Abnormalities in endocrine system

Birds are susceptible to pesticide toxicity owing to large consumptions of pesticide contaminated seeds. Lindlane impairs the regulations of serum hormones and ultimately reproductive behavior.

1.7.7.5. Abnormalities in reproductive system

Organophosphate mediated toxicity aggravates degeneration and interrupt the development of sperm cells. Likewise, parathion also declines corticosterone and progesterone shortly after intake. Besides, pesticides diminish clutch and litter size, parental care and alter sexual behavior owing to pesticides triggered changes in sex hormones.

1.7.7.6. Abnormalities in immune system

Lindane mediated toxicity downregulates hemoglobin capability to supply oxygen. Thymus cells (T-cells) are synthesized in thymus glands and render immunity by binding antigens to the surface of receptor cells. A sub lethal dose of endosulfan declines number of thymus lymphocytes, decrease the size of follicles and aggravate atrophy in thymus. Organophosphates pesticides mediated toxicity triggers changes in DNA, proteins and affect non-cholinergic and anti- cholinergic pathways.

1.7.7.7. Abnormalities in thermal regulations

Interaction of freezing temperature and pesticide pollution causes inability of birds to regulate body temperature and ultimately death owing to fall in body temperature.

1.7.8. Impact on honey bees

Pesticides contaminated pollens and nectars affect whole family of honey bees. Honey bees with pesticide contaminated nectars if find its way to hive then contaminated nectar is discarded from honey making process and contaminated honey bee is fed on non-contaminated honey. This honey bee starts to collect nectars again however, it has life of only few days.

1.7.9. Biomagnification of pesticides

Biomagnification is a process whereby pesticides find their way to food web and food chain through contamination of water bodies, small insects and plants which are consumed by secondary and other tertiary consumers. Biomagnification of pesticides can be discerned to three phases. During phase one, pesticides are transformed to comparatively lesser toxic products after hydrolysis, oxidation and reduction. During the second phase, conjugation renders the pesticides still in a lesser toxic storable form. During third phase, pesticides undergo deconjugation and convert to highly toxic, bioavailable and water-soluble forms and gain entry in food web (Malik et al. 2011).

1.7.10. Management options

1.7.10.1. Improving allelopathy research

Validity of allelopathic interactions can be improved using some cares in allelopathic studies. Inderjit et al. (2005) proposed some management options to enhance ecological viability of allelopathy as detailed below.

I. Aggregated root systems

Elucidation of allelopathic processes using aggregated rhizosphere of different plants in an ecosystem enhances the ecological viability of allelopathy. While, aggressor species can develop inhibition zones below or above the soil and relating allelopathy to inhibition zones of aggressors' species leads to faulty information. Hence, spatially aggregated root systems are more illustrative to describe below ground allelopathy.

II. Mixture of allelochemicals

Single phytotoxic chemical triggered inhibition or pattern development of species has no significance under field conditions. So, determination of total and specific activity in mixture of allelochemicals is of enormous importance. Moreover, bioassay fractionation of allelochemicals also depicts lower efficacy since allelochemicals convert to more bioactive compounds in soil. Hence, evaluation of allelochemicals based on soil physical, chemical and biological properties offers better inferences about allelochemicals.

III. Modes of release of allelochemicals

Plant organelles that release allelochemicals through leaves or roots should be characterized using electron microscopy, genes expression and enzyme biosynthesis. Moreover, foliar release of allelochemicals and transformations at different pheno-stages of plants should be explored. Similarly, foliar released mediated improvements in stress tolerance should also be elucidated.

IV. Soil characterization

Degradation and decomposition of allelochemicals over spatial and temporal variations are of vital importance. Similarly, allelochemicals mediated changes in soil physical, chemical and biological traits give more factual illustration of allelochemicals. Similar, study at community level, influx and outflux and persistence time of allelochemical further improve ecological pragmatism of allelopathy.

V. Allelopathy at ecosystem level

Defining ecological conditions while reporting allelochemicals mediated changes in environment enhances the practicality of allelopathy. Since, dominance of species can be ascribed to innumerable chemicals and processes hence defining of allelopathy based on ecosystem level increases credibility.

1.7.10.2. Vegetated buffers

Vegetation buffers reduce the runoff speed and enhance infiltration which reduces contamination of water resources from pesticides. Similarly, grassland water ways, grassed depressions and grassed ditches reduce the runoff volume, slows down gully development and ultimately retain pesticides residues. Performance of buffer strips depends on hydrological factors (infiltration, runoff and precipitation), buffer characteristics (width, species used in buffer, slope, density, height and root depth) and nature of pesticides (persistence, half-life, polarity and water solubility). It has been recorded that atrazine concentration in soil was diminished by 45-80% using vegetation buffers (Popov et al. 2005). Similarly, vegetation buffers of 0.5 to 20 m width declined metribuzin, iso-proturan, lindane and pendimethalin residues in soil by 11-100% (Sabbagh et al. 2009).

1.7.10.3. Good agricultural practices

It refers to set of practices carried out from sowing to harvesting that minimize pesticide contamination in food items, water, soil and environment. Allied to application of pesticides, those nozzles should be used in spraying operations that minimize drift of spray. Similarly, distance of at least 200 m from water bodies should be maintained from crops being sprayed. Band application of pesticides is recommended in row crops to reduce environmental pollution. Application of pesticides in foggy, wet weather conditions is prohibited to reduce the environmental losses of pesticides. Soils that are already contaminated should be avoided from pesticide applications.

Moreover, plant protection should base on integrated approaches instead of a single approach. During spraying operations, non-spray buffers of 5 m width can be maintained at regular intervals. Mechanical manipulation of soil alters physiochemical and biological attributes of soil and thus affect pesticides mediated soil toxicities. Soils where large flow is prevailing should be ploughed conventionally. Since, conventional ploughing breaks capillary action in macro-pore spaces and thus declines pesticide leaching. Whereas, conventional tillage remarkably aggravates pesticide leaching over conservation tillage practices in soils where water flows in soil matrix. Conservational tillage practices increase sorption of pesticides when organic components of conservational tillage interact with pesticides. Although, bioavailability of pesticides for biological degradation decreases significantly in conservational tillage; this persistence is compensated by the boost in microbial activities. Therefore, adopting conservational tillage declines sorption of pesticide overall. Areas with shallow water table are recommended to build tile drains system to avert water contamination (Tang et al. 2012).

1.7.10.4. Bioremediation of pesticides

Bioremediation of pesticides is an imperative management option and actinobacteria are gaining attention in this regard. Other genera that can degrade pesticides encompass Rhodococcus, Streptomyces, Nocardia, Mycobacterium, Frankia, Pseudoncardian and Janibacter. These microbes can multiply in diverse environmental conditions and can degrade organophosphates, organochlorines, pyrethroids and chloroacetanilides. Arthobacter species AK-YN10 degraded the atrazine in soil to cyanuric acid (Sagarkar et al. 2016). Similarly, atrazine was degraded in a period of two weeks by Rhodococci and atrazine was utilized as carbon and nitrogen source by bacteria (Kolekar et al. 2013). Likewise, endosulfan was degraded by 93% by Rhodococci in 15 days (Verma et al. 2011).

1.7.10.5. Incineration of pesticides

This technology deals with the excavation and burying of pesticides residues at site of synthesis of pesticides. Landfills are prepared with cemented embankments and filled with pesticides waste material (Usman et al. 2014).

1.7.10.6. Immobilization of pesticides

Addition of organic matter enhances adsorption sites and thereby reduces bioavailability as well as leaching and volatilization. Partially burnt carbonaceous material when produced from a living source is called biochar. Although, it was initially introduced to improve soil organic matter but recent findings have explored its capability to immobilize pesticides also (Diez et al. 2013). Addition of biochar in soil caused irreversible sorption of atrazine, pyrimethanil, bentazone and terbuthylazine (Cabrera et al. 2014).

1.7.10.7. Soil washing

Soil washing is a technique whereby contaminated soil is excavated and washed with numerous solvents and extractants with a subsequent settling of soil particles and refilling of landfills.

I. Solvents

Solvents are selected on the base of type of contaminant, soil attributes, solvent concentration, exposure time, speed of soil + solvent mixing and ratio of soil to solvent. However, lower efficacy of pesticide removal for high molecular weight substances restricts the utilization of this technique on commercial level.

II. Surfactants

These are substances that reduce the surface tension of pesticides and enhance solubility in a medium. This technique is useful to enhance solubility of persistent pesticides. Mixing of tween-80 in soil declined soil DDT by 94% (Betancurt-Corredor et al. 2015).

1.7.10.8. Soil flushing

Soil flushing is a technique where by contaminated areas are inspected and landfills are prepared in contaminated soil. Landfills are filled with chemicals and pollutants are removed using interactions of chemicals with pollutants. Chemicals used for extraction are usually surfactants or solvents. Fluid is passed across the contamination zone and brought at surface where contaminated fluid is collected, recycled and reused.

Electro kinetic flushing is a technique whereby electrodes are buried in contaminated soil and electric current is passed. Passage of electric current alters soil physiochemical and biological attributes and favors the removal of pollutants from soil. Electro kinetic flushing removed 2,4-D from contaminated soil by 94% (Souza et al. 2016).

1.7.10.9. Chemical reduction

Chemical reductants denote electrons and thereby alter solubility and bioavailability of pesticides. Nano scale zero valent iron is usually used as economically viable chemical reductant of pesticides in soil. Nano scale zero valent iron escalates degradation of organochlorines by removing chlorine (El-Temsah et al. 2016).

1.7.10.10. Oxidation

Oxidation techniques convert the pesticides in soil to inorganic compounds such as carbon dioxide and water. Most frequently used oxidizing agents are ozone, chlorine, hydrogen peroxide and chlorine dioxide. Oxidation efficacy of these oxidizing agents is poor hence it is improved by using conductors, salts and ultraviolet light. Photocatalysis using TiO_2, Fenton processes, ozonating and plasma oxidation are most commonly used in oxidation process.

1.7.10.11. Phytoremediation

It is technique whereby plants are used to extract pesticide residues from contaminated soils. Low molecular pesticides can be taken up by plants and can move across bio membranes. Plants can degrade pesticides by releasing root exudates in rhizosphere that is called rhizo-degradation. Other modes of detoxification encompass phytovolatilization, phytodegradation and phytoextraction (vacuolar sequestration). Pesticides that undergo sequestration are eliminated from agro-ecosystem through incineration. Phytoremediation depicts innumerable advantages over other techniques. It is non-destructive and economically that improves soil health and enhances aesthetic value of contaminated sites.

1.7.10.12. Vermi-remediation

It is use of soil earthworms to detoxify pesticide residues in soil. Earthworm is capable to modify soil physiochemical and biological attributes and this potential is also useful to detoxify pesticides in soil (Garcia-Jaramillo et al. 2014).

1.7.10.13. Integrated approach

Integrated method of pest control comprises of best combination of agronomic, biological, chemical, physical, mechanical and other methods against the entire complex of pests with the objective of bringing down their infestation to economically insignificant level with no or minimum interference on activity of natural beneficial organisms. It is recommended to use multiple approaches for pest management instead of single strategy (Khandelwal et al. 2016).

I. Preventive method

Preventive methods deal with cares that make cut on introduction, establishment and spread of pests. It emphasizes on utilization of weed seed free mechanical equipment, crop seed, cleaning of water channels etc.

II. Cultural methods

Cultural methods deal with enhancement of productivity of crops and suppression of weeds by disruption of life cycle, decreasing availability of growth factors and creating suitable environment for crops and unfavorable for weeds. It encompasses tillage management, crop rotation, cover crops, trap crops, intercropping, crop competition, stale seed bed preparation etc. Intercropping of maize and cowpea decrease infestation of Portula olercea, Echinochloa colona and Sorghum halpenesein maize crop and improves profit. Moreover, growing of pearl millet after harvesting of wheat and before rice transplantation diminish weed infestation in rice-wheat cropping system.

III. Mechanical/physical methods

It includes eradication of weeds using hoeing, mowing, digging, tillage and hand pulling of weeds.

IV. Non-mechanical methods

Non-mechanical methods of weeds control comprise of flooding, burning, solmization and mulching.

V. Biological methods

It is technique whereby infestation of pests or weeds is brought below the economic injury level using predators, pathogens or parasites of pests. Lantana weed can be managed by infestation of tinged bug. Parthenium weed can be eradicated using insects of Zygogramma species. Similarly, leafy spurge, milk thistle and field bin weed can be controlled by infestation of beetle.

1.8. Risks during Post-Harvest Operations

Risks associated with harvesting and post-harvest operations which deteriorate quality of end use product are discussed in this section.

1.8.1. Risks during harvesting

Post-harvest operations are followed by harvesting operations and numerous damages are caused by improper harvesting time and method under field conditions. Regarding the time of harvesting, too early harvesting of crop contains higher moisture and often encumbers harvesting operations. Moreover, it exposes the product to the attack of insects, diseases and mold growth. Whereas, drying operations are often required in case of early harvests which add to cost of production. Contrarily, too late harvesting deteriorates product quality, disturbs biochemical attributes and increase shattering losses. Besides, crops are also exposed to climatic skepticism, rodents and birds attack.

1.8.2. Risks in threshing and cleaning

During threshing grains are separated from chaffs, spikes and panicles. Threshing action usually comprises rubbing, impact action, stripping, beating and trampling or any combination of these. Major risks associated with threshing include poor efficacy of grain separation from chaffs, grain breakage and grain loss in thresher while threshing. Delay in threshing operations enhance breakage of grains and leaves crops in field for insects, birds and rodents' damages while early threshing causes poor separation of grains from chaffs. After threshing, cleaning is performed through winnowing or mechanical methods. Poor cleaning efficacy aggravates insect damages and biochemical alterations in final product (Sarkar et al. 2013).

1.8.3. Risks in drying

Safe moisture contents for long term storage of cereals crops is < 12% and for oilseeds is < 10%. Higher moisture contents cause mold attack while lower moisture enhances shattering losses in cereals while in oilseeds it causes the formation of free fatty acids followed by lipid peroxidation and declined germination. Sun drying is the most common method of drying and associated risks are climatic extreme events and birds' attack. Mechanical drying requires expertise to operate and smaller variation in temperature and air speed alters morphological appearance of seeds. While, prolonged drying often induces ultrastructural changes and proteases, lipases and dehydrogenases activities enhance that deteriorate quality of seed (Abass et al. 2014).

1.8.4. Risks in seed storage

During seed storage, most prominent abiotic factors that induce deterioration in quality are relative humidity and temperature. Slight alterations in temperature increase lipid peroxidation and alter enzymatic activities. Increase of temperature causes breakdown of triglyceride and enhances lipase activities which impairs seed viability.

1.8.5. Risks in transportation

Transportation mediated risks involve spillage and bruising losses. Most of the crops after harvesting are transported using trolleys and jute bags in ambient conditions. Jute bags are loaded and unloaded nearly ten times before any further processing and during each loading grains are lost through spillage from jute bags. Hooks used to lift and unload bags in another trolley increase spillage. While, seed viability also reduces owing to exposure to environmental conditions during the transportation (Alavi et al. 2012).

1.8.6. Risks during milling

Milling operations vary with the different crops. In rice crop, milling comprises of removing husks and bran from rice to convert it into human consumable form. Presence of foreign material i.e. weed seeds, dust, stone etc. damages milling machines and enhances grain breakage and cracking as well.

1.8.7. Insect infestation

Insect infestation is the most common damage during post-harvest operations. Each 1% rise in infestation of insect attack deteriorate maize seed quality by 0.6-1%. Major insects of stored maize grains are Sitophilus zeamais (weevil) and Prostephanus truncates (grain borer). Both these insects are responsible for most of damages in maize. Under field conditions, this cause weight loss of maize seeds. Sporadic nature of grain borer makes it arduous to keep below economic injury level. Likewise, Sitophilus, Tribolium, Cryptoleptes and Oryzaephilus species also deteriorate grain quality of stored wheat, rice and maize.

1.8.8. Mycotoxins

Many mycotoxins are synthesized in grains owing to insect damage, fungal growth and grains deterioration. Mycotoxins not only cause loss of dry weight and quality but also introduce numerous injurious compounds in human's food chain. Ochratoxins, fumonisins, alfa toxins and deoxynivalenol are most frequent mycotoxins found in cereal grains.

1.8.9. Fumigants triggered resistance in insects

Cereal grains in storage are fumigated with phostoxin to control large grain borer. However, continuous use of fumigants enhances resistance in insects and endanger human food chain through residual toxicity (Shaaya et al. 1997).

1.8.10. Management Options

Management options that can be used to reduce risks associated with post-harvest operations are

1.8.10.1. Principles for safe storage of seeds

Principles for safe storage of seed and post-harvest operations deal with temperature and humidity.

I. James' rule

Sum of temperature (°F) and relative humidity (%) of storage environment should be less than 100 OR sum of temperature (°C) and relative humidity (%) of storage environment should be less than 60 for safe storage of seeds (James et al. 1967).

II. Harrington's rule

Seed storage life enhances by twice for each 1% decline in seed moisture contents or each 5°C drop in temperature of storage environment provided seed moisture contents are 5-14% (Harrington 1972).

III. Bradford's metronome rule

This rule deals the seed as clock which has definite number of ticks before its death. According to Bradford's rule, the 'clock' starts running as soon as seed matures and 'clock' has definite number of ticks before death. The rate at which 'clock' ticks depends on seed moisture and temperature of storage environment.

1.8.10.2. Seed moisture contents

Higher seed moisture contents decline storage life. Moisture contents > 15% aggravate insect attack, disease infestation and mold growth while moisture < 4% causes desiccation. Recommended and safe limits for long term storage are 10-12% for cereals and < 8% for oil seeds.

1.8.10.3. Seed shape

Round and regular shaped seeds are less prone to post harvest damages than irregular shaped seeds.

1.8.10.4. Climate of crop

Crop grown in climate that is suitable for its growth usually depicts lesser damages during post-harvest operations.

1.8.10.5. Gaseous composition of warehouse

Gaseous composition and relative proportion in in storage house are also important determinant of post-harvest damages. Seed storage life usually enhances with the increase of carbon dioxide and nitrogen pressure while declines with the increase of oxygen and ethylene (Cardoso et al. 2008).

1.8.10.6. Storage types

I. Conditional storage

Seeds are stored at temperature of 20°C and dried to moisture of 10-12%. It is usually recommended for storage of cereal seeds and seeds can be stored for 1-3 years.

II. Cryogenic storage

Seeds are stored at temperature of – 196°C using liquid nitrogen. It impairs enzymatic and metabolic activities of fresh seeds and maintains these to a level like fresh seeds. Storage life using this method is 3-5 years.

III. Hermetic storage

Seed is stored at < 5% moisture contents and ambient air in container is replaced by carbon dioxide and nitrogen. In this method, storage life of seed is up to 10 years using this method.

IV. Containerized storage

Air in container is replaced by desiccants to impair mold growth and respirational heat. Chemical desiccants that are used are silica gel and salt solutions.

1.8.10.7. Management of warehouses

Storage house should be provided with characteristics that facilitate post-harvest storage and operations. Floor of storage house should be 90 cm higher from earth level and doors should be provided with tin or metal sheets at the lower sides to prevent attack of rodents. Older jute bags should be replaced at regular intervals and fumigated with aluminum phosphide. Bags should be stacked in 6-8 tires and should be turned after each 3 months.

1.8.10.8. Management during seed processing

Mechanical drying is usually advantageous over sun drying. Bin, continuous flow, wagon batch dryer and rotary dryers can be used to reduce seed moisture. These uses heated or non-heated air and dry seeds through conduction or convection. Regarding seed cleaning, air screen cleaners and gravity separators can be used to grade seeds of different sizes and remove inert matter. Indent cylinder separators and disc separators are used to grade seeds on the base of length. While, seeds with dissimilar texture can be distinguished using velvet roll, magnetic separator, inclined draper and spiral separator. Pre-conditioning of seeds using dehuller, scarifiers, debearders and sheller decreases the risk of post-harvest operations mediated damages (Kumar and Kalita 2017).

1.9. Conclusion

Agronomic practices often enhance productivity of agro-ecosystems however, pose serious threats to environmental sustainability concurrently. Ultimate sinks of pollutants generated by agronomic practices are soil, air and water from where these enter in human food web. Improving soil organic matter contents enhances water and nutrient use efficiencies and biological activities while decreases the soil susceptibility to physiochemical and biological damages. Selection of varieties using biochemical and physiological markers that exhibit strong correlation with morphological attributes enhances selection efficacy of genotypes. Maintenance of weeds population below economic threshold level using integrated approaches is considered most viable approach economically and environmentally. Seeds of different crops being different in composition should be handled accordingly during post-harvest operations to maintain viability, vigor and quality for end use purposes. In short, risks associated with agronomic practices can be minimized by adopting approaches that are close to natural ecosystem.

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Chapter 2

Agricultural Risks within Plant Protection Approaches

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Abstract

Current world population is expected to reach 10.5 billion by 2050; further adding threats to global food security concerns. With the rising human population and increasing livestock production, it is a well accepted fact that agricultural production must be increased considerably in the foreseeable future to meet food and feed demands. According to FAO, in the developing countries, the problem of competition from insect pests is further complicated with a rapid annual increase in the human population (2.5-3.0%) in comparison to a 1% increase in food production. Crop protection research mainly focused on the curative control of pests, diseases and weeds. In which, agrochemicals are widely used in agriculture and have significant benefits by contributing to a sustainable production of food and feed. If these are used in an inappropriate manner, they also can present unacceptable risks to human and animal health and to the environment. The sustainable and efficient use of available protection resources is the basis for ensuring food security, which means an adequate level of own long-term satisfying the demand of food, which may have the positive impact on the stability and quality of food supply in the global market that is increasingly at risk. Therefore, governments set high standards for the registration of new pesticides as well as for re-evaluation of pesticides that are

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already on the market to ensure that they meet the current health, environment and safety standards.

Keywords: Plantprotection, foreseeable future, sustainable production, agrochemicals

2.1. History of Plant Protection

Plant protection history can be taken back to 19th century and in the 20th century an active area of research was the breeding of pest resistant plant genotypes. Various varieties of cotton wheat, fruits and vegetables develop resistance to many diseases and pests. The development of resistant cultivars against diseases and nematodes has been accelerated from the past many years (Gururani et al. 2012). Now allelopathy is considered an important tactic for weed control (Bhadoria 2011). Limited applications of pesticides begin around 2000 years ago but with the passage of time, these applications become boundless (table 2.1). In the late 1800s and 1900s excessive use of pesticides has been started. By 1903 gasoline powered spraying and dusting equipment was in use, by 1915 it became standard practice to use chemical - insecticides and fungicides. The inorganic pesticides pre-dominated in 1940's until the development of DDT, BHC and other synthetic compounds. With the time, unfortunately, the use of chemical insecticides has been increasing many fold which is an alarming situation for the living beings. We had seen that microbial insecticides have been explored but only *Bacillus thuringiensis*, at present, is in extensive commercial use for the control of agricultural insect pests (Sanchis and Bourguet 2008). Recent development has been investigated for the control of insect-pests by employing attractant or repellent lure, which could be in the form of species-specific sex pheromones (attractant) and/or the bouquet of chemical signals (repellent). Sex pheromones are species specific and are used to find their partner. Attractant lures i.e. pheromones modify the behavior of insects towards the trap instead to find their partner but their ultimate role in plant protection is yet under investigation. For example, Gossyplure and Methyl Eugenol are sex pheromones and are released by one partner to attract the others. Gossyplure and Methyl Eugenol are used for the control of Pink Bollworm and Fruit Fly, respectively (Qureshi et al. 1984; Nandini and Mohan 2014; Ullah et al. 2015).

Table 2.1 Historical time line for pesticide-related developments

Year	Pesticide development	Remarks	Reference
1825	BHC produced by Michael Faraday	But insecticidal properties not known	Ordish (1976)
As early as 1848	Rotenone used as insecticide	Usage not common until 1920's, expanding greatly in 1930's	Mrak (1969)
1867	Unknown inventor discovers that the dye Paris Green killed insect	For chewing insects	Shepard (1951)

Year	Pesticide development	Remarks	Reference
1860's	Paris Green (arsenical) used to control Colo. Potato beetle in Rocky Mountain Region, as inorganic chemicals emerge as pesticides	-	Shepard (1951)
1873	DDT first made in a laboratory (Otto Ziedler)	But insecticidal properties not discovered until 1939	Ordish (1976)
1882	Bordeaux mixture discovered in France to control plant diseases	Mostly copper sulfate; became mainstay for many years	Shepard (1951)
1883	John Bean invents pressure sprayer to apply pesticides, leading to fire engine mfg. by FMC	Key development leading to efficient applications to crop surfaces	
1877-78	Kerosene emulsified in soap developed to kill sucking insects	Prof. John Cook, Mich. Ag. College.	Perkins (1978)
1886	Inorganic lime sulfur washes introduced to control scale insects in California; also fumigation with hydrogen cyanide introduced	Hydrogen cyanide led to one of first instances of insect resistance to a chemical	Shepard (1951)
1892	Lead arsenate discovered as control for gypsy moth in Massachusetts	-	Perkins (1978)
1893/ 1906	Lead arsenate found to be effective against many insects and usage of home-made preparation Expands	Widely accepted by home gardeners	Perkins (1978)
1894/ 1900	Steam/mechanical/horse driven spray equipment developed	Permitted larger-scale field applications	Ordish (1976)
1901 1908 (Revised version)	USDA issues Farmer Bulletin 127 containing recommendations for preparation and use of arsenicals (Paris Green, copper arsenite, arsenite of lime, London purple, lead arsenate) for chewing insects.	For sucking insects, it recommended soaps, pyrethrum, tobacco decoction and sulfur. Resin and lime-sulfur was for scale.	USDA (1992)
1907/ 1911	Chemical industry begins production of lead arsenate; home manufacture no longer recommended	Usage reaches 40 mil. lbs. by 1934	Perkins (1978)
1921/ 22	First airplane field application of insecticides (cotton, La., 1922)	Ohio experiments in 1921	Shepard (1951)
1913/ 1915	Organic mercury compounds introduced in U.S. from Germany as seed treatments	Mercurial fungicides were widely adopted for fungi/disease control by late 1920's.	Ennis and McClellan (1964)
1920's/ mid-1930's	Calcium arsenate dust developed by USDA found to be effective against boll weevil, but chemical is toxic to many plants	Usage quickly adopted for usage in cotton, potatoes and tomatoes, plants that would tolerate its toxic properties.	USDA (1992) Perkins (1978)

Year	**Pesticide development**	**Remarks**	**Reference**
1928	Sodium chlorate tested at rates of 200 lbs. per acre to control Johnson grass	Landowners desperate for controls of the pest in South	Harper (1930)
1928	Ethylene oxide patented as insect fumigant		Shepard (1951)
1932	Methyl bromide first used as fumigant (France)		Shepard (1951)
1932/ 39	Search by Swiss firm, Geigy, (Dr. Paul H. Mueller) for insect controls/seed disinfectants results in discovery of DDT	Compound had extraordinary killing power and duration outdoors, exposed to weather; Mueller won Nobel prize.	Perkins (1978) Perkins (1978)
1940	BHC insecticidal properties discovered in France and England		Price (1973)
1941/ 42	DDT used on crops and for human lice control in Switzerland	Geigy makes DDT available to other Countries	Perkins (1978)
1942	Liquefied gases used for aerosol propellant for pesticide application		Shepard (1951)
1942/ 45	DDT made available for use in U.S., military use first; civilian and agricultural use by July, 1945; prevented typhus plague in war-torn Europe	USDA and War Production Board controlled the chemical’s introduction	Perkins (1978)
1944	Phenoxy acetic acids discovered as first selective herbicides, typified by 2,4-D	Followed discovery of selective herbicidal activity of certain dinitro dye compounds in France in 1930's; revolutionized broad leaf weed control in U.S.	Ennis and McClellan (1964)
1946	Organic phosphate insecticides of German invention made available to American producers		Shepard (1951)
1945/ 53	Numerous important synthetic organic insecticides come on U.S. market (two dozen chemicals or more)	Chemicals included chlordane, BHC, toxaphene, aldrin, dieldrin, endrin, heptachlor, parathion, m. parathion and TEPP, leading to widespread soil applications as well as broadcast/aerial	US EPA (1996)
1949	Captan, first dicarboximide fungicide introduced		US EPA (1996)
1940's	D-D mixture discovered to have value as Nematicide	Much more cost effective than other chemicals, leading to expanded usage	OPP registration Files

Year	Pesticide development	Remarks	Reference
1950’s/ 60's 1965	Formulation developments, particularly granulars (along with numerous new chemicals) lead to adoption of soil applications of insecticides and herbicides on major crops Atrazine registered as herbicide (heterocyclic nitrogen type)	Corn, sorghum, soybeans and cotton become major users of pesticides rather than fruits/vegetables. Breakthrough in control of broad leaf and grassy weeds in corn/sorghum and other crops	US EPA (1996)
1969	Alachlor registered as herbicide (amide type)	Mainly for grass control	“
1972	Bacillus thuringiensis (Berlinger) (Bt), a biological, registered as an insecticide	Led way toward more related Bt registrations and biologicals more generally	“
1974	Registration of glyphosate as herbicide	Important because first modern systemic non-selective herbicide with quick inactivation in soil	“
1979	First of synthetic pyrethroids registered as insecticides (fenvalerate and permethrin)	Greatly reduced application rates, replacing older chemicals with regulatory and resistance problems	“
1985	Registration of urea-based herbicides, including sulfonylureas	High efficacy at lower application rates by an order of magnitude.	“
1994	Registration of imidacloprid as first of nicotinoid insecticides	Nicotine based insecticides have great potential	“
1990's	Accelerated registration of biologicals and safer pesticides	50 percent or more of new AI’s registered in mid to late- 1990's	-
1997	Fipronil registered as systemic insecticide of fiprole type	Likely to be important type of insecticide in 2000 and beyond	-

Source: Anonymous (2017a)

2.2. General Principles

- The measures of plant protection should be carried out according to the site, crop and the situation
- It is very indispensable that proven cultural, biological and non-chemical measures should be espoused to control the pests and diseases. These measures should be economically and practically feasible.
- The main aim is infestation reduction to avoid economic damage rather to eliminate harmful organisms.

- Farmers should seek help from extension workers and also look for advance training agendas.

2.3. Main Crops of Pakistan and their Insect Pests

The major cash crops of Pakistan are cotton, wheat, rice, sugarcane and maize. Other may include vegetables, pulses and edible oil seed crops. In order to meet the food requirements, it is very much important to harvest maximum yield of these crops, but the insect pests' attack reduces the overall production rate. Hence, the farmer also suffers to uplift the input cost compared to net profit. Cotton and its insect pests are cotton jassid, surface grasshopper, cotton whitefly, cotton aphid, thrips, spotted bollworm, American bollworm, pink bollworm, and armyworm (Arshad and Suhail 2010; Mamoon-ur-Rashid et al. 2012). Wheat as the staple food of subcontinent people but decrease in its yield occurs due to aphid, armyworm, stem fly, and wheat weevil (Hashmi et al. 1983). Sugarcane is mostly attacked by top borer, stem borer, Gurdaspur borer, root borer, pyrilla, termites, mealybug, and balckbug (Chaudhry and Ansari 1988). Rice crop is damaged by many insect pests like grasshopper, brown plant hopper, stem borer, white backed plant hopper, pink borer, and rice leaf folder (Ramzan et al. 2007). Insects cause different kind of damages to crop as they have different types of mouthparts (Cranshaw 2004; Pedigo and Rice 2006). They cause losses in yield by sucking sap from the plants, biting plant parts, attacking roots, stem and leaves, boring into fruits bark, twigs and branches. Larvae and adults are the damaging stages of insects in many cases. The effects of insects can be further divided into direct and indirect effects.

Table 2.2 List of important insect pests of different crops

Crop	**Insect Pests**			
	Common Name	**Technical Name**	**Family**	**Order**
Cotton (*Gossypium hirsutum*)	Cotton jassid	*Amarsaca biguttula*	Cicadallidae	Homoptera
	Cotton whitefly	*Bemicia Tabaci*	Aleyrrododae	Homoptera
	Cotton aphid	*Aphis gossypii*	Aphididea	Homoptera
	Cotton thrips	*Thrips tabaci*	Thripidae	Thysonoptera
	Spotted bollworm	*Earias insulana, E. vitella*	Noctuidae	Lepidoptera
	Pink bollworm	*Pectinophora gossypiella*	Gelichiidae	Lepidoptera
	American bollworm	*Helicoverpa armigera*	Noctuidae	Lepidoptera
	Army worm	*Spodeptera litura*	Noctuidae	Lepidoptera
	Cotton leaf roller	*Sylepta dorgata*	Pyralidae	Lepidoptera
	Cotton grey weevil	*Myllocerus undecimpustulatus*	Cruculionidea	Coleoptera
	Cotton semi looper	*Tracche notabilis*	Noctuidea	Lepidoptera
	Dusky cotton bug	*Oxycarenus lactus*	Lygaeidae	Hemiptera
	Read cotton bug	*Dysdercus koenigii*	Pyrrhcoridae	Hemiptera
	Cotton mealy bug	*Phenococcus gossipiphilous*	Pseudococcidea	Hemiptera

Crop	Insect Pests			
	Common Name	**Technical Name**	**Family**	**Order**
Sugarcane (*Saccharum officinarum*)	Top borer of sugarcane	*Scirpophaga nievella*	Pyralidae	Lepidoptera
	Sugarcane top borer	*Scirpophaga nivella*	Pyralidae	Lepidoptera
	Stem borer	*Chilo infescatellus*	Pyralidae	Lepidoptera
	Root borer	*Emmalocera depressella*	Pyralidae	Lepidoptera
	Gurdaspur borer	*Bissetia steniella*	Pyralidae	Lepidoptera
	Sugarcane pyrilla	*sugarcane pyrilla*	Lophopidae	Homoptera
	Sugarcane mealy bug	*Saccharicoccus sacchari*	Pseudococcid ae	Hemiptera.
	Sugarcane black bug	*cavelerious excavates*	Lygaeidae	Hemiptera
	Sugarcane whitefly	*Aleurolobus barodensis*	Aleyrodidae	Homoptera
Rice (*Oryza sativa*)	Brown plant hopper	*Nilaparvata lugens*	Delphacidae	Homoptera
	White-backed planthopper	*Sogatella furcifera*	Delphacidae	Homoptera
	Rice grasshopper	*Hieroglyphus banaian*	Acridide	Orthoptra
	White rice leaf hopper	*Cofana Spectra*	Cicadelidae	Homoptera
	Yellow stem borer of rice	*Scirpophaga incertulas*	Pyralidae	Lepidoptera.
	White stem borer of rice	*Scirpophaga innotata*	Pyralidae	Lepidoptera.
	striped stem borer of rice	*Chilo supressalis Lepidoptera*	Pyralidae	Pyralidae
	Rice leaf folder	*Cnaphalocrocis medinalis*	Pyralidae	Lepidoptera
	Rice hispa	*Dicladispa armigera*	Chrysomelida e	Coleoptera
Wheat (*Triticum aestivum*)	Wheat aphid	*Macrosiphum miscanti*	Aphididae	Homoptera
	Wheat army worm	*Mythumna seperata*	Noctuidae	Lepidoptera
Sorghum (*Sorghum bicolor*)	Sorghum shoot fly	*Atrigona soccata*	Muscidae	Diptera
	Stem borer	*Chilo partellus*	Pyralidae	Lepidoptera
	Greasy cutworm	*Agrotis ipsilon*	Noctuidae	Lepidoptera
Vegetables	Cabbage butterfly	*Pieris rapae*	Pieridae	Lepidoptera
	Diamond back moth	*Plutella xylostella*	Plutellidae	Lepidoptera
	Cabbage semi looper	*Autographa nigrisigna*	Noctuidae	Lepidoptera
	Red pumpkin beetle	*Aulacophora faveicolollis*	Crysomelidae	Coleoptera
	Hadda beetle	*Eplichna dodecastigma*	Coccinelidae	Coleoptera
	Brinjal fruit borer	*Leucinodes orbonalis*	Pyralidae	Lepidoptera
	Brinjal stem borer	*Euzophera particela*	Pyralidae	Lepidoptera
Fruits	Mango leaf hopper	*Amritodus atkinsoni*	Cicadelidae	Hemiptera
	Mango maly bug	*Drosica mangiferae*	Margarididae	Hemiptera

Crop	Insect Pests			
	Common Name	**Technical Name**	**Family**	**Order**
	Mango fruit fly	*Bactocera dorsalis*	Tepiritidae	Diptera
	Citrus whitefly	*Dialeurodes citri*	Aleyrodidae	Hemiptera
	Citrus caterpillar	*Papilio demoleus*	Papilonidae	Lepidoptera
	Citrus leaf-miner	*Phyllocnistis citrella*	Phyllocnistidae	Lepidoptera
	Citrus psylla	*Diaphorina citri*	Aphalaridae	Hemiptera
	Woolly apple aphid	*Eriosoma lanigerum*	Aphididae	Hemiptera
	San jose scale	*Quadraspidiotus perniciosus*	Diaspididae.	
	Peach fruit fly	*Bactrocera zonata*	Tephritidae	Diptera,

Source: Saleem and Shah (2010)

2.4. Pests

Noxious organisms detrimental to humans, his possessions and cause economic losses, are called pests. They are also responsible for causing many epidemic diseases associated with high mortality rate. Any living organism that is invasive, harmful, destructive, create nuisance to plants, animal and humans is included in this category.

2.5. Types of Pests

It can be categorized into vertebrate pest and invertebrate pests, which are as following:

2.5.1. Invertebrate Pests

Invertebrate pests belong to the class Insect of animal kingdom. They are not only harmful to the human beings in causing many diseases but also responsible for dramatic damages in agricultural crops. Insects have specific characteristics like they possess one pair of antenna, one pair of eyes, three pairs of legs, three body divisions like head, thorax and abdomen, two pairs of wings, and spiracles for breathing.

Based on degree of damage insects can be categorized into the following types:

- Major or key pests
- Minor pests
- Occasional pests
- Potential pests
- Migrant pest

2.5.1.1. Direct effects

i. ***Damage by biting and chewing insects***

By feeding in the leaves, they reduce the area available for the photosynthesis. They attack on the stem and interrupt the flow of sap. These insects also destroy the growing points of plants. Their attack on roots causes the disruption in the absorption of nutrients from the soil. They also reduce the seed production and germination after attacking on the fruits. Examples of biting and chewing insects are armyworm, grasshoppers, beetles, crickets.

ii. ***Damage by piercing and sucking insects***

Their attack causes the plant to wilt if they suck the sap in excessive quantity. These are responsible for the low seed production and damage floral organs. If the insects having these types of mouth parts attack, then infestation cause by these invite the fungal, bacterial and pathogen attack as well. Many of the sucking insects also inject toxins which may induce abnormalities like premature falling of leaves, formation of galls, leaf deformations. The examples of these are aphids, whiteflies, thrips, and various bugs.

2.5.1.2. Indirect effects

They reduce quality of plant products. Many insects are vector of diseases. They are responsible for monetary as well as goodwill losses.

2.5.2. Vertebrate Pests

Mostly the focus is given only on the damage by insect pests but one cannot forget the losses by various vertebrate pests like rodents, birds, weeds, mites, mollusks, and nematodes. These can be pests in many cropping system and situations. They cause damage not only to crops but also to the livestock.

2.5.2.1. Birds

Birds are warm blooded, and their activities are not affected by the high or low temperature. They are destructive for all the time of the year (Bhatnagar 1976). Their flight is more powerful and purposeful as compare to insects. Birds cause the damage by uprooting the seeds, feeding of planted seeds, shattering of seeds, and pecking of flowers. It is also stated that health issues may occur at their roosting and nesting site. They mostly cause damage to germinating cereal crops, ripening oilseed crops like sunflower, peanut and also destroy quality of stored grains. Examples of them include myna, starling, pigeons, sparrows, cockatoos and parrots.

2.5.2.2. Rodents

Rodents are regarded as major vertebrate pest of field crops as they destroy food quality more as compare to consumption. They also eat away large amount of human food and are also responsible for the losses of stored grains. Rodents cause loss in all cereal and grain crops as well as too many fruits and vegetables. There are various kinds of rodents like palm squirrel, house shrew, wild pig or boar, long haired plague rat, house mouse, desert jird, collared pika, but mainly the rodents found in the field crops are lesser bandicoot rat, brown or Norway rat and roof or house rat. These rats uproot large tracts of ground in search of young shoots and roots, make burrows in the field due to which irrigation problems arises. They also affect the quality of stored grainsin bulk and silos by depositing their infected urine and faecal pellets (Harris and Lindblad 1978). Rodents not only reduces crop production but are also responsible for spreading of many diseases as they are carrier of these, the famous example of which is bubonic plague spread by them almost six hundred years ago. They are also responsible for Leptospirosis (a form of jaundice spread by house mouse), rat bite fever and salmonellosis. The public health issue and various sanitation problems may arise if their control is not advised

2.6. Other Kinds of Pests

2.6.1. Mites

They look like insects but they have four pairs of legs and also very minute in size. They belong to the order ACARINA and the class is ARACHNIDA. They are mostly red or yellow in color. They cause the damage to the crop by sucking the sap. The cereal products are mostly infested by Acarussiro (Thind and Clarke 2001).

2.6.2. Weeds

Weeds and many invasive plant species are referred as pest as they can compete and interfere with the planted crop for nutrients which ultimately results in low productivity (Lehoczky and Reisinger 2003). Common weed examples may include chickweed in the wheat field, Jerusalem artichoke often compete with soyabeans, potato and wheat

2.7. Viruses and Diseases

Viruses and diseases are often indebted of creating widespread devastation in the industry of agriculture. Once they establish, they spread very quickly and difficult to eliminate. Examples of recent importance is spongiform encephalopathy epidemic in Britain, also known as mad cow disease, causes degeneration of spinal cord and brain, or in sheep, it is the infection around the mouth. History of the world had seen many traumaticised diseases, spreading of which devastated many nations. Like potato blight in Europe during 19thcentury, engulfed the lives of millions of people and forced the subsequent migration from countries like Russia and Ireland.

2.8. Methods of Crop or Plant Protection

Several methods can be employed for the protection of the crop or plant to enhance the yield and income of the farmer. The most important control strategies are described below.

2.8.1. Natural control

The control which does not depend upon the man, in order to destroy insects, is natural control. This is the kind of control not influenced by human and involves both non-biological and biological factors. From the past one hundred years, this control has been used against invasive species. The climatic factors, parasites, predators, parasitoids, diseases, competition, quality and quantity of available food, space for territory and topographical features keep check and balance on insect population. Natural control is in the hand of nature and man cannot mould these factors for his own advantage (DeBach and Rosen 1991). Natural control has the advantages like it do not have any harmful impact on ecosystem, do not require much expenditure, and have no threat to human health but one also cannot ignore its negative side as this control takes time and one cannot predict its complete impact.

2.8.2. Applied control

The control measures that are used for control lengthen infestation of insect pests, depend upon the human activities and its success. This includes the following kind of measures:

2.8.3. Mechanical control

When various kinds of simple devices, equipments, and various hand on techniques are used for regulating insect pest activity it is known as mechanical control. On the large scale this control measure is ineffective and cannot be undertaken commercially. Various methods are employed for the achievement of mechanical control like:

- Hand picking
- Bagging
- Trapping (chemical and mechanical)
- Physical barriers
- Screening
- Banding
- Shaking and sieving
- Harvesting
- Shredding
- Tillage
- Flooding

2.8.4. Physical Control

These methods aim to retard the development or prevent the spreading of insects and provide immediate control. These are time consuming and laborious but very convincing to the farmers. Physical factors like temperature, humidity and solarisation is manipulated in a way to destroy insect pests. The important physical control measures are low temperature, superheating, light trap, and radiant energy (Banks 1976).

2.8.5. Cultural control

Cultural practices are modifying to reach the goal of required crop production. In this method either cropping system or crop production practices are intentionally altered to lessen the attack of insect pests. The history of cultural control is as old as agriculture and mostly used for the control of disease, nematode, and weed. The effectiveness of this measure depends upon insect pests if they do not spread far or during their life, have complicated food and habitat requirements (Cook et al. 2007). For the utilization of this technique, it is very much necessary that a grower must be aware of environment context of field, yield, production efficiency, soil conservation, natural enemy habitat, and climate. These methods include sanitation, clean culture, destruction of alternate host plants, trap crops, fertilizer management, pruning and thinning, rotation of crops, use of pest free planting stocks, time of sowing, regulation of irrigation, and use of resistant varieties. The availability of economical and effective pesticides, herbicides, fungicides and insecticides has reduced the dependence of a farmer on these methods

2.8.6. Biological Control

By using other living organisms, destruction or suppression of other unwanted insect pests is made (DeBach and Rosen 1991). This control can be achieved either by the introduction of new species into the environment or by increasing the effectiveness of those already present (Way and Khoo 1992). Chinese were the first to use this to control ants in citrus orchards. In 1890, Vedalia beetle was introduced in the citrus groves of California for the control of cottony cushion scale (Caltagirone and Doutt 1989) and in 1925, in Australia; lepidopterous insects were released for the prickly pear cactus. Biological control has many advantages as it does not involve any kind of danger in its application, is economical in the long run, provides long lasting control; when once natural enemy is introduced as most importantly, pest do not develop resistance. Biological control agents include predators, parasitoids and pathogens. The importation, augmentation and conservation are three important types of biological pest control. Most of the predators belongs to the order Coleoptera, Neuroptera, Hymenoptera, Diptera, Odonata and Homoptera Lacewings, ladybird beetle, hoverfly, dragonfly, pirate bugs and entomopathogenic nematode are some of the predator examples, whereas parasitoids include braconid wasps, chalcid wasps, ichneumonidwasps and techinid flies and they belong to the order Hymenoptera, Lepidoptera, Neuroptera, and Strepsiptera. Various microorganisms like bacteria, viruses, entomic pathogenic fungi and protozoa are also used for this purpose (Sandhu et al. 2012).

2.8.7. Reproductive, genetic or autocidal control

One of the effective techniques of controlling insect pests by lowering their reproductive potential is also known as SIT (sterile insect technique). Work on this was started in 1930s by a USDA Entomologist E.F. Knippling and then in 1950sby R. Bushland. SIT is the technique in which population of sterile male is flooded to replace the normal mating, in this way population declines. The main objective is the eradication rather than control. In genetic control, the competition enhances between gametes of mutant and normal insects, which altered the genetic makeup of an insect in such a manner that increases the sterility of progeny, reduces fecundity and reduces the survival in other suitable environments (Weinkove and Leevers 2000). The methods like radiation, chemo sterilization, chromosomal rearrangements, meiotic derive mechanisms and cytoplasmic incompatibility is employed to achieve this control.

2.8.8. Chemical Control- A Miracle in the History

If one looks at history of agriculture, it can be clearly stated that chemical control brought revolution in agriculture and its related branches (Muthomi et al. 2007). It gave the new vision to the farmers who were using their control methods before the chemicals were introduced. Various chemical was synthesized which not only provide immediate control of pests but also enhancesthe yield of crops. To have more food productivity from the less land is the need of the time (Egho 2011). The synthetic chemicals like pesticides, insecticides, fungicides, rodenticides, silvicides, molluscicides, weedicides and herbicides were made, and all these gave a new improved path to the growers (Aktar et al. 2009). Regarding agricultural crops pesticides and insecticides are of prime importance with herbicides at second. Most of the world population is related to the agriculture and have small landholdings. To meet the present food demand, intensification of crop production is necessary through more productivity per unit area (Noor et al. 2012). From the past 2000 years pesticides are in use but now its use has been declining from the past few decades. According to the FAO (1986) pesticides can be defined as,

"Any substance or mixture of substances intended for preventing, destroying, or controlling any pest, including vectors of human or animal disease, unwanted species of plants or animals, causing harm during or otherwise interfering with the production, processing, storage, transport, or marketing of food, agricultural commodities, wood and wood products or animal feedstuffs, or substances that may be administered to animals for the control of insects, arachnids, or other pests in or on their bodies. The term includes substances intended for use as a plant growth regulator, defoliant, desiccant, or agent for thinning fruit or preventing the premature fall of fruit. Also used as substances applied to crops either before or after harvest to protect the commodity from deterioration during storage and transport."

These can be further classified according to the mode of entry, action, toxicity and chemical nature. Insecticide families of prime importance are organ chlorines, organophosphates, carbamate and synthetic pyrethroids. Now bio pesticides have also been in the market, these pesticides are taken from natural materials. Pesticides are used to kill or control the organisms that are harmful. DDT had done magical service for the humanity in controlling malaria, typhus and insect borne human diseases among both civilian and military populations (Othmer 1996). It was developed in 1940s and used against many agricultural pests like codling moth, corn earworm, tobacco bud worms and cotton bollworms. Grapes, potatoes and fruits were prevented from the attack of disease organisms by applying liquid lime sulfur and Bordeaux mixture (Keneth 1992). Many of the new insecticides have been developed with the time according to the peat problem and need of the time. There are many advantages of using these chemicals and because of them even in the 21st century farmers still wanted to have them in their hands like these are very effective against many pest specie in different circumstances, give direct benefits to the receiver, easily availability, low prices, improve human health by limiting outbreaks of diseases, and protection of environment (Drum 1980). Along with the good side of this scientific invention, there is also a bad side, similarly pesticides are serving humanity, but these chemicals are creating harmful impact as well, reducing the beneficial species, residues are left in the food, cause ground water contamination, develope resistance in the pests, have direct impact on human, contamination of soil, air and non-target vegetation and organisms. Approximately 2.5 million tons of pesticides are applied around the world but still more than 40% of the food prior losses due to insect, pathogen and weeds. After the harvesting an additional 20% is lost

2.9. Risks Related to Chemicals Used in Plant Protection

Pesticides brought revolution but at the same also warn the living beings to be careful while using them. Improperly stored chemicals can be highly toxic and can also bring accidental injuries at elevated level of exposure. An estimated 26 million human poisonings, 220,000 fatalities per year takes place around the globe due to pesticide spraying. Following are the hazards related to pesticides or synthetic chemicals:

2.9.1. Impact on human health

In human symptoms of poisoning include nausea, numbness, blur vision, diarrhea, rapid pulse and muscle fatigue. If exposure occurs at low level, symptoms are rash, fever, headache, diarrhea, respiratory problems, and skin allergic reactions, swelling of mucous membrane of eyes, throat, nose and mouth. The long-term health issues may involve acute and chronic injury, cancer, neuromuscular effects, and lung damage, and compromised immune system, reproductive difficulties like infertility or hormonal interference. The deaths and chronic diseases worldwide occur due to pesticide poisoning is 1 million per year. The compounds of OC could pollute the tissues of every life on earth virtually (Hurley 1998). The US National Academy of

Sciences stated that the DDT metabolite DDE causes eggshell thinning and that the bald eagle population in the United States declined primarily because of exposure to DDT and its metabolites (Liroff 2000). That's why in 1972 it was banned in the world.

In India, a study revealed the neurological symptoms (21%) in the workers busy in manufacturing HCH (Nigam et al. 1993). The risk was also involved in praying methomyl, a carbamate insecticide. In the spray men significant changes were noticed in ECG, the serum LDH level, and cholinesterase activities, all these indicate cardio toxic effects of methomyl. The generalized symptoms of poisoning had also been noticed in male workers involved in the manufacturing of dust and liquid formulations of pesticides. A study was conducted in which data was collected from 1,106 couples, where males were engaged in spraying of OP, OC andCarbamte pesticides in cotton field (Rupa et al. 1991). It has also been indicated that the risk of some type of cancer is also high among agricultural workers. In 1976 in Italy SEVESO disaster occurred during the production of 2, 4, 5, an herbicide, concluded that chloracne was the only effect established with certainty because of dioxin formation. In many farmers, diabetes was also found. Various studied has also been conducted that showed increase in the occurrence of cancer gastrointestinal sites and of the lymphatic and hematopoietic tissue. Regarding the health hazards of pesticides, the tragedy of Kerala's people exposure to endosulfan in Kasaragod district is in front of us. In this district alone 31510 liters of endosulfan was sprayed from 1990 to 2000. The toxic residues are still present in the environment affecting the health of more than 9000 people. Remember that daily intake of 0.06 mg per kg of body weight by human could be harmful. The people of this district are still suffering and more than 1000 are living a miserable life. In Kasaragod, the new cases of congenital abnormalities, neurological disorders, abortions and epilepsy have been reported. Most of the pesticides are highly toxic to human beings causing acute or chronic toxicity, juvenile cancer, and endocrine disruption, developmental and have reproductive toxicity. In the developing countries, statistics had revealed that in every hour farmersare dying from pesticides poisoning. More than ten thousand people die and four hundred thousand get sick every year due to these chemicals. It's an alarming situation as there is high risk of chlorosis chance in young seedlings. With the repeated use of insecticides, insects develop the ecological backlash or chemical resistance. About 116 people were affected in Hong Kong in December 1987 due to consuming methamedophos contaminated spinach. When farmer in the countryside of Philippines use Genocholrine pesticides, the death rate among children increases 27 times. A mysterious disease affected 200 people in 40 villages of south India. In 1958 in Kerala, over 100 people lost their lives due parathion contaminated wheat flour (Karunakaran 1958). Pesticides problems also have very direct impact on human health through food residues. A study was conducted in India's 12 states on bovine milk samples from which 82% of 2205 samples were contaminated with the DDT residues. By most of the Indians, average daily intake of HCH and DDT is about 115 and 48 mg per person, respectively (Kannan et al. 1992). Pesticides also threaten the environment by contaminating soil, water, turf, vegetation and threw dramatic effect on the beneficial flora and fauna. Most importantly soil beneficial organisms are declining, according to the soil scientist Dr. Elaine Ingham, "If we lose both bacteria and fungi, then the soil degrades. Overuse of chemical fertilizers and pesticides have effects on the soil organisms that are like human overuse of antibiotics. In Pakistan there is no statistics available regarding the poisoning by pesticides, but claims are there that its effects do prevail. The use of pesticides in Pakistan was started in the early sixties with the green revolution technologies. Before this, pests' population was regulated by other available means or by farming practices. Pesticides used by the farmers provide direct and long-lasting control. A survey was held which concluded that the most dangerous problem in this country is the handling and the storage of pesticides. In Pakistan, 80% of the farmers store spraying chemicals in separate room, 5% in animal, and 1% in sitting room. As the farmer is uneducated only 50% of them followed protective measures during spraying and unfortunately just 19% is getting training on the handling and spraying of synthetic chemicals.

Table 2.3 Toxicity levels of different pesticides

Insecticides	Oral LD_{50} (mg a.i./kg)* (Mammalian)	Discovery/Registration
Nicotine	50-60	1690
Rotenone	132-1500	1840's
Paris green	22	1880's
Lead arsonate	150	1890's
DDT	113	1930's
Carbaryl (Sevin)	246-283	1950's
Chlorpyrifos (Dursban)	96-270	1970's
Cypermethrin (Cymbush)	250	1970's
Imadacloprid (Admire/Merit)	450	1990's
Indoxacarb (Avaunt)	687-1867	2000
Fungicides		
Lime Sulphur	400-500	1800
Copper sulphate	472	1880's
Mercuric chloride	37-100	1860's
Pentachlorophenol	50-500	1930's
Captan	9,000	1940's
Benomyl (Benlate)	>10,000	1960's
Mancozeb (Dithane)	11200	1960's
Chlorothalonil (Bravo)	>10,000	1970's
Vinclozolin (Ronilan)	>16,000	1990's
Herbicides		
Arsenic acid	48-100	1900/1920's
Copper sulphate	472	1890's
2,4-D amine	1492	1940's
Atrazine	1600	1950's
Glyphosate (Roundup)	>5000	1970's
Fenoxaprop-ethyl (Excel)	2565	1980's
Imazethepyr (Pursuit)	>5000	1980's
Nicosulfuron (Accent)	>5000	1990's

Source: Anonymous (2017b)

**The relative toxicity of a pesticide can be measured by its LD_{50}. This is the amount of the active ingredient (ai) of the chemical in milligrams used per kilogram of test animal (usually rats) that kills 50% of the test animals, with a single high dose.*

Many crops are under application of synthetic chemicals like grams, cotton, banana, apple, watermelon and pulses. On cotton alone, about 80%of pesticides are sprayed in respect to total usage in the country, as it is the cash crop of Pakistan and need to be protected. Because of extensive pesticide application on the cotton crop, induced pest resistance development results.

After spraying of chemicals, disposal of remaining pesticides is also a big issue, as most the farmers throw this wastage in fields, lakes or rivers, which became the direct cause of environmental pollution. In 2004, mass killing of fish occurred in Rawal Lake and it was considered that some of the pesticides traders thrown chemical wastage into lake. In the world carcinogenic pesticides have been banned but people in the Indo-Pak region still use them without any government knowing. Although DDT is banned in the world but in1986-1987spraying of banned toxic pesticides increased 10-fold. Remember that harmful effects of the pesticides depend upon the number of factors involving amount of daily intake by the individual, farmer health, and degree of toxicity of the pesticides. Nearly 50% of the pesticides either extremely or highly hazardous are used in Pakistan. Inappropriate usage of these synthetic chemicals results in the contamination of ecosystem and has bad health effects on the small farm animals. Farmer of the world is unaware about the judicious use of pesticides, which resulted in the pest resistance, ultimately posing greater threat to the agricultural industry of the world. Pakistan is an agricultural country, but its share in GDP is 24% because almost 40 to 60% of the crop loss occurs annually. So, it’s need of the time to save this world from contamination by the poisonous chemicals. It is not possible to ban the pesticides immediately as this may result in food shortage, which is not acceptable and suitable with the increasing population of the world.

2.10. Integrated Pest Management - A Pragmatic Finding

The pragmatic and logical approach should be adopted while using pesticides and the activities regarding synthetic chemicals must be based on scientific judgment rather than commercial considerations. The best approach in this case is Integrated Pest Management (IPM), which move the world in a new direction (EPA). IPM is an ecosystem penetrating approach to pest management which uses pooled means of common sense practices.

This technique can be applied to agricultural and non-agricultural practices. Its mechanism laid stress upon the healthy growth of a crop with least disturbance to the ecosystem and by utilizing natural control to protect the plants.

IPM is designed in such a way that it integrates all the biological, physical, mechanical, cultural and chemical control measures that will do less harm to the non-target organisms and remain less harmful to the surroundings. The combination of these measures provides greater effectiveness (Ehler 2006). The main goals or aims of IPM is to increase income or benefits of the farmer, make the environment more healthy and free of contamination, aware a grower to use pesticides judiciously and where it is necessary, and to improve the health of a farmer by limiting exposure to pesticides, as this technique provides safer means of managing insect pests (Alston

2011). Regarding the IPM, its major or key components are identification or recognition of the pest, monitoring, estimating pest number and damage, understanding crop dynamics, providing guidelines about management strategies, preventing pest problems and infestation, helping in selection or making use of all controlled methods as management keys or tools. But these key components can vary according to the site and situation (Kogan 1998). IPM is not adopted by the farmers due to lack of awareness and because of many social and economic norms. The efforts should be there to realize growers about these kinds of new and improved techniques or mechanisms. There is the need of more comprehensive assessment on environment cum health risks, pesticides related health issues, exposure of humans to synthetic chemicals in the developing countries, and accidental pesticides exposure. It is very essential to aware the farmer about the importance of education and to train them to ensure the safe use of pesticides, this factor can play a key role in the implementation of IPM. For the economics to develop sustainability and solid foundation, there is a need to prevent adverse health effects and promote healthy environment among the growers or employees. It is difficult to sum up all this because of limited or confined information as certain ambiguity exists regarding long life exposure of people. So, based on information, knowledge, aptitude and practices specific health programs should be built to lessen the ecosystem destruction and make this world healthy and safe for the next generation.

2.11. Conclusion

The role of synthetic chemicals in the protection of the crop to meet the world’s increasing food demand, the related department like public and private sector as well as the traders involved in this sector must need to review their policies. To protect the crop plants by using pesticides is the need of the time but the negative externalities related to pesticides have also increased in number. In these externalities including damaging impact on marine life, beneficial flora and fauna, increased mortality rate of humans in the developing countries and most importantly, excessive exposure to pesticides are creating severe health issues for the farmers. Despite these devastating effects, today’s farmer is still using pesticides in extreme quantities not even bothering about the increasing cost. Although pesticides provide quick, easy and inexpensive control ofweeds, pests and other unwanted organisms but theses synthetic chemicals are beneficial for those who play around with risk benefit ratio. There is an appreciable difference in the total cost benefit scene regarding pesticides usage between developed and undeveloped countries.

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Chapter 3

Role of Agricultural Mechanization in the Risk Management and Productivity Enhancement

Anjum Munir and Abdul Ghafoor*

Abstract

The replacement of animal and human power with machines in agriculture is termed as mechanization that has transformed the traditional agriculture into modern agriculture. The research has shown that mechanization results in increased crop production by timely sowing and harvesting of crops, effective utilization of the biological, chemical and hydrological inputs, bringing more land under cultivation and enhancing cropping population intensity per unit area. It also makes farm life easier and comfortable and helps to uplift the socio-economic status of the farming community. This mechanization has been fully adopted in developed countries. So far, Pakistan has experienced only selective mechanization, featuring only ease and speed of operations previously done by man or animals. The most popular package consists of a tractor and a tine cultivator for tillage, seed drill for sowing, stationary thresher for threshing of wheat and rice and diesel and electric driven tubewells for the irrigation purpose. Despite the increasing trend of tractors adoptability in Pakistan, the use or implement of machinery has not reached a satisfactory level. In advanced countries, the cost of implement utilization is equal or higher to the tractors cost. However, in Pakistan, it is about 12-15% of the cost of tractors. This deficiency

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is the major factor in the reduction of crop yield. Moreover, the lack of knowledge and information to the farmers about the selection and the use of agricultural machinery is another hindrance in the increase of crop yield. According to FAO, a range of 0.5 to 0.7 hp/acre was considered an optimum power requirement for crop production. Presently, the available power in Pakistan is about 0.58 hp/acre, which shows that farm power has reached its optimum range, however, it is still less than many developed and developing countries like Japan (12.3 hp/ha), USA (2.4 hp/ha), France (3.1 hp/ha), Italy (4.0 hp/ha) and India (2.5 hp/ha). Farm machinery is still needed to be adopted and promoted in the country to transplant/harvest rice, sowing/harvesting sugarcane, harvesting and threshing of maize, picking/harvesting of cotton etc. Moreover, the cropping intensity is also low as compared to many of its neighboring and developed countries. This may be increased by timely sowing and harvesting of different crops. Keeping in view the current status of mechanization, some strategies are proposed to promote full mechanization in the country like increasing agricultural extension services, demonstration of recommended agricultural implements by setting up demonstration plots at union council level, standardized local design and development of different low cost agricultural machinery, establishment of machinery pools at tehsil levels which must be equipped with all kinds of power and agricultural machines at low rents to farmers, promoting media services, devising farmers friendly incentivizing/subsidizing policies by the government.

Keywords: Mechanization, risk management, productivity enhancement, tube wells

3.1. Farm Mechanization

Farm mechanization means replacement of animal and human power with machines; and performing different farming operations by means of different machines. It includes hand tool, animal and tractor drawn equipments, processing equipment and machinery, irrigation equipments or any other farm equipment. The transition from animal power to mechanical power in early twentieth century to operate different farm machines hasrevolutionized the farm production system. Farm mechanization aims to increase crop production by timely sowing/harvesting crops, effective utilization of biological, chemical and hydrological inputs, bringing more land under cultivation and enhancing cropping population intensity per unit area. Farm mechanization is a very vast field covering a whole range of farm equipments and power units which may be divided into two groups, namely: farm power and farm machinery. Though the actual farm operation is performed by using an implement or machine, but it cannot function unless it is powered by some suitable power source whether through animal, tractor or electric motor. Thus, farm machinery and power source are complementary to each other. The two should be properly integrated in any modern farm mechanization strategy.

3.2. Historical Background of Farm Mechanization

The use of mechanical power in Pakistan in the field of agriculture first appeared in the early fifties in the form of private tubewells to tap groundwater for irrigation purposes. The progress of tubewell installation in the fifties, however, was slow despite a full decade (1959-69) of development as their number did not exceed 4200. After 1959-60, the pace of the development of private tubewells gained momentum and the recorded number of tubewells reached to 25,000 by 1964. Following the advent of seed-fertilizer revolution and rapid increase of tubewell inthe subsequent years, introduction of tractors and tractor-tillage implements became inevitable for mid-sixties and onward. Farm mechanization initially encountered bitter opposition of planning and development from bureaucrats, agricultural economists and national and international policy making agencies. The economists and bureaucrats were of the view that the farm machinery would displace farm labor and create unemployment problems. After mid-sixties, the fear of labor displacement proved to be a mere apprehension and tractorization made headway because of following three factors:

a. Firstly, the tubewell technology and seed-fertilizer revolution were to double the labor requirement in agriculture, leading to unprecedented labor shortage during peak seasons.
b. Secondly, the two developments also resulted in a considerable increase in cropping intensities that in other case was unattainable with the use of bullocks for cultivation.
c. Finally, as a consequence of the above developments, bullock’s prices, wages, and opportunity cost of feeding bullocks rose tremendously.

Therefore, this migration created labor shortage in the agriculture sector. With rapid growth of population, the trend of fodder crops changed with the food and fiber crops. It is generally realized among farming community that better crop yield can be achieved through the use of tractor and farm machines. All these factors were sufficient to convince the farmers to adopt the use of tractors and related equipment in order to alleviate power constraint and to keep the costs at a low level. The historical perspective of the tractors in agriculture sector of Pakistan is shown in figure 3.1.

It is important to mention here that despite the increasing trend of the tractors adoptability in Pakistan, the use of implements did not reach a satisfactory level. It is worth proven that farm implements play a very important role in improving agriculture. In advanced countries, the cost of implements utilization is equal or higher to tractors cost. However, in Pakistan, it is about 12-15% of the cost of tractors. This deficiency is the major factor in the reduction of crop yield. Moreover, the lack of knowledge and information to the farmers about the selection and use of agricultural machinery is another hindrance in the increase of crop yield. It is therefore, the prime duty of agricultural extension workers to create awareness among the farming community for the proper selection and use of different farm machines to increase the crop yield.

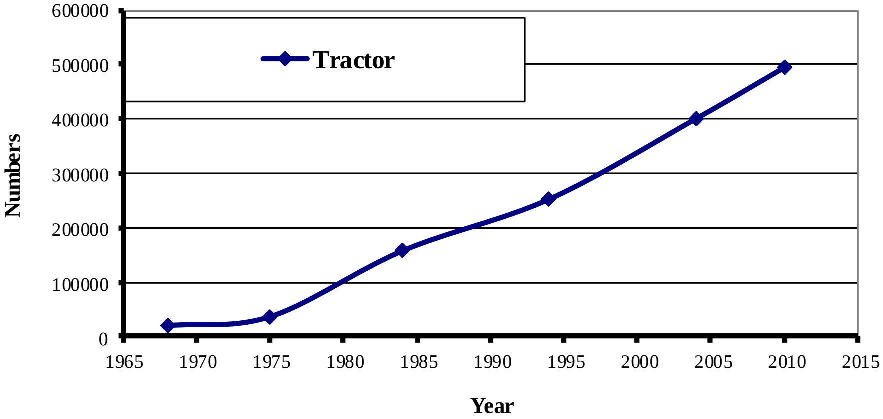

Fig. 3.1 Historical Perspective of Tractors in Agriculture Sector of Pakistan
Source: Census of Agriculture Machinery (2004); Khan et al. (2011)

3.3. Status of Farm Mechanization in Pakistan

The liberal import, local assembly and manufacturing of tractors and farm equipments have now laid a good foundation for farm mechanization in Pakistan but emphasis had always been given to tractors only. So far, Pakistan has experienced only selective mechanization featuring ease and speed of operations previously done by man or animals (bullocks). The most popular package consists of a tractor and a tine cultivator for tillage, seed drill for sowing, stationary threshers for threshing of wheat/rice and diesel/electric driven tubewells for irrigation purpose. To evaluate the factors responsible for crop production, there is need to compile the status of farm mechanization in the country.

Table 3.1 Status and trend of selected implements and farm machinery of Pakistan

Implements / Machinery	Year 1984		Year 1994		Year 2004*		Year 2010	
	Pakistan	Punjab	Pakistan	Punjab	Pakistan	Punjab	Pakistan	Punjab
Cultivator	146863	123755	236272	203444	369866	317506	512067	445276
MB Plow	7319	2780	28413	17980	40050	27093	42477	36937
Disc Harrow	8140	2734	13233	8302	23764	16032	25663	22124
Ridger	4711	4030	10984	10872	71338	66806	192167	173121
Drill	11251	10669	64126	60835	70810	66700	295184	251112
Trolley	98787	81668	176412	145557	242655	195332	286041	248732
Thresher	78377	71195	112707	96655	137270	122737	353768	265546
Reaper	-	-	8073	-	13600	12528	66958	58099
Combine Harvester	-	-	359	-	3355	2899	29344	21369
Chisel Plow	712	-	6535	-	8514	6719	-	-
Rotavator	2101	-	5594	-	47919	44192	210394	196234
Blades	69004	-	164489	-	233126	189965	315423	285645
Sprayers	-	-	20778	-	21756	20976	1438991	1121110
Laser Land Leveler	-	-	-	-	2785	1692	7756	4843

Source: Census of Agriculture Machinery (2004)

In 2004, a survey on the status of farm mechanization was conducted and it was found that the total farms in Pakistan are 6.6 million, out of which 5.7 million (12.5 acre or less) are considered as small farms while 0.9 million are large farms. The status and trend of selected farm machinery in Pakistan during last few decades are shown in table 2.1.

3.4. Prospects of Farm Mechanization

The scope of farm mechanization in Pakistan is quite encouraging as the population of country is increasing very rapidly which would need huge quantity of food and fiber in near future. The main prospects of farm mechanization include: (i) the irrigation water in Pakistan is becoming scarce. For efficient use of existing irrigation supplies and to control salinity, sprinkler and drip irrigation technologies should be adopted and promoted on a large scale as a water conservation technologies, (ii) tubewells should be installed in fresh water zones to supplement scarce irrigation water while in water logged areas, tubewells may be used to control the issues of water table, (iii) mulch tillage, conservation tillage and minimum tillage should be preferred in suitable areas in order to minimize energy consumption, irrigation and drainage requirements, (iv) Pakistan has adopted selective mechanization for few crops. Farm machinery is still needed to be adopted and promoted to transplant/harvest rice, sowing/harvesting sugarcane, harvesting and threshing of maize, picking/harvesting of cotton etc., (v) thousands of acres of agricultural land is still barren due to salinity and sodicity problems. Most of these lands can be brought back to cultivation by breaking up their sodic or hard pan, (vi) the cropping intensity of Pakistan is low as compared to many of its neighboring and developed countries. This may be increased by timely sowing and harvesting of different crops. Combine harvesters should be used for timely harvesting of wheat, rice and other cereal crops, (vii) land leveling has proven to increase the water use efficiency and crop production increases about 15 to 20%. In Pakistan, this is only possible through adoption and promotion of laser land leveling technology and (viii) Pakistan has about 24 million acres of cultivable wasteland. The development of such land is only possible through heavy earth moving machinery.

3.5. Farm Power

Farm power is essential component of modern farm mechanization system. In Pakistan, tractors of various sizes ranging from 50 to 85 horsepower (hp) are working right now. Majority of these tractors falls into the category of 50 hp. According to FAO, a range of 0.5 to 0.7 hp/acre was considered an optimum requirement of power for crop production. Presently, the power available from tractors is approximately 0.58 hp/acre which shows that the farm mechanization has reached its optimum range in the field of farm power. However, it is still less than many developed and developing countries like Japan has 12.3, USA 2.4, France 3.1, Italy 4.0 and India 2.5 hp/ha. The comparison of hp available per ha in Pakistan with other developed countries of the world is shown in figure 2.2. The crop yield in Pakistan is also 2 to 4 times lower than Japan, Europe, Canada, USA, Taiwan, U.A.R, India, etc. due to

i) the improper use of both the tractors and other farm implements/equipments such as plows for seed bed preparation, drills and planter for sowing and planting, sprayers for plant protection, harvesters for harvesting and threshing etc. However, the crop yield in Pakistan is not up to its optimum level because of little and improper use of these farm implements, equipment and machines ii) the human and animal power is not as efficient as tractor and therefore, should not be mixed together in the cropping system iii) farm power in the form of tractors is still not available to all the farmers which resultantly can be seen in delayed agricultural practices, thus reducing the crop yield.

3.5.1. Sources of the Farm power

The farm power is one of the most reliable and useful input source to perform different agricultural practices using machines. For production of agricultural products, the sources of power such as humans, animals and tractors etc. are being utilized. During different farm operations, different working activities required to fulfill these tasks. These activities require a suitable and reliable power source. Power is defined as the rate of doing work and is expressed in horsepower or kilowatt (kW). Apparently, 1 hp is equal to 0.75 kW.

3.5.1.1. Human Power

Human power is still used for performing different tasks on farm. The main tasks performed by human beings include i) preparation of land (ploughing, levelling, formation of bunds and drainage system) ii) sowing and planting activities iii) spraying application for plant protection iv) harvesting and threshing of crops v) transportation of good to the storage structures vi) processing of grains to get by-products.

Now a day, labor shortage is a major problem in many countries. Therefore, in order to perform different agricultural activities well in time, different types of machines have been developed and are in practice on farms. It is worth mentioning here that one man can shift 2 to 3 m^3 soil in a day. In terms of tillage process, it is equivalent to ploughing around 60 m^2 of soil in a day which means that 160 persons are required to plough 1 ha in a day.

3.5.1.2. Animal Power

The production of food and fiber to meet the needs of the population is a basic requirement of any civilization. The application of power in agriculture sector other than human muscles has been a matter of great importance. Animals have been used in agriculture for farming operations well before the recorded history. Egyptians first used the ploughs and animals to perform different agricultural activities. Later on, the people of Indus Valley used such animals for power requirements. They were amongst the pioneer of the agriculture at that time. The most common animals that are used as a source of power are oxen and buffalo. Horses, donkeys, mules and camels are used in many countries for transportation purposes. The main advantages of using animals as a power source are:

i) Multi-purpose (also used for milk and meat production),
ii) Production of fertilizer/manure
iii) No maintenance is required
iv) Lower initial and running cost per hectare.

The main disadvantages of using animals as a source of power include:

i) Limited working hours
ii) Need food and shelter against diseases
iii) High man to power ratio
iv) Animals require training for performing different farm operations.

3.5.1.3. External Combustion Engine

Transition from animal power to mechanical power started early in the twentiethcentury. The first tractor used in agriculture was steam powered. Steam engine was invented in the mid of the 19^{th} century and efforts were made to use it for farming operation. The early steam engines supplied belt power only and had to be transported from one field to another using horses or oxen. It is generally considered that the steam driven tractor was first developed successfully in USA in 1876. The steam tractor was forceful but was quite bulky and cumbersome to use for many operations on the farm. Therefore, the use of the steam driven tractors remained limited until the invention of internal combustion engine. The internal combustion engines were used in the tractor and it has left a remarkable impact in the field of agriculture.

3.5.1.4. Internal combustion engine

Internal combustion (I.C) engine using petrol was invented in the last decade of the 19^{th} century (1889-1900). The earlier I.C engines were bulky and were as cumbersome to use as the steam engines. However, later on, improvements were made and in 1903 gas traction engines were commercially produced. Up to 1906-1907, the word “tractor” became familiar and popular at many places. The use of tractors in Pakistan has reached a satisfactory level while the use of implements is still lacking in the country. In Pakistan, various makes and models of tractor are used to carry different type of agricultural practices. The major makes and model along with their horsepower and manufacturer is shown in table 2.2.

3.6. Scope of Farm Power

Agriculture is a set of different farm practices starting from land preparation to the final harvesting of the crops. To perform all these processes, using implements as a power source is complimentary. Farm power has wide scope in the field of agriculture. The major application of farm power includes: i) use of cultivable waste land ii) to solve water problems iii) timely field operations iv) to address the labor shortage problems v) the electrification of farms vi) increased productivity through farm machines vii) the use of multiple horsepower tractors for different jobs viii) the use of farm implements to increase farm productivity ix) the possibility of better land leveling x) improved weed eradication xi) better plant protection practices. The detailed utilization of farm power for different purposes is discussed in the following section.

Table 3.2 Makes and models of standardized tractors in Pakistan

Make	Model	Horse power	Manufacturer
Massey Ferguson	MF-135	47	Millat Tractors, Pvt.
(MF)	MF-240	50	Ltd., Lahore/UK
	MF-260	60	
	MF-375E	75	
	MF-385	85	
	MF-385S	85 (4WD)	
Ford	3000	42	Allied Tractors, Pvt.
	3600	45	Ltd. Lahore/UK
	3610	52	
	4000	55	
	4600	60	
FIAT	480	55	Al-Ghazi Tractors,
	Ghazi	65	D.G. Khan/Case-New
	640	65	Holland
	640 Special	85	
IMT	533	45	Associated Tractors,
	540	52	Ltd., Lahore
	560	60	/Yugoslavia
Belarus	MTZ-50	50	FECTO Belarus, Ltd.,
	MTZ-60	60	Lahore/USSR
	MTZ-80	80	

Source: Census of Agriculture Machinery (2004)

3.6.1. Use of Cultivable Waste Land

The total cultivable area of Pakistan is around 79.41 million ha. Out of which 23.84 million ha is cultivable. The remaining area can be made available for cultivation by using earth moving machinery which can only be operated using a greater and compact power source.

3.6.2. Water Problems

In agriculture, two types of problems are associated with the use of water in agriculture. Those are (i) excess of water in the soil creates a problem of water logging and (ii) inadequate supply of water in agriculture reduces the crop yield.

These problems can be solved by using a power source e.g. excessive water can be pumped out with the help of tubewells operated with a power source and can be supplied to inadequate water deficient areas, the tubewells will also provide additional water for different agricultural crops.

3.6.3. Timely Operations

Most of agricultural operations are associated with timely operations which otherwise may severely reduce the crop yield. Some of these operations are discussed below:

i. Harvesting and threshing

a) For good quality grains.

b) Time saving for sowing of the next crop.

c) Labor shortage.

Combine harvester and rice trans-planters etc., are the reliable solutions to these problems.

ii. Mechanical rice transplanter

The main objectives of using mechanical transplanter are:

a) Labor shortage.

b) Optimum plant population etc.

c) Conservation of moisture

3.6.4. Labor Shortage Problems

In old ages, farmers were used to co-operate in performing different agricultural practices. During this age of industrialization, large number of workforce has shifted to cities or overseas for employment opportunities which has created a problem of labor shortage in the villages and increased the demand of power source and machines. The increasing labor shortage problem in agriculture has increased the demand of power sources for the following reasons:

- Timely seed bed preparation.
- Timely harvesting of mature crops.
- Timely threshing of different crops e.g. wheat and rice.
- Transportation of inputs required for agriculture from cities to the villages.
- Transportation of agricultural produce from villages to cities.

3.6.5. Electrification of Farms

It is essential to make the farming pleasant. Electrification is done to create the pleasant farming environment. Electrification on farms will also encourage the installation of tubewells.

3.6.6. Increased Productivity through Farm Machinery

In Pakistan, the crop yield is much lower as compared to developing and developed countries of the world. The research has proven that the use of agricultural machinery has resulted increased farm productivity. The right input at right time and right place has produced the concept of precision agriculture which can only be carried out by using precise agricultural machinery. To operate these agricultural machines, reliable and plentiful power sources are needed to fulfill the required job. The use of farm power and agricultural machinery allows performing all the agricultural related activities well in time, thus enhancing the crop production. Unfortunately, the power input available in Pakistan is 0.58 hp/acre while the optimum power input is considered as 1 hp/acre.

3.6.7. Land Levelling

The availability of sufficient and reliable power sources also provides an opportunity to use land leveling equipment. The land leveling has also proven lot of benefits in the field of agriculture. The few of the major benefits for using land leveling equipments include: i) saving of irrigation water, ii) reducing the problem of water logging, iii) efficient use of fertilizers, iv) uniform stand and growth of crops and v) increase in crop yield from 15-25%.

3.6.8. Weed Eradication

Weed eradication is also an important practice in agriculture. The existence of weeds in the crop uses nutrients and produces stress on the plants thus decreasing the crop yield. The timely eradication of weeds brings beneficial results in the crop production. Generally, hand hoe is used for the eradication of weeds. However, in case of larger crops and higher area under crop, it is difficult to eradicate the weeds manually. Therefore, using sweep shovels attached with tool bar or other suitable weed eradication machines can be used for large crops by using mechanical power source. To control the attack of weeds, certain weedicides are also used; however the use of machine for weed eradication is also an attractive option to increase crop production.

3.7. Problems and Constraints in Adoption of Mechanization

There are various problems faced by developing countries in the adoption of full mechanization. The main problems and constraints faced in the adaption of farm mechanization are:

3.7.1. Problem of Land Tenure

The availability of land is an important factor in the production of different agricultural produce. The land tenure refers the owned land in a country by individuals. The prevailing land tenure systems reduce the possibility of agricultural machinery use for farming operations. The landholding has decreased from generation to generations. The increasing population in the country has resulted in various alternatives to utilize agricultural land. The small landholding discourages the use of high cost agricultural machinery to perform different agricultural practices.

3.7.2. Problem of Basic Amenities

The availability of basic amenities in the villages in the form of better education facilities, hospitals, availability of electricity, recreational parks, roads for transportation, job opportunities often leads to the followings:

a) Rural-urban drifts: Migration of the village population to the urban areas to enhance its standard of living, thus causing low attention to agricultural land.
b) Reduction in the work force in rural areas to perform different agricultural tasks well in time.
c) Delayed agricultural operation causes reduction in crop yield.

3.7.3. Financial Problems

Unfortunately, the financial status of rural farming community is not satisfactory which results in following problems:

a) Cannot avail the loan facilities to purchase inputs for agriculture.
b) Cannot afford the high interest rate on the agricultural loans offered from bankers or money lenders.
c) Unable to purchase high cost sophisticated machinery to perform all kinds of agricultural practices.
d) Unable to afford the employment of agricultural specialists due to their higher salaries and wages.
e) Cannot afford the full utilization of costly fertilizers and chemicals for plant protection.

3.7.4. Poor Transportation

The poor transportation facilities and link to the urban areas and industries encourages growingof agricultural produce being transported. The main reasons include:

a) Poor road infrastructure for transportation of good to cities and industries.
b) Lack of proper vehicles and equipment for transportation.
c) Lack of repair and maintenance facilities and absence of good quality spare parts.

d) High cost of transportation to shift the agricultural produce from farm to industries.
e) Involvement of the middleman reduces the profit of farming community thus discouraging the use of high cost agricultural machinery.
f) Spoilage of perishable products due to lack of improper processing and storage facilities at farm level.

3.7.5. Poor Communication

The lack of information about the latest technology is also a major hindrance in the adoption of farm mechanization in rural areas. This includes lack of multimedia facilities in the form of newspaper, radio and television. Most of the farmers are not educated and can not avail the opportunity of newspapers and thus, are unable to understand the introduction to highly technical agricultural machinery.

3.7.6. Problems of Standard Storage and Processing Facilitie

The lack of adequate and reliable storage facilities at farming sites e.g. storage structures, silos, storage bins etc. leads to the following problems:

a) Spoilage of perishable products like pepper, tomato etc.
b) Attack of insects, pests and rodents on different kind of agricultural produce.
c) Quality and quantity loss of agricultural produce due to conventional drying techniques like open sun drying.
d) Reduction in the quality of agricultural produce using conventional non-standard processing facilities.
e) Due to higher cost of common agricultural machinery like thresher, grater, milling, canning and sealing machines, most of the product is not properly processed and handled thus, resulting in huge quality and quantity losses.

3.7.7. Lack of Agricultural Education

It is unfortunate that most of the farming community is not educated and feels difficulties in understanding the technicalities in the field of agriculture. Most of the farmers are very superstitious in their beliefs and are hesitant in the use of new innovations and technologies. On the other hand, their low level of education makes them hesitant to adopt these high cost and modern agricultural machinery due to their nonscientific thinking and mentality. Furthermore, the uncooperative, hostile and un-accommodating behavior of some farmers makes them unwilling to even learn about the efficient use of high cost fertilizers and chemicals used for plant protection and thus reducing the overall farm agricultural productivity.

3.7.8. Poor Extension Activities/Services

In developed countries, the role of agricultural extension workers is remarkable in disseminating recent information and technologies to strengthen the farming community and thus increasing the farm output. Unfortunately, in Pakistan the role of agricultural extension workers is not at par with standard job responsibilities. Extension workers can play a positive and vital role about technology transfer and training of farming community to adopt most efficient and innovative technologies and thus increasing the crop yield. Alternately, the uncooperative behaviors of some farmers discourage the involvement of extension workers for technology transfer in a better way. Moreover, the extension workers are not supplied with proper vehicles and paid with satisfactory remuneration and salaries which decreases their interest in performing their job responsibility with full devotion and dedication. Furthermore, the frequent training of extension workers for latest design and developments of agricultural machinery is also not carried out thus slowing down the technology transfer process.

3.7.9. Poor Tools and Farm Machines

Most of the farmers still use poor quality hand driven tools like hoe, cutlass, sickle, rake, etc. to carry out different agricultural activities instead of using sophisticated mechanized implements like ridges, ploughs, cultivators, drills, harvesters etc.

The use of poor quality hand driven tools result in the wastage of time, farmers health issues, short life span, low crop yield and finally low income generation while on the other hand, the use of mechanized implements result in time saving, easier farm life, considerable increase in crop yield and high income generation.

3.7.10. Unstable Policies and Programs of the Government

The policies and programs developed by the government officials are also not stable. The policies are made on personal choices which resultin heavy losses for the farming community and thus affecting the economy of the country. The trend of the government toward farmer's friendly policies is lacking and thus severely affecting the agricultural status of the country. Most of the farmers cannot afford high cost agricultural machinery. Thus, it is the responsibility of the government to provide subsidies to the farmers to purchase this high cost agricultural machinery. Furthermore, the government should establish community center/machinery pool in the each tehsil of the district, so that farmers can afford high cost machinery at low rents.

3.7.11. Poor Marketing System

The strong marketing system in the field of agricultural plays a vital role in strengthening the farmer's status and economy of the country. The poor marketing system results in:

a) The involvement of the middleman who collects the agricultural produce and stores them thus creating the artificial scarcity and earns extra profit. The quality of food and crops gets lost due to late supply in the market.

b) The market prices cannot be controlled thus affecting the prices of the commodities in the society which creates disturbance among the common people.

3.7.12. Sociological and Psychological Attitude towards Farming

Following are the reasons for sociological and psychological attitude towards farming:

a) The young generations and educated community have associated farming with dropouts and profession of poor people and feel that they have nothing to do well in the society.
b) Farmers are considered from the low class and are not given the status of a respectable society member like doctors, engineers, lawyers etc. thus reducing the interest of people in agriculture and use of machines.
c) Even the community with landholding and residing in villages seeks white collar jobs where it can uplift its social status.

3.8. Farm Mechanization Strategies

The following strategies are proposed for adaption of full mechanization in the country:

- The Agricultural extension department of different provinces can render a great help in introducing the different agricultural implements/machines other than commonly used manual and conventional agricultural tools. This can be accomplished by appointing assistant engineers/scientists at the tehsil level like agricultural engineer, agronomists, soil scientists, plant protection officers etc. in order to popularize the recommended machinery to perform different agricultural practices.
- The provincial agricultural engineering departments should corporate to demonstrate the recommended agricultural implements by setting up demonstration plots at union council level. This would help the farmers in appreciating the use and benefits of recommended agricultural machinery and consequently adopt them without any hesitance.
- The standardized local design and development of different low cost agricultural machinery should be made available and encouraged.
- The machinery pools should be established at the tehsil levels and it must be equipped with all kinds of power and agricultural machines at lower rents to farmers.
- Farmers may be advised to select and purchase selective machinery by alternate farmers and then exchange them to mechanize their farms economically.
- Media should play their positive role to promote mechanization through popular talks, talk shows with agricultural specialists, and programs on demonstration of different type of machine under actual field conditions.

- The government should announce subsidies to attract the farming community to adopt and promote mechanization.
- The private sector should be encouraged to establish agri. machinery workshops at the each tehsil of the district and providing the necessary machines to the farmers at lower rents.
- Pakistan Agricultural Machinery and Implements Manufacturers Association (PAMIMA) need to be encouraged to play its due role of upgrading manufacturer’s premises facilities, creating their own R&D and producing quality products at competitive prices to meet WTO challenges.
- Use of renewable energy sources e.g. biogas and biomass should be promoted at farms to decrease the cost of operation. For this purpose, biogas operated tubewells using 25 m^3 and 40 m^3 floating drum or fixed dome biogas plants can be installed to operate 0.75 cusec tubewell. Similarly, the solar energy can be used for drying for fruits, vegetables, medicinal plants and cereal crops by using hybrid solar dryers. Biomass gasification units can be installed for engine operation for farm electrification.

3.9. Conclusion

Mechanization aims to increase crop yield due to timely sowing/harvesting crops, effective utilization of biological, chemical and hydrological inputs, bringing more land under cultivation and enhancing cropping population intensity per unit area. The concept of farm mechanization was introduced in Pakistan in mid-fifties, but encountered opposition from stakeholders which delayed the adoption of mechanization in Pakistan. However, the increasing population results in higher demand of food and fibrous crops. Furthermore, it was realized that mechanization increases the crop production. These factors were sufficient to convince the farmers to adopt the use of tractors and related equipment in order to alleviate power constraint and to keep costs at a low level. However, the adoption of mechanization in Pakistan was slower due to higher initial cost of machines, mismatch of agricultural machinery with farm size, lack of technical knowledge and repair facilities, lack of agricultural education, poor extension activities, lack of poor machinery manufacturing facilities, lack of unstable policies and programs of government etc. Pakistan has adopted selective mechanization for few crops. Farm machinery is still needed to be adopted and promoted to transplant/harvest rice, sowing/harvesting sugarcane, harvesting and threshing of maize, picking/harvesting of cotton etc. Similarly, thousands acres of agricultural land have still barren due to salinity and sodicity problems. Much of effort is needed to convert it into cultivated land and increasing the cropping intensity. Due to increasing population and decreasing labor intensity, it is dire need of the time to develop farmer friendly strategies to promote full mechanization in the country. For this purpose, agricultural extension services should be improved, developing demonstration plots at farmers locations, standardization of local design and development of different low cost agricultural machinery, establishment of machinery pools at the tehsil levels equipped with all kinds of power and agricultural machines at lower rents, promoting cooperative farming, media should be involved to promote mechanization through popular talks, talk shows with agricultural specialists, and programs on demonstration of different types of machine under actual field conditions, incentivizing the farming community to adopt and promote mechanization, arranging awareness workshops and seminars about the latest technologies, use of renewable energy technologies. viz. solar energy for drying for fruits, vegetables, medicinal plants and cereal crops by using hybrid solar dryers, biogas plants and gasification units for tubewell operation and power related farm activities. The full scale mechanization will play a vital role in increasing plant population, crop productivity and increasing the socio-economic status of the farming community.

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Chapter 4

Agricultural Risks under Climate Change

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Abstract

Agriculture is the only source to feed the mounting population of world but agriculture is at knife edge because of persisting climate change. Climate change is transmuting ecosystem of planet and threatening the well-being of not only current generation but of future generations as well. Increase in temperature above 2°C in global temperature will pose unprecedented threats in future as well. Already natural resources are depleting and agricultural productivities are lowering because of unusual behavior of climate change globally. Mounting incidences of floods, droughts and earthquakes are pertinent to varying climate changes and likelihood is higher in coming years. For the survival of future generations, it is essential to keep agriculture protected from climate changes. To hold global temperature below 2°C and avoid evil of climate change, it is urgent to control global emissions. On the other hand, adaptive capacities of farmers are urgently required to be strengthened enabling them to tackle climate change. Aforestation, awareness and motivational campaigns, research on compensatory growth of crops, development of heat tolerant

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varieties can be the possible solutions through collection actions of research, extension and concerned governmental sectors.

Keywords: Climate change, catastrophes, floods, mitigation, awareness, insurance,

4.1. Introduction

Global existing population will increase by one-third in 2050. Most of these additional 2 billion people will reside in developing societies. Similarly, more people will also be living in urban areas. That means, we need more food to feed the increasing mouths, in spite, natural resources are squeezing, present income and growth rate is insufficient to feed such enormous population. Extended agricultural productivity will also provide basis for the economic growth and poverty reduction. But, unfortunately, the unpredictable climate change is in middle to tear the efforts. Agriculture is one of the leading areas under devastations of climate changes.

Climate change is one of the leading threats to global communities because of increasing likelihoods of natural catastrophes. Generally, climate change is the variations in climate but scientifically climate change is the process of transformation which is endorsed directly or indirectly by human activities changing the symphony of the global atmosphere. According to the Inter-Governmental Panel on Climate Change (2007), climate change is identified by changes in the mean and the variability of its properties and its persistence for an extended period, typically decades or longer. In addition, it also refers to natural climatic variability observed over analogous time periods (United Nations Framework Convention on Climate Change 1992). Climate change has been seen as one of the complex and challenging environmental problems facing the world today (Ojwang et al. 2010). Therefore, climate change is top burning issue around the globe as several problems and conflicts are associated with the climatic variability hindering the global efforts to secure development among resource poor's.

Horizon of climate changes is pertinent to some causes like the gap between potential impacts of climate changes and poor adaptive capacities nationwide. Developing countries are on knife edge to the devastations of climate changes; may be subjected to the gap between potentiality of climate change and sluggish adaptive capacities. On contrary, potential of impacts of climate changes is wider holding tendency to grasp not only developing nations but also to developed nations though they have sufficient resources to tackle the cause. Climate changes may pose devastations to many important sectors like farming, livestock, fisheries etc. and on various places these damages have been observed and documented for the future course of actions.

4.2. Climate Change and Agriculture

Agriculture is stated as most risky business and at present climate change is the major threat to lower the productivity. FAO (2013) highlighted adverse impacts on agriculture and Tetteh et al. (2014) revealed that impacts of climate change on crop production may vary region to region and area to area and farmers to farmers i.e. small farmers in particular who are depending upon rain-fed agriculture somewhere and lacking sufficient adaptive capacities. These small resource poor dwellers are the most vulnerable and disadvantaged groups. Therefore, climate change and agriculture is hot topic today having tendency to reduce agricultural productivity and enhance food insecurity through erratic rainfall and mounting temperature. According to the Gerber et al. (2013), increased atmospheric CO_2 concentrations can have a direct effect on the growth rate of crop plants and weeds. Furthermore, CO_2-induced changes of climate may alter levels and variability of temperature, rainfall and sunlight that can influence plant productivity. Oram (1989) stated that agriculture is one of the most weather-dependent of human activities. Generally, it can be concluded that agriculture is climate susceptible and any alterations in climate may turn the capacities of growers down. Not only the potential may face a decline but crops production may also exhibit erratic ups and downs. For example, in coming couple of years, cotton production scenario around the world will be altering. It is anticipated that China will be no longer major producer of the cotton by the end of 2017 though China is ruling as largest producer since 1982. India is expected to replace China as leading producer. Climate change is causing considerable changes in the hydrological cycle producing the likelihood of more natural disasters in future pressurizing the agricultural sector in particular.

4.3. Impacts of Climate Change on Agriculture

Agriculture is one of the prime contributors of development for any nation worldwide. Livelihood of the billions of people around the corner of the world is dependent upon agriculture. Being source of national income, employment and contribution to poverty reduction and food security are multiple benefits of agriculture. Agriculture owns extended productivity potential which has been attained for the fulfillment of dietary needs. Though, obtained productivity is lower than the potential among some of the leading as well as deprived agricultural economies. Various impediments including climate change are major cause of sluggishness and decline. Erraticness of climate change has raised immense farming problems especially affecting the crops' life duration because of shorting or increase of day light.

Rainfall variability has significantly impacted on crop farmers and pastoralists who rely mostly on rainfall for crops and livestock production (Admassie et al. 2006; Deressa et al. 2008; Allamano et al. 2010). Livestock farmers who do not own grazing land, female headed households and households with low level of education who do not have assets are the most affected people by climate change and rainfall variability (Lemos et al. 2002). Rainfall, among other factors has always dictated how land is used (Kori et al. 2012). According to IPCC (2007), climate change and rainfall variability has led to significant reduction in land under crops and pasture affecting crop and livestock productivity. Livestock production is the main source of food for the arid and semi-arid communities in Sub-Saharan Africa. It is mainly rain-fed and exposed to high seasonal rainfall variability (Ogen 2007; Niggol and Mendelsohn 2008; Alvaro et al. 2009).

Climate and rainfall variability affects the production and productivity of the agricultural sector by increasing pests and crop diseases, aggravating lack of land under pasture and water sources (Admassie et al. 2006; Yesuf et al. 2008; Zoellick 2009). The effects are exacerbated by lack of access and use of seasonal climate forecasts, poor health, undernourished population, high population pressure and lack of institutional capacity to adaptation. The impact of rainfall on crop and livestock production can be related to its total seasonal amount or its intra-seasonal distribution (Bewket 2009). In a study, carried out in Middle Belt of Nigeria Ayanlade et al. (2009), indicates that annual rainfall variability has considerable effects on crop and livestock produce. Rainfall has been regarded as the most significant climate parameter affecting pastoralists' activities (Vogel 2000) and its variability has significantly reduced land under pasture affecting production. Due to drought episodes, the number, distribution and productivity of permanent pastures and water points are likely to decline (Mkutu 2001; Mureithi and Opiyo 2010). Behnke and Scones (1993) observed that pasture availability is largely determined by rainfall and not grazing, directly impacting on ultimate livestock production in areas affected by drought. Drought induced displacement is shaped by grazing land, pastoralists ability to access it, herd sizes and composition, livestock marketing strategies, remittance flows, market prices and the scale and type of humanitarian interventions (Ginnetti and Franck 2014).

Climate change has impacted on livestock water points influencing livestock productivity (Kaur et al. 2010). Climate variability has led to reduced water sources especially in semi-arid areas leading to high demand for the scarce resource and conflicts among the pastoralist community (Agwata 2006). It also poses a lot of challenges in water management practices that can guarantee sustainability (Kundezewicz et al. 2008). Chao and Peiwang (2005) identified a number of challenges to water resources in many countries. These include: increasing and competing water demands; uncertainty caused by unpredictable climates; co-ordination of trans-boundary water resource management; water shortages in arid andsemi-arid areas and absence of proper management of water resources.

The small farmers' production in the Kenya is partly attributed to climate change impacts (Davis and Place 2003). For instance, it has been stated that erratic nature of rainfall and temperature are affecting the cocoa crop in the country and also affecting the traditional farming setup. Likewise, several other developing and developed countries are at stake in context of climate change. Ghana is of no exception and facing disastrous impacts of climate variability. Impacts are also anticipated to be worsening in the near future. Environmental Protection Agency (EPA) had reported varying minimum and maximum temperatures in all the ecological zones of Ghana. Report further depicted that in 2006, mean year temperature ranged from 26.4ºC (Forest)-28.6ºC (Sudan savanna). Report also presented the change in total rainfall in various ecological zones falling from 1.1 to 20.5% for 2020 to 2080; this will devastatingly reduce the agricultural productivity. Study particularly depicted the decline of production in root and tuber crops by 40% by 2080 (EPA 2007). The climate change will affect agricultural productivity and as well as agricultural prices, trade and food self-sufficiency (Wang et al. 2010).

Wang et al. (2013) assessed the impacts of climate change and quoted that average impact of increased temperature on net revenue of crop is negatively associated. However, it holds options of being partially offset through income generation in result of anticipated rainfall increase. It may be said that this anticipation is also erratic having least probability because climate change probability is at extreme at that time. Impacts of climate change are diversified having no boundaries. World Bank (2000) was of the view that climate change is more significant towards dry land regions particularly, two-thirds of the African continent comprising approximately 50 million people. Similar prediction was presented by Slater et al. (2007) that by the end of 21st century climate change will have considerable impacts on farming outlet especially in rain fed agriculture setup like in Sub Saharan Africa. Musemwa et al. (2012) documented that globally average increase in high temperature and low precipitation has been observed along with droughts and shortage of surface and ground water as well. Consequences of varying climate are mounting particularly in developing societies due to their limited resources, unstable farming infrastructure and lower adaptive capacity of farming identities. Potential harms of climate change are not limited to developing countries even Australia is suffering from yield fluctuations in the crop production from past years (Lajos 2012).

Extended temperature has been observed in Asia and Pacific regions. In these regions, agriculture sector is declared as more vulnerable excreting 37% of the global emissions from agriculture production. Countries most vulnerable to climate change include Bhutan, Indonesia, Pakistan, Papua New Guinea, Sri Lanka, Thailand, Timor-Leste, Uzbekistan, and Vietnam (ADB 2009). Considering the severity, climatic situation and impacts are analyzed in single table for comprehension and comparison.

Almost in entire Asia, most of the countries rely on farming for their livelihood and national economy uplift but climate change is posting question mark on that development.

4.4. Climate Change Variables (Temperature & Rainfall) and Risks

Temperature and rainfall are the prominent variables of climate change. In forthcoming decades, climate change impacts are likely to be felt due to greater climate variability, increased intensity of extreme events along with their frequency and variation in average climate conditions. It is believed that temperature and rainfall holds combined effects on crop productivity. Global warming and climate change are detrimental to production of wheat and maize in particularly in mid-latitude core cropping regions. About 4-5% yield reduction can be occurred with no change in precipitation and slight warming (+1°C); and a warming of 2°C might cause reduction of average yield by about 7-10%. In addition, reduction in precipitation can also cause reduction of average yield in case of wheat and maize especially in core areas. While combined effects of increased temperature and reduced precipitation can lower average yields by over a fifth. Recently, KImengsi and Tosam (2013) indicated that variability of rainfall and temperature affects the sprouting and growth of the cocoa tree and production of cocoa pods. This variation also has promoted the magnitude of insects' pests and diseases having negative influence on cocoa crop. Likewise, in England, increasing trends in temperature values may lead to condition where crops will be smothered due to excessive heat thereby reducing food production in the state (Emaziye et al. 2012). Crops respond to climate change in positive or negative manner showing increase or decrease in productivity. In cold regions, very near temperature may increase, even as much as the 7 to 9°C indicated for high latitudes under a doubling of CO_2, can be expected to enhance yields of cereal crops. For example, near the current northern limit of spring-wheat production in the European region of Russia, yield increased by about 3%/°C, assuming that there is no concurrent change in rainfall. In Finland, the marketable yield of barley increases by 3 to 5%°/C (Kettunen et al. 1988).

Monteith (1981) was of the view that temperature more often determines the potential length of the different crops growing seasons with significant effect on the timing of the development processes and on the efficiency of solar radiation used to develop biomass. As mentioned above, development process is highly associated with temperature. Development process doesn't initiate until temperature exceeds to threshold; while at optimum, temperature development increase broadly, however above optimum it decreases broadly linearly (Squire and Unsworth 1988). This type of temperature influence has also been reported in Pakistan during cotton season 2013. Increased night temperature caused severe flowers shedding and promoted the insects, pests attack on major crops. Earth is becoming warmer with the passage of time. According to report of FAO (2007), average global temperature has been increased in lie with precipitation increases since 1850 just because of accumulation of greenhouse gases in atmosphere. For instance, in Central England, temperature has been increased about 1°C since the 1970s and it is likely that human activity has significant contribution to this increase (Emaziye et al. 2012). As population of the world is increasing at pace as projection is to reach 9billion by 2050 which means more food is required to feed such an enormous population. If climate change persisted to decrease the productivity, then consequences will be more adverse. In addition, climate change is also posing serious threats of natural disasters and risks injurious to agriculture. This is also injurious to the rural households in context of poverty and food insecurity. Schmidhuber and Tubiello (2007) argued that higher rainfall variability and more severe droughts in semi-arid Africa, particularly, will hinder efforts to boost food security and combat malnourishment.

Table 4.1 Summary of Impacts Associated with Changing in Climate Variables

Climatic variables	Impacts
Higher Mean temperatures	Increased evaporation and decreased water balance Increased severity of droughts Reduced alpine winter snow cover Reduced range of alpine ecosystem and species Increased stress to coral reefs
Higher maximum temperatures, more hot days and more heat waves	Increased incidence of death and serious illness particularly in older age groups Increased heat stress in livestock and wildlife Increased risk of damage to some crops Increased forest fire danger (frequency and intensity) Increased electric cooling demand and reduced energy supply reliability
Higher minimum temperatures, fewer cold days and frost days	Decreased cold-related human morbidity and mortality Decreased risk of damage to some crops and increased risk to others Extended range and activity of some pest and diseases vectors Reduced heating energy demand
Decrease in precipitation	Decrease average runoff, stream flow Decreased water quality Decreased water resources Decreased in hydro-power potential Impacts on rivers and wetland ecosystems
Increased severity of drought	Decreased crop yields and rangeland productivity Increased damage to foundations caused by ground shrinkage Increased forest fire danger
Decreased relative humidity	Increased forest fire danger Increased comfort of living conditions at high temperatures
More intense rain	Increased flood, landslide and mudslide damage Increased flood runoff Increased soil erosion Increased pressure on disaster relief systems
Increased intensity of cyclones and storms	Increased risk to human lives and health Increased storm surge leading to coastal flooding, coastal erosion and damage to coastal infrastructure Increased damage to coastal ecosystems
Increased mean sea level	Salt water intrusion into ground water and coastal wetlands Increased coastal flooding (particularly when combined with storm surge)

Climate change is posing direct and indirect risks for agriculture. Potential direct impacts of rising temperature create variation in precipitation frequency and intensity on crop growth. Increase in temperature alone results in reduced food production in upcoming decade already surrounded by food security issues. Temperature rise combined with variation in change, magnitude and precipitation distribution is supposed to enhance moisture and heat stress on crop and livestock. World Bank further highlighted the indirect risks pertinent to climate change like increased risks of soil erosion, runoff and land sliding; reduced river flows particularly in dry seasons due to stunted glacier runoff and enhanced crop production losses due to insect pest and diseases outbreak. IPCC (2007) projected that climate change impacts will apparent most likely in the form of floods, droughts, wind storms and increased atmospheric temperature. Impacts are anticipated to associate with more than one variable might be derived from some other impacts.

4.5. Climate Change and Natural Hazards

4.5.1. Flooding

The geographical scope of the floods of June and July 2007 and the physical and economic damage they caused, were on a scale not seen for sixty years. What made the floods particularly unusual was that about two-third of the flooding was caused by surface water, often after intense rainfall overwhelmed drainage systems.

Flash Flood of 2010 in Pakistan was the result of intensive monsoon rainfalls and cost loss of millions damaging standing crops and orchards in particular. During the 2009/2010 agricultural season, floods and cyclones damaged substantial areas of agricultural production in southern and central Mozambique, resulting in loss of livestock, livestock infrastructure and crops needed in livestock production (FAO 2000).

In 1997/98, Kenya was affected by El Niño event which resulted in severe floods after major rivers in the country attained record peaks (Gadain et al. 2006). The event resulted in huge loss of livestock and the destruction of large crop fields thus destroying livelihoods. With the passage of time intensity of floods had been seen increasing as clearly highlighted in the figure below.

Given recent experience, drought is the most glaring natural hazard in Afghanistan, but local flooding is also common, as are sand storms and other hazards. Earthquakes may have a major indirect impact on agriculture, since they affect migration patterns. After the earthquake in Bam, Iran, a large number of Afghan refugees returned from Iran.

4.5.2. Drought

Drought risk assessment framework utilizes the historical climate and yield data to characterize and quantify the impact of drought (Wilhelmi et al. 2002). Data collected provides useful information in the decision making concerning the drought disaster prevention and agricultural sustainable development planning. Studies indicate that one of the key interlinked challenges for agricultural production (Stringer et al. 2007) is drought. Farmers across the world have adapted the timing of ploughing and planting accordingly to minimize the threat to their livelihoods. Pastoralists have also responded by adapting various coping strategies to minimize loss. Following the Sahelian droughts of 1970s, its occurrence and effects have been studied as part of international response to the environmental emergency. The study provides framework through which future and further studies on drought related issues can be undertaken. Drought study findings suggest that intervention strategies should be away from expensive and unsuccessful interventions towards more considered schemes targeted at boosting local capacity (Batterbury 1998; Batterbury and warren 2001).

Short and long-term impacts of drought and degradation are greatest in region that are poor (Batterbury and warren 2001). The Sahelian drought is considered as the most dramatic example of climate change that has been quantitatively measured across the world. The main challenge is that climatologists have failed to predict the extent of the crisis. Despite continuous improvements in modeling techniques, there is still inability to accurately predict the onset of a future drought or its impacts (Batterbury and warren 2001), and there is need for more studies on drought issues with local focus. According to Wilhite (1990), effects of drought are dependent not only on the duration, intensity and areas affected by drought episode and water supplies but also on the level of economic development in a given country. Therefore, consequences of identical droughts may differ between regions. Due to drought episodes, the number, distribution and productivity of permanent pastures and water points are likely to decline (Mureithi and Opiyo 2010; Mkutu 2001). Behnke and Scones (1993) observed that pasture availability is largely determined by rainfall and not grazing, directly impacting on ultimate livestock production in areas affected by drought. Drought induced displacement is shaped by grazing land, pastoralists ability to access it, herd sizes and composition, livestock marketing strategies, remittance flows, market prices and the scale and type of humanitarian interventions (Ginnetti and Franck 2014).

A country's plans to convert rangelands to arable land risk reducing pasture and impacting pastoralist displacement trends. A point at hand is the Government of Kenya's plan to convert 1.2 million hectares of its arid and semi-arid lands to irrigated agriculture with possible effects on pastoralists' ability to access traditional grazing lands. Reduction in pastureland reduces the amount of grass fodder for the livestock leading to higher death rates and smaller overall herd, situation likely to be magnified through following drought events. Increasing severity of droughts leads to decreased water resource quantity and quality and decreased productivity (Vera et al. 2009). The major aspects of drought that increase or decrease its adverse effects are the frequency, severity and the spatial extent.

4.6. Conclusion

Climate change has become most threatening phenomena globally. Developing as well as developed countries are vulnerable to climate changes and with the passage of time vulnerabilities will increase. Agriculture is the key source to fee the people around the corner of world. Already population pressure is demanding more food to feed. On contrary, efforts are still partially successful in increasing the vertical growth of agriculture in the presence of shrinking natural resources like soil and water. In addition, climate change is affecting the productivities badly. Natural catastrophes like floods, droughts and earthquakes are increasing with the passage of time affecting agricultural production. Erratic weather patterns are altering cropping patterns. On other hand, farming stakeholders including farmers are not fully aware of climate change; thus not capable to tackle the magnitude of devastations. Climate change cannot be controlled but still there are options of mitigation with some feasible strategies like enhancing adaptive capacities of farmers mainly dependent upon resources, capacity building, financial stability and enough awareness. These capacities vary from region to region and country to country naturally. Therefore, resultantly no one can predict that which country is more vulnerable or which country will be more vulnerable. Therefore, collective actions in research, extension and all concerned quarters is required to build research to develop varieties according to climate change and dissemination of awareness like early warning systems and government interventions for growers like crop insurances.

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Chapter 5

Livestock Related Threats

Qamar Bilal and M. Iqbal Zafar*

Abstract

It is fact that the livestock sector is playing a leading role in national economy and food security. Its contribution in total agricultural value is higher than crop sector. There is need of hour to boost livestock productivity to meet the increasing demand of our public for milk and meat. Currently, we are facing a shortage of quality milk and meat. God has gifted us a lot of valuable resources in the form of animals, land and personals. The judicious use of these resources can lead to white revolution in Pakistan. We are harvesting only 50% potential of animal and rest is not being exploited mainly due to underfeeding and traditional mindset. Raising livestock on traditional way is a threat to food security and friendly environment. This chapter covers very important aspects of the livestock sector, including the leading factor of low productivity and measures to boost productivity. Readers will also get information about livestock pollution, its contribution to global warming and threats to human and aquatic life, along with strategies to reduce it.

Keywords: Livestock, threat, production, pollution, food security.

5.1. Current Situation of Livestock Sector

Livestock is an important sector of agriculture in Pakistan and is playing a leading role in the national economy by contributing 56.3% in total agricultural value and 11.8 percent of GDP. About 30-35 million rural population is engaged in livestock rearing, having 2-3 cattle/buffaloes and 5-6 sheep/goat per family, that help the

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people derive 30-40 percent of their income from it. The value of livestock in Gross National Product (GNP) at current factor cost is worth Rs.801.3 billion, indicating an increase of 3.0 percent (Govt. of Pakistan 2015)

Pakistani people have inherited traditions of rearing dairy animals and livestock production, and it has remained a complementary activity to crop production. Dairy animals have had a central position in livestock farming and rural people used to consider it a taboo to sell milk and milk products. Now, the supply and demand situation has encouraged enterprising farmers to sell milk to the city dwellers, and the concept of taboo has gradually diminished almost to the point of vanishing. There are so many families in Pakistan that totally depend on the sale of milk/milk products for their needs. Dairy animals are also being used for producing draught and beef purpose. When a dairy animal becomes unfit/ uneconomical for milk production or draught purpose, then it is sold to butchers. As a food group, all milk (both milk and milk equivalents) is second only to cereals in the level of per capita consumption. By weight, all milk makes up nearly one third of all food consumed.

During the last year, livestock produced about 15 million hides, 53 million skins, 44000 tons wool, 25000 ton hair, 64000 ton blood, 827000 ton bones and 26300 ton fat. These livestock products are valuable and play a key role in increasing the per capita income. However, by improving the quality of products and providing the export opportunity, a significant increase in GDP and GNP share is possible. It is a fact that livestock is an important sector of agriculture. In Pakistan, livestock sector can be used as engine for food security, economic growth, poverty alleviation and uplift of rural socioeconomic.

Table 5.1 Livestock population in Pakistan (million)

Years	Cattle	Buffalo	Sheep	Goat	Camels	Horses	Asses	Mules
2009-10	34.3	30.8	27.8	59.9	1.0	0.4	4.6	0.2
2010-11	35.6	31.7	28.1	61.5	1.0	0.4	4.7	0.2
2011-12	36.9	32.7	28.4	63.1	1.0	0.4	4.8	0.2
2012-13	38.3	33.7	28.8	64.9	1.0	0.4	4.9	0.2
2013-14	39.7	34.6	29.1	66.6	1.0	0.4	4.9	0.2
2014-15	41.2	35.6	29.4	68.4	1.0	0.4	5.0	0.2
% increase	20.1	15.58	5.75	14.19	0	0	0.69	0

Source: Govt. of Pakistan (2015)

The milk is consumed as fresh, boiled, powdered and processed milk, and as yogurt, ghee, lassi, butter, cheese, ice cream, and sweetmeats and in other confectioneries. About half of the total milk produced is consumed as fresh or boiled milk; about one fourth as ghee; and one sixth as yogurt or curd. The average consumer spends, on the average, one fourth of his food budget on milk and/or milk products, indicating that even with low average national income levels, the consumers can go for spending if product diversification is suitably introduced matching their national attitude. Rapid urbanization and rising per capita income levels do affect, yet other parameters are also projecting the increase in the demand for milk and milk products in cities.

Milk plays a tremendous role in building a healthy society. Most people like milk, especially for its flavor, which is enjoyed. In addition, milk can be easily flavored with many flavoring materials and can be made palatable very readily for those who do not like it in its natural flavor. Milk is highly digestible as compared to other foods. In fact, it is possible for certain individuals to utilize as much as 98 percent of milk protein and 99 percent of the carbohydrates and fats contained in it. The digestibility of milk protein is 90 to 100 percent, but that of cereals /fruits/vegetables and legumes is 80 to 90 percent and 70 to 80 percent, respectively.

The dairy sector in Pakistan plays a significant role in its national economy. It is estimated that every third household in the country supports a milk animal and the average herd size is about three.

The annual milk production exceeded 50 million tones, making Pakistan the fourth largest milk producing country in the world. However, Pakistan ranks 2nd in buffalo milk production and 17th in cow milk production at world level. It has been estimated that about 60 percent of the calories are met from milk and its products. Milk's economic importance could be well understood considering that the value of milk procured annually in the country is alone more than the total annual value of wheat and cotton and twice than that of sugarcane and rice together. About 55 million landless/small land holding farmers are responsible for the bulk of milk produced in the country. About 93% of these farmers have an average herd size of 4 milch animals and milk remains to be the mainstay of their household income. However, despite having great value, the milk production is the least commercialized enterprise in the agricultural economy. Nevertheless, milk and milk products enjoy higher status of single largest commodity of the agricultural sector, having a worth of rupees 160 billion per annum.

Table 5.2 Milk and meat available for consumption (million tons)

Years	Total Milk	Cow milk	Buffalo milk	Sheep milk	Goat milk	Camel milk	Meat	Beef	Mutton	Poultry
2009-10	36.29	12.43	22.27	0.036	0.739	0.808	2.96	1.65	0.603	0.707
2010-11	37.47	12.90	22.95	0.036	0.759	0.818	3.09	1.71	0.616	0.767
2011-12	38.61	13.39	23.57	0.037	0.779	0.829	3.23	1.76	0.629	0.834
2012-13	39.85	13.89	24.28	0.037	0.801	0.840	3.37	1.82	0.643	0.907
2013-14	41.13	14.42	25.00	0.038	0.822	0.851	3.53	1.88	0.657	0.987
2014-15	42.45	14.96	25.74	0.038	0.845	0.862	3.69	1.95	0.671	1.074

Source: Govt. of Pakistan (2015)

It is a fact that demand for milk is increasing day by day due to increase in human population and rising living standards, but milk production is not increasing at the same pace. Out of total milk produced in Pakistan, only 42.45 million tonnes are available to the consumer.

This necessitates the import of dried milk and milk products to meet the increasing demand of human population and it is a burden on the national economy. However, over the period of time, the import figure has been fluctuating for one or another reasons.

The per capita availability of milk is 170 liter and meat is 21.5 kg in Pakistan. However, looking at the production and utilization pattern, it has been reported that the bulk of milk is produced in rural areas, whereas it is majorly consumedin the urban sector. The trend of urbanization will potentially result in further reduction in the quantity and quality of raw milk in respect of nutritional as well as public health standards. God has gifted us a huge population of the livestock which is increasing day by day (table 1). No doubt, milk production is also increasing each year (table 2), but this increase is mainly due to increase in the livestock population. It is the need of the hour to increase per annum production, which is possible only by doing faming on the scientific lines and getting rid of the traditional practices. Commercial dairy farming has remained dormant in the past, but now this sector is gaining popularity and peoples' interest day by day. It is a very encouraging situation that would lead to strengthening the economy of Pakistan.

Table 5.3 Gross milk production in Pakistan (million tons)

Year	Gross Production (milk)	Cow	Buffalo	Sheep	Goat	Camel
2009-10	44.97	15.54	27.84	0.036	0.739	0.808
2010-11	46.44	16.13	28.69	0.036	0.759	0.818
2011-12	47.85	16.74	29.47	0.037	0.779	0.829
2012-13	49.40	17.37	30.35	0.037	0.801	0.840
2013-14	50.99	18.02	31.25	0.038	0.822	0.851
2014-2015	52.63	18.70	32.18	0.038	0.845	0.862
Increase (%)	17.03	20.33	15.58	5.550	14.34	6.680

Source: Govt. of Pakistan (2015)

5.2. Feed and Fodder Situation

The availability of adequate amount of quality fodder is considered essential to get optimum production from the dairy animals. Green fodder plays an important role in minimizing the cost of feeding. Though in Pakistan, it is available during most part of the year, yet it is difficult to keep the supply regular. Due to seasonal fluctuations, the animals are subjected to shortage of fodder leading to lower production, which in turn results in heavy monetary losses to the owners. The estimated potential of livestock for increased production is large, but development has been constrained due to many factors. One of them is supply of inadequate quality fodder year round to meet the requirements of dairy animals.

While raising animals more than 70 percent expenditures are incurred on feed. Forages are the major and cheap source of feed for livestock. In Pakistan about 12 to 14 percent of the total cropped area is put under fodder crops annually, even then the regular supply of adequate and quality fodder is not being made. That is why in our country production per animal unit is much lower than that of the developed countries. This is simply because an underfed animal uses a higher proportion of its feed for body maintenance. Thus, less of its feed intake is converted to products useful to mankind. May to June and December to January are fodder scarcity periods in our country. However, it is possible to ensure a regular supply of quality fodder year around by introducing high yielding fodder varieties and silage making.

In Pakistan, dairy animals are raised under three different managerial feeding circumstances:

i. In irrigated rural areas of the Punjab and Sindh, the small herds of cows and buffaloes are kept, and these mainly rely on fodder crops and crop residues
ii. Under Peri-urban areas, dairy animals are fed fodder crops, agro-industrial wastes and concentrates.
iii. Large herds of cattle are raised under range and barani conditions, where they are kept on naturally grown grasses, shrubs and trees.

It has been reported that the livestock get 51, 38, 3, 6 and 2% of their required nutrients from green fodder/crop residues, grazing vacant lands, post-harvest grazing, cereal by products and oil cakes/meals, respectively.

The major constraint in the development of the dairy industry in Pakistan is poor availability of feed and fodder both in terms of quality and quantity for dairy animals. Due to increasing human population, the area under fodder production is decreasing @ 2 percent after each decade. The situation is further aggravated by the continuous increase in the number of animals, as the fodder production is not increasing at the same pace. The reasons for poor production are low yielding varieties, inadequate agronomic practices, low inputs, and improper harvesting techniques.

Due to traditional agronomic practices, the yields are less than half the potential of the same crop and are estimated to be a quarter of the potential for improved hybrid varieties. The trend to bring more of the cultivated area under cash crops at the expense of fodder crops may further deteriorate the green fodder supply to the livestock. The majority of our farmers do not care about the stage of ‘cut and fed’, for carrying out harvesting of such fodder at an advanced stage of maturity. Such fodder is low in protein, high in fiber and low in digestibility.

The nutrient reservoir like rangelands are subjected to deterioration and still no proper attempt has been made to sustain and improve their productivity. Dairy farmers hesitate to use non-conventional feed resources because they are unaware of the usefulness of such materials and strictly following the traditional feeding patterns. Only cotton seed cake is being considered a quality concentrate by a majority of the farmers. In fact, it is only a part of the balanced ration.

5.3. Milk Marketing

Milk is the balanced most food available in nature and holds an important position in our diet. Milk is a highly perishable commodity. It must reach the consumers as early as possible after production. All possible efforts must be made to preserve its quality during storage and transportation. The marketing channels must ensure the supply of quality milk to the consumers without adulteration. The traditional marketing system for milk is unorganized and does not meet modern requirements. It is extremely un-economical, costly, and unhygienic and provides numerous opportunities for adulteration and addition of un-suitable preservatives, which demands improvement without further loss of time (SMEDA 2002).

Apparently, the producer is totally ignored and "Kacha Pacca" Dodhi is the main option. In this system, the long chain of middlemen (dodhies, etc) makes the maximum profit and both the producers and consumers are victims as it results in less income to the producer and a higher consumer price.

In the existing marketing system, the supply of quality milk to the consumer is not possible, as a lot of time is consumed in milking process till it reaches the target groups. The milk containers are dirty and unsuitable, resulting in adverse effects on the milk quality. Processed milk is much safer if processed according to the international hygienic standards. In Pakistan, there are 26 milk processing plants. Most of these plants are not in operation. Only a few are working with limited capacity. The important reasons for such a situation are: Low preference trend of consumers for processed milk, High price of processed milk than raw milk, No encouragement to the milk producers, High cost of production per liter processed milk and limited measures taken to reduce this cost,The over built UHT milk-processing capacity to suit the needs of consumers, Lack of funds for working capital, Unskilled and un-experienced management, Non-availability of funds to revive the units, High level of capitalization at the time of setting up, resulting misuse of funds, Problems in milk collection due to improper purchase system (not acceptable to the producers).

The demand of processed milk can be increased if it is available to the consumers at a rate compatible to raw milk. It is possible if the economical milk production package (to reduce the cost of production per liter milk) along with technical assistance and incentives is provided to the producers. Secondly, if manufacturers reduce the cost of production of a product through minimizing their own profit margin and packing cost by using cheap packing material.

5.4. Risks of Food Security

In Pakistan, milk and meat production is not increasing at the same pace as the human population, resulting in a deficiency of animal protein in the diet of our people. Despite annual production of over 50 million tons of milk and 3.69 million tons of meat, per capita availability here is lower as compare to recommended level of the World Health Organization. This situation is becoming severe day by day due to increasing human population and improving living standards. The important reasons of low production along with their solutions/remedies are discussed below.

5.4.1. Low genetic potential of our animals

It is a fact that God has blessed Pakistan with the best dairy animals, having a good genetic potential, but due to wrong breeding policy, their genetic potential has beendeteriorating over time. At the farmer level, the facility of artificial insemination is not available easily and timely. When any female shows the symptoms of heat, she is mated with any available male (no matter having poor record). Secondly, the fertility rate due to A.I is very low under field conditions.

There are many factors responsible for low fertility, including semen collection to insemination. Technicians pick the semen doses from the collection center and do not keep them under the same conditions, resulting in a decrease in the semen quality. When technician visits the animal, he does insemination even when the proper time has already passed. All these factors lead to no conception, so ultimately the farmer prefers natural breeding. Crossbreeding with purebred dairy cattle (particularly with Sahiwal breed) has also severely deteriorated the genetic potential of this breed. At present, availability of the pure Sahiwal breed is very limited (Bilal 2004). No beef breed is found in Pakistan. Draft purpose and dairy animals (when become unfit, aged and weak animals, animals at death point and even very young calves) are being used as beef animals. The quality and quantity of meat taken from such animals are very poor.

Following steps can solve these problems:

- Strengthening the A.I sector by involving trained technical staff and providing quality semen in the field, accelerating the production of progeny-tested bulls, Introducing an organized program of bull production at the farmer levelto meet the demands of natural service, particularly among buffaloes, preserving the local dairy cattle breeds by limiting crossbreeding with non-descript cows only, specifically feeding/fattening the animals prior to slaughters, at least for 3-4 months.

5.4.2. Late age of maturity and long calving interval

In our country, calves are a neglected class of animals at the farmer level that are fed the ration not consumed by other animals (refusals). Such refusals are high in fiber, but poor in protein, resulting in slow growth, late age of maturity and age of first calving, so obviously less life time milk production. The above problems are more severe in buffaloes than in cows. According to one estimate, economic losses due to late age of maturity and longer calving interval are Rs. 8.99 billion annually. In most buffalo heifers, age of first breeding varies from 4 to 5 years and cow heifers 2.5 to 3 years under field conditions. But if these animals are raised on scientific lines, optimum growth rate can be achieved, resulting in more beef production in males and early maturity in females. Such females can product at least one calf more in their life resulting to boost life time productivity per animal. Thus, the best option to increase the productivity of our dairy animals is to reduce the age of first calving and calving interval. All this is possible if the following measures are taken: Calf raising on milk/ milk replacer and calf starter as under modern dairying, Feeding according to requirement in order to get the desired weight of heifers at breeding time (66 percent of adult body weight).

Reduction in age of maturity and calving interval will lead to boost in lifetime productivity per animal. Ultimately, more milk will be available to meet the demands of the population.

5.4.3. Exploitations of full genetic potential

It is a fact that dairy animals are not producing milk according to their genetic potential. This is mainly due to feed and fodder deficiency, resulting underfeeding of animals. An underfed animal utilizes a major portion of its feed for maintenance requirement and less is converted to milk and meat. This situation becomes more severe during slump periods. Deficiency is accounted for both in terms of quantity and quality. The fodder offered to animals is low in nutritive value, not cut at the proper stage. The concentrate given is also not a balanced ration. Most of the farmers consider cottonseed cake a complete ration, which is a totally wrong notion on their part. It is an important ingredient of the balanced ration, though. The following measures may solve this problem: Collaboration between crop and animal production sectors, hybrid seeds, be these imported or indigenously produced and distributed among the farmers, legume and non-legume crop combination may also improve the feeding status of the livestock, superior fodders germplasm should be identified and propagated in the field, infrastructure and inputs required for enhancing the fodder production should be provided to the farmers, year-around fodder production systems should be devised according to the geographical conditions of the area, With seed provision, a complete package of agronomic practices should be transferred to the farmer, improvement of range lands is also imperative, as grasses, shrubs and tree leaves are the potential feed reservoir for the livestock in Pakistan, Rangeland act should be devised and implemented properly, integration and collaboration between range management and livestock management departments is important for the betterment of range resources, introduction of best local forages, species and exotic varieties of grasses (which could tolerate low moisture content) be evaluated and finalize the best suited, irevention of the deterioration of range resources, artificial rain or water catchment areas should be developed to overcome water shortage, range management, conservation and improvement be considered for the betterment of range resources, water conservation techniques (drip irrigation, plastic mulching, pitcher irrigation etc.) may improve the range conditions, use of agro-industrial byproducts for livestock feeding should be encouraged, sugarcane pith could be used as an important nutrient source if steam treatment is done, molasses feeding through urea molasses blocks and liquid supplement could minimize the existing nutrient deficiency for the livestock, about 1.17 billion tons of the livestock dung is available and may be used as livestock feed after recycling through chemical and biological methods, corncobs, cottonseed hulls, rice hulls may be used if proper treatment is done and awareness is created among the farmers, bakery, citrus industry and banana byproducts could contribute a lot to animals feed, ensiling and hay making systems should be devised and extended to farmers, according to the local livestock production systems.

5.4.4. Farming on traditional lines

The dairy sector is not appreciably commercialized yet. The entrepreneurial class is not coming forward to invest because they feel that profit margin in dairying is not enough. Their concepts are based on certain perceptions, i.e., lower production/animal, high incidence of diseases, weak data base utilization, long production cycle and milk production is not market driven. Due to the absence of commercial activities, rural small holders dominate the present traditional production system with less than 5 heads of cows/ buffaloes. Small herd size does not permit profitable adoption of modern production techniques. Small holders are unable to market their milk efficiently and cannot end their dependency on milk middlemen.

The middlemen monopolize most of the profit earned on milk, which does not allow any increase in producer's income. Majority of dairy holders are laymen, strictly following the traditions and hesitate to do farming on scientific lines even they are provided techniques. The adoption of traditional practices by the farmers causes high economic losses and low profit. Some of these practices are:

- Colostrum feeding to the calf after placenta expulsion of dam; that is totally wrong. It is recommended that colostrum should be fed within an hour as calf born without any immunity and immune globulins absorption decrease with the passage of time and become zero at 24 hours post calving.
- No naval cord cut of calf with an aim by the farmer that it will dry and slough off, but so many times it breaks from any spot before drying and become the best spot for the entry of bacteria, resulting omphalitis and septicemia. Finally, death of calf occurs.

There is an urgent need to change the existing mindset of the farming community. For this purpose, the following recommendations are important (Bilal et al. 2008)

> The rural small holders (maintaining about 80% of total dairy animals) must be trained through meetings/lectures/practical demonstrations and extension articles for efficient dairy production. Maximum attention should be given to small holders at the time of policy making for their support and assistance in running day-to-day activities. At farmer level, registration of animals be done for a selection of high yielders. Research conducted by various research institutes must be based on farmer's problems and be done under field conditions. A national policy must be designed with the objective of self-sufficiency in dairy foods. A vertical expansion model be introduced as in modern dairying. Instead of keeping more dairy animals, increase in productivity per animal is imperative. Dairy sector should be recognized as an industry and loaning by various agencies be done accordingly. At present interest on loaning for industry is far less as compare to dairy farming. Change in policy will attract the investors in the sector. Model dairy farms be established at least at district level. There is a need for an independent organization with a mandate in planning, monitoring, technical guidance and overseeing the progress of the dairy sector on modern lines.

5.4.5. High economic losses due to diseases

The incidence of diseases is very high in Pakistan affecting the dairy sector adversely, resulting economic losses both in terms of mortality and morbidity. There are certain diseases causing the death of animals and many diseases decrease the milk yield to a large extent. For example, due to foot and mouth disease mortality rate in lactating animals is less, but it drastically decreases the milk production. Similarly, high incidence of mastitis is one of the limiting factors in the development of the dairy industry. The economic losses due to mortality rate are negligible, but the production losses due to lowered milk quality/quantity, destruction of affected quarters, increased charges of treatment and culling processes are tremendous in the case of mastitis (Ahmad and Bakhat 1987). Parasitism is one of the leading factors of low productivity in terms of growth rate and milk yield. Due to worm infestation, up to 50% drop in growth rate occurs, resulting in a negative impact on meat quality and quantity. The reduction in economic losses due to diseases is possible through:

- Vaccination to the animals with quality vaccine, recommended dose on time.
- Control of internal and external parasites.
- Adoption of mastitis control package.
- Feeding the animals according to the requirement.

5.4.6. Unorganized marketing system

At present, dairy farmer is unable to get the profit of milk on the basis of quality and cost of production. Maximum profit is taken by the middlemen and minimum by the producers. On an average the cost per liter milk production is Rs.40. Dodhi collects the milk from the producer @ Rs. 50/liter and sales @ Rs. 75-80/liter, indicating a profit of only Rs. 10 for the producer who invests a lot and Rs. 25-30 for middlemen. The fresh milk marketing system is traditional. Milk sold is often adulterated leading to poor quality of raw milk. The use of raw milk may a risk factor because milk borne diseases may transmit to human beings. No doubt antibiotic residues and aflatoxins in milk are also deleterious to human health. The use of processed milk is a safe option if processing is done according to international hygienic standards. At present some milk processing companies are doing screening of the milk and rejecting such milk positive in antibiotic residues and aflatoxins. It is a positive indicator in terms of availability of quality and safe milk to the consumers. There is no assured marketing shelter to milk producers resulting to discourage them to produce more.

Following are the remedies for efficient milk marketing:

A year-round fair priced market for milk be ensured along with provision of inputs to producers, necessary to increase the milk production is ensured. In order to replace the conventional dodhi system, price based packages be offered to milk producers. Milk collection centers are established at least at union council level. Here milk should be purchased on cash payment based on fat contents. The participatory/co-operative approach would be the right step. Village dairy co-operatives managed by the producers themselves will enable them to market milk more efficiently.

5.4.7. Lack of extension services

For profitable dairy farming, awareness of the farmers about modern production techniques is very imperative. This is possible through extension services but unfortunately extension is missing very badly. In the absence of extension link, the problems of producers cannot be catered. There is an urgent need to strengthen the linkages among producers, researcher and extension workers. To increase milk production and meat production, there is a need to strengthen the extension on the following lines.

The basic working units of extension services (professional graduates, vet/livestock/field/stock assistants and technicians) need to be highly trained and skilled. Milk production enhancement program be launched with an extensive package of services in health care, artificial insemination, fodder production management, ration formulation, establishing dairy enterprise and marketing. Audio visual aids must be utilized to train the producers about various aspects of dairy farming. Produce and consume more milk campaigns be launched on media to enhance/popularize the use of dairy products among the masses. To increase the adoption trend of recommended techniques, short term trails be conducted at farmers level by comparing recommended practice with traditional practice.

5.5. Livestock and Environmental Pollution

In Pakistan, human population is increasing @ 2.69 percent, while livestock population is crossing the human population curve with the accelerating rate of 3.4 percent, and we still are an animal protein hungry nation. Therefore, the demand for animal protein is increasing with the passing of every movement. However, annual population is increasing with a very little improvement in genetic worth. This dilemma is causing more environmental fatalities and the situation is worsening day by day. With economic development and living standard improvement, livestock breeding have grown rapidly; also have become the leading source of pollution, as animal waste and wastewater can enter water bodies from animal waste (manure) and non-agricultural application of manure to cropland. This contamination has resulted in degraded quality of surface and underground drinking water supplies. Areas with concentrated livestock operations are showing elevated nutrients (especially nitrogen and phosphorus) and organic pollutant contents in surface water. Confining areas of animals have become a major source of animal waste. Direct drainage of manure into surface water and leaching from saturated soils is a feature associated with the livestock industry. In areas with high livestock concentrations, the spreading of manure on land can lead to nitrogen leaching into water. This contamination has resulted in degraded quality of surface and ground water supplies.

5.5.1. Livestock pollution

If livestock is fed excessive amounts of dietary nutrients that are not used efficiently for milk production, large amounts of nutrients will be excreted in feces and urine, resulting in pollution of the environment. The purpose of livestock farming is to convert the carbohydrates and proteins of animal feed to food sources for humans; however, only 25 to 30 percent of animal feed nitrogen usually meets this goal. The rest is excreted by animals and can escape into the environmental nitrogen that is of primary environmental concern because of losses of ammonia in the air and nitrate contamination of surface water and groundwater. Feeding nitrogen in excess, feeding of excessive amounts of ruminally degradable protein or feeding diets properly balanced for ruminally degradable and un-degradable protein, amino acids or energy may increase nitrogen excretion in feces or urine.

As ruminant animals are unique of their special digestive systems, they can convert otherwise unusable plant materials into nutritious food and fiber. The same helpful digestive system, however, produces methane, a potent greenhouse gas that can contribute to global climate change. There are about 77.8 million large ruminants in Pakistan and more than 1.2 billion large ruminants in the world. Global warming is the gradual increase in the temperature of the earth's atmosphere due to the greenhouse effect caused by increasing levels of gases like water vapors, carbon dioxide (CO_2), methane (CH_4) nitrous oxide (N_2O) and others. Earth temperature increases 1.4°F over the past century and it raises 2-11.5°F over the next 100 years. NASA reported 10 warmest years in the 134 year record, 2005 ranked as the warmest year since 1880 (Cole and McCarthy 2015). Human's activities are largely responsible for climate changes. Carbon dioxide and other gases which affect the atmosphere come from burning fossil fuels, industrial processes, deforestation, and agricultural practices. Greenhouse gases, just act like a blanket surrounds the earth, which traps energy in the atmosphere and results into global warming. This phenomenon is necessary for life, but increasing rate of greenhouse gases can change the climate of the earth and cause dangerous effects to our ecosystem and humans as well (EPA 2014).

Livestock production systems can also emit other greenhouse gases such as nitrous oxide and carbon dioxide. An adult cow may be a very small source by itself, emitting only 80-110 kg of methane/year, but with about ruminants are one of the largest methane sources. In the globe, cattle emit about 102 billion kg of methane per year into the atmosphere. Pakistani animals are facing malnutrition, both in terms of crude protein and energy. Our animals consume more fibers in the form of roughages and some green fodder, without fulfilling the energy requirements for the better utilization of roughages by the microorganisms, resulting in much more methane production. Nitrates and phosphorus emission in the animal excreta is not our problem because our animals are living below the minimum protein requirement line, and our land is deficient in Phosphorus, especially the irrigated areas of Punjab and Sindh provinces.

Livestock and livestock waste produce gases, some of which are localized, such as ammonia (NH_3) whereas others, such as carbon dioxide (CO_2), methane (CH_4), Nitrous oxide (N_2O) and other trace gases emitted to the atmosphere. Accumulation of carbon dioxide and certain other gases in the atmosphere may be contributing to a global warming trend or the greenhouse effect. Ammonia volatilization the emission contributes to acid deposition, while emission of N_2O plays a role in global warming and in the deterioration of the ozone layer. Ruminant animals produce methane as a by-product of their digestive fermentation. Methane is produced in the rumen by a group of Archea belong to the phylum Euryarcheata among livestock, methane production is greatest in ruminants as methanogens are able to produce methane freely through the normal process of feed digestion. The relative contribution of livestock to global production of methane is approximately 14 percent. Methane is much more dangerous (24 times) than carbon dioxide in causing global climate change. Nitrous oxide is the most aggressive greenhouse gas (320 times that of CO_2) contributing to global warming. Fluorinated gases have 3% part in GHGs. Its global warming potential is more than all the other GHGs. Hydrofluorocarbons, sulfur hexafluoride, and perfluorocarbons are powerful gases to produce a greenhouse effect that are emitted from the industrial processes (EPA 2014).

Rangelands in Pakistan comprise of about 49.50 million hectares (62 %) and only the province of Balochistan is sharing as 27.40 million hectares (79 %) of the total rangelands of the country, with such a vast and expanding rangelands, we are still away to achieve the goal of proper utilization and judicious use of the ranges. By just increasing the number of ruminant livestock without keeping in view the productivity at priority, we are degrading our ranges. The ranges are now changing into the desert even with the more accelerating rate. By the process of desertification, a huge quantity of phosphate rocks runoff with the rain water falling in the Indus basin. This process causes two types of losses to the environment, i.e., filling the belly of Indus basin, which results in the expansion of water at more vast area, resulting in the destruction of the crop lands in Sindh and secondly increase in phosphates and nitrogen result algae production, lowering oxygen availability to the aquatic life.

Industrial production can create enormous pollution problems because it brings large quantities of nutrients in the form of concentrate feed and then has to dispose of the manure to nearby land which quickly becomes saturated. As a result, land and groundwater are polluted. Commercial farming, which is now slowly introducing in the country livestock production systems also, is shifting the nutrients from the agricultural lands to the non-agricultural and livestock producing area. This phenomenon is resulting in the land hunger at one hand and the surplus nutrient on the other hand causing the environmental problems. Landhi colony of Karachi is the best example of such type of commercial farming. Environmental issues continue to be one of the biggest challenges faced by livestock producers. To address emerging air quality issues, such as ammonia emissions, antibiotic transfer, human health impacts of emissions from animal agriculture, and estrogens in the environment; experts in physiology, genetics, animal management, and nutrition must play the role. Drugs, medicines, hormones and other additives using in our production system is a more serious issue. It is a big dilemma of production system, especially in the peri-urban community of the Metropolis cities like Lahore, Faisalabad, Rawalpindi and other cities. No data are available on the use of medicines and hormones, which can provide an overview of the situation. About 4.8 million equines are also contributing a lot towards the environmental pollution, as during working hours, particularly, their dung and urine is not properly managed, spread on the roads and inhaled by the human population, resulting ill health.

5.5.2. Pollutants

Livestock farms, feedlots that house thousands of cows, buffaloes and poultry produce staggering amounts of animal wastes. The way these wastes are stored or used has profound effects on human health and the environment. On most of the farms, animals are crowded into relatively small areas; their manure and urine are funneled into massive waste heaps. The leak or overflow, send dangerous microbes, nitrate pollution and drug-resistant bacteria into eater supplies. The animal waste also emits toxic gases such as ammonia, hydrogen sulfide and methane. From an environment standpoint, nitrogen and phosphorus are the nutrients of primary concern, whereas the ammonia, carbon dioxide, hydrogen sulfide and methane are the gases of primary concern. Livestock farming is a significant source of reactive nitrogen in the environment. Of all the NH_3 and NO_2 released into the environment are estimated to arise from livestock farming. Concerning phosphorus on average, livestock manure is estimated to account for 39.4 percent of the agricultural P_2O_5 supply. Livestock is the dominant agricultural source of P_2O_5 around urban centers and in the livestock specialized areas. Improper animal manure management, as in the case of any other highly bio degradable material, can have a serious effect on wells and on the quality of drinking water. The major effects of animal waste miss-management on the environment are eutrophication of surface water; nitrate leaching, pathogen transfer and water pollution in natural areas, such as wetlands (Hammond 1983)

5.6. Threats to Human Health

People who live near or work at livestock farms breathe in hundreds of gases, which are formed as manure decomposes. The stench can be unbearable, but worse still are the gases that contain many harmful chemicals. For instance, Hydrogen Sulphide, a gas released by the livestock waste is dangerous even at low levels. Its effects, which are irreversible, range from sore throat to seizures, comas and even death. Other health related effects associated with the gases from farms include headaches, shortness of breath, wheezing, excessive coughing and diarrhea. Animal waste contaminates drinking water supplies. For example, nitrates which often seep from manure into groundwater are potentially dangerous for the new born babies due to oxygen depletion in the blood. These also enhance the risk of blue baby syndrome (methahemoglobinemia), a respiratory problem, which can cause death in infants. Blue baby syndrome occurs only in babies of less than 3 months of age. Excess nitrogen can result in a baby’s blood taking up nitrogen instead of oxygen, causing respiratory failure.

Nitrogen pollution of public water supplies is a health concern because of the risk of stomach cancer. Nitrogen in food or water may produce nitrosamines in the stomach, which can cause cancer. High levels of nitrates in drinking water have also been linked to spontaneous abortions. In 1996 the centers for disease control established a link between spontaneous abortions and high nitrate levels in Indiana drinking water wells located close to feedlots.

E.coli (cause of gastroenteritis) in drinking water mostly coming from manure runoff. Several disease outbreaks related to drinking water have been traced from waste. The widespread use of antibiotics to promote growth or to compensate illness resulting from crowded conditions; promote development of antibiotic resistance in bacteria that are present in animal waste. These antibiotics are entering the environment and the food chain, contributing to the rise of antibiotic-resistant bacteria and making it harder to treat human diseases.

Several diseases from microorganisms in livestock waste can be contracted through direct contact with contaminated water and consumption of contaminated shellfish. Animal waste is responsible for shellfish contamination in some coastal waters. The pathogen Cryptosporidium, a protozoan parasite is common in surface water, especially those containing high amounts of animal waste. It may cause gastrointestinal illness and may lead to death in persons with compromised immune systems. The risk of nitrogen pollution from waste of livestock is high because nitrogen is easily converted to gaseous forms that escape into the atmosphere and are leached from the soil into ground water. Such atmospheric pollution contributes to formation of acid rain.

5.7. Threats to Aquatic Life

Increasing nutrient levels (nitrogen and phosphorus) in water can cause excessive growth of aquatic plants and algae. The decomposition of aquatic plants depletes the oxygen supply in the water, creating anaerobic conditions, which can lead to fish mortality and endangering the health of other animals in the area. It also deprives light and space that fish require.

One toxic microorganism, *Pfiesteria piscicida* can cause the death of more than one billion fish. Amines and sulfides are produced in anaerobic waters, causing the water to acquire an unpleasant odor, taste and appearance. Such water can be unsuitable for drinking, fishing, and other recreational uses. Dissolved ammonia at concentrations above 0.2 mg/l may be toxic to fish. Phosphates, although less mobile than nitrates, can cause similar problems, such as eutrophication and damage to the aquatic and wetland ecosystems. The ultimate effect is loss of bio-diversity.

5.8. Strategies

If the efficiency of nutrients used for milk production and weight gain is to be maximized, nutrient losses may be reduced. A simple and inexpensive procedure to reduce the livestock pollution is to improve the digestibility of poor quality roughage and residues. Urea molasses blocks or just the inclusion of a few nutrient supplements will substantially increase the efficiency of rumen function with a significant reduction in the amount of methane liberated. Since approximately two thirds of the world’s ruminant population is located in Asia and Africa, where crop residues and by-products are the common diet, anything that improves digestibility would also decrease methane. Digestible energy fermented into methane is approximately 15 percent when straws are alone fed to ruminants but by adding urea, minerals and bypass protein supplements or urea molasses blocks, this loss of energy can be reduced to 8 percent.

Components of feed, especially carbohydrates are important for methane production because they affect the pH of rumen and ultimately affect the micro-flora of the rumen (Johnson 1995). CH_4 production is highly affected by hemicelluloses and celluloses as compared to soluble carbohydrate. Hemi-cellulose digestibility has a positive relation with CH_4 production while cellulose digestibility has a negative relationship with it in dairy cows fed all forage diet. Hemicelluloses digestibility is not an important variable to measure CH_4 production when cows fed diets with concentrates and forages. Methane production reduces by concentrate feeding. High lipid content in the feed is thought to decrease CH_4 production by decreasing protozoa, increase production of propionic acid and bio hydrogenation of unsaturated fatty acids. Unsaturated fatty acid may be used as a hydrogen acceptor instead of carbon dioxide. Fatty acids are also thought to reduce CH_4 production directly through binding to cell membranes and interrupting membrane transport. By lipid supplementation in locating cows a decrease of 2.2% in CH_4 output per 1% of supplemented lipid in diet. Another scientist worked on sheep and cattle found that 5.6% decrease in CH_4 production by 1% lipid added in the diet (Beauchemin et al. 2008).

Refined soy oil fed to beef bulls at 6% inclusion rate reduced the amount of CH_4 by 39% in terms of liters per day. Sunflower oil can decrease the amount of CH_4 11.5-22%. Linseed oil at the rate of 5% of DM fed to lactating cows reduced the CH_4 production 55.8% in grams per day. Coconut oil is most popular to reduce CH_4 production; methane reduces with increasing level of oil. Digestibility of cell wall was decreased by coconut oil (Machmuler et al. 2003). By in vitro study coconut oil reduced CH_4 by 21% and palm kernel oil reduced CH_4 by 34%, giving evidence that palm kernel oil is better than coconut oil. However, it is important to note that in vivo studies in which oil supplementation given with diet also has reduced DM intake, so it can also reduce CH_4 production (Machmuller et al. 2000). Defaunation reduced CH_4 output 13%, but the magnitude of reduction varied with diet. The greatest reduction in methane production with defaunation was measured with a high-concentrate diet (Knapp et al. 2014)

Monensin also used as a migitation strategy for CH_4 production, as it is known to inhibit gram-positive microorganisms responsible for supplying methanogens with substrate for methanogenesis. The effects caused by minensin on the microbial cell are mediated by its ability to interfere with ion fluc (Bergen and Bates 1984). Monensin selects for gram-negative microorganisms, which causes a shift towards propionate production in the rumen. Monensin treatment was found to cause a 7-9% reduction in CH_4 output versus control cows and this reduction was sustained for the entire treatment period with no adaptation detected (Ondongo et al. 2007). Condensed tannins are thought to directly inhibit methanogens, as well as indirectly limit methanogenesis through a reduction in hydrogen availability. Condensed tannin-containing Lespedeza cuneate was fed to goat's ad-libitum and found to reduce CH_4 57% in terms of g/kg DMI (Puchala et al. 2005). On an individual-cow basis, CH_4/ECM can be reduced by 3 different approaches. The first is to increase milk yield per cow with correspondingly smaller increases in DMI, which dilutes the maintenance energy costs of the cow and increase gross energy efficiency. The second is to reduce body size without reducing yields of milk and milk components, which also has the effect of increasing gross energy efficiency, but by decreasing the maintenance energy requirements of the animal. The third is to select for residual feed intake or residual solids production, which are both measures of feed efficiency. There is a greater reduction in methanogens by targeting directly methanogens. Select the animals which produce less enteric methane. Improve production of animals by genetic selection so methane production reduces per product. The best route to reduce methane production involves improved management practices and selective breeding. Many ruminants are needed for draft purposes in developing countries and if fossil-fuel-burning machines replaced these working animals, some reduction in methane might result, but this would be offset by higher carbon dioxide production and this is not possible under our conditions. Nitrogen and phosphorus should be fed to animals according to requirement. In case of dairy animals the simple method to check that either the nitrogen being fed is according to the requirement or not, is to check the blood urea nitrogen or milk urea nitrogen. The normal value for milk urea nitrogen is 12 to 17 mg/dl. If the value is higher than this, it indicates that excessive nitrogen is being fed, but the value is less than reported value, then less nitrogen is being fed less than their requirement. Phosphorus fed to animals should be of high quality.

An alternative farming practice is to promote methods of raising livestock that reduce the concentration of animals and use manure safely. Many alternative methods exist; they rely on keeping animal waste drier, which limits problems with seepage, spills, runoff and air pollution. To reduce excretion of nitrogen, there should be a proper balance of ruminally degradable and un-degradable protein in dairy ration. To fix the ruminally degradable protein into microbial protein there should be a proper provision of energy so the ratio of soluble carbohydrates to ruminally degradable protein should also be considered, otherwise degradable protein in the form of NH_3 will be absorbed from rumen, and coming in liver will be converted into urea. This urea is excreted through urine causing environmental pollution. If the nitrogen pollution has been occurring, then the options to reduce nitrate concentration of polluted water may be a blending of high and low nitrate water or chemical treatment. Blending is usually the cheapest way of reducing nitrate concentrations in polluted water. Chemical gentrification is more expensive. Emphasis should be given to increase per head production that may result low levels of pollution. Proper stocking density on ranges is a good tool to minimize soil erosion in the rangelands of Pakistan. It will be far better if the process of re-vegetation and reforestation start without delay

Abundant use of drugs must be prohibited to minimize the flow of residues of medicine into the human body, which affects the human health very adversely. Oxytocin and Boston, being used blindly, must be strictly prohibited for the betterment of both the man and livestock. At present, use of Boston is banned in Punjab but being used in other provinces of Pakistan. Proper management of animal waste to minimize the bad odor in the animal surrounding area and the nearby human population. For this purpose, the effective microorganism technology (EM technology), may be used. To minimize the excess excretion of nitrogen ionophores may be used. The data indicate that monensin in the diets of ruminants may decrease protein degradation in the rumen and may indicate that monensin in the diets of ruminants may decrease protein degradation in the rumen and may increase feed protein utilization by an average of 3.5 percentage units. The inclusion of monensin in beef and dairy cattle diets may benefit air quality by reducing CH_4 and N emissions and water quality by reducing N in manure, which can potentially leach into ground water and through runoff into surface water.

Growing imbalances between livestock systems and ecosystems need to be corrected. Good and clear understanding about ecosystems and their links with livestock systems is imperative for correct decisions.

5.9. Risks to Human Health from Livestock

There are certain diseases that are transmitted from animals to the human beings. Here is the list of some zoonotic disease, along with their symptoms, path of transmission and necessary precautionary measures (Bellet al. 1988; Fraser et al. 1991)

5.9.1. Tuberculosis

This disease is caused by the bacteria of genus Mycobacterium. The transmissibility of tuberculosis is infections other than host species. Constitute is one of the most important problems in the control of this disease. *Mycotuberculosis, Mycobovis* and *Mycoavaium* are the causative organisms in man, bovines and avaians, respectively.

5.9.1.1. Symptoms in human beings

The bacterium Mycobovis can affect many tissues, but mostly can cause pulmonary tuberculosis, cervical identities, bone and joint tuberculosis, meningitis and abdominal tuberculosis.

5.9.1.2. Transmission

- Never use raw milk (without processing)
- Milk from the cow affected from Mycobovis
- Meat and milk or meat products form affected animals
- Contaminated air expired from the infected animals
- Butchers and meat inspectors can content the bacteria from the affected carcasses

5.9.1.3. Precautions

- Do not use the milk and meat products from infected animals
- Clean the barns because tubercle bacilli can contaminate the milk
- Tuberculin testing before slaughter and pasteurization of milk
- Meat inspection services are necessary (antimortem and postmortem examination)
- T.B. may be transmitted from bovines, caprines, canine and avians etc.
- Vaccination of animals

5.9.2. Anthrax

Baccilus anthracis is the causative bacteria found in the blood. The spores are very hardy and resistant. Cattle, horses, mules, sheep are most susceptible. Per acute stage is most fatal. No external signs. In acute and sub-acute forma, excitement, depression, spasm, respiratory or cardiac distress and bloody discharge from natural opening after death.

5.9.2.1. Symptoms in human beings

Intestinal form, cutaneous anthrax, meningitis, pulmonary anthrax, brain is more receptive.

5.9.2.2. Transmission

- Meat milk and their products
- Spores may be present on vaccination or incubation instruments
- Blood
- Workers dealing with hide, skin leather, hair and wool (wool sorters disease)

5.9.2.3. Prevention and control

- Eradication of disease in animals through vaccination
- Elimination of industrial infection
- Earlier diagnosis and more prompt treatment of infected cases
- Destruction of bedding and dung
- Fly control
- Dead animals should be buried or incinerated
- Skin wound should be dressed
- Education of workers and disinfection of industries
- Anti-anthrax serum use in man

5.9.3. Brucellosis

Brucellosis is a worldwide disease of animals and man in which animals serve as reservoirs of infection from man. The disease is caused by three species of *Brucella*, namely melitensis, *B. abortus* and *B. suis*. In animals it is named as Bang's disease. It causes abortions. Many animals show no clinical evidence of disease and our laboratory tests fail to detect. So, it is very difficult to eradicate the disease.

5.9.3.1. Symptoms in human beings

Called indolent fever in man or malta fever. Chills, headache, fever, severe nights sweats and intense weakness are common symptoms. In chronic cases anima may develop.

5.9.3.2. Transmission

- Drinking unpasteurized milk and raw dairy products from infected animals
- Veterinaries, farmers and employee in abattoirs and meat packing plants acquire the disease from contact with infected animals and infected raw meat
- Laboratory workers become suddenly or accidentally infected by culture or experimental animals

5.9.3.3. Prevention and control

- Pasteurization of milk
- Eradication disease in animals
- Deletion of dairy products from diets of patients' hyper-sensitive to brucella antigen to eliminate allergic symptoms
- In animals brucella can be control by the use of BRT screening test
- Blood test and removal of infected ones
- Immunization of calves with non-virulent strains of B. abortis (19 strains)

5.9.4. Vibriosis

Vibriosis is a communicable disease of cattle and sheep, caused by *Vibro fetus. Vibro fetus* caused abortions, retained placenta, Salpingitis and vaginitis. Sterility in cattle is a conspicuous signs. In sheep abortion is standing manifestation

5.9.4.1. Symptoms

Placentitis and abortion with fever are the predominate signs in human beings.

5.9.4.2. Transmission

- Ingestion of unpasteurized milk
- Laboratory exposure to animals
- Contact with infected animals
- Abattoir worker may contact disease from infected animals

5.9.4.3. Prevention and control

- Perform intra uterine test in animals. Change the infected one with new ones
- Sanitation of barns
- Use of pasteurized milk and other essential precautions related to people in close contact to animals

5.9.5. Salmonella food infections

There are 650 types salmonella organism all which possibly may cause the gastroenteritis in man. The number of salmonella organisms ingested in an important factor which determines whether or not illness will follow.

5.9.5.1. Transmission

- House flies are mechanical carrier of organism
- Domestic fowls or the reservoirs
- Meat, egg and milk from infected animals

5.9.5.2. Prevention

- Proper cooking and refrigeration of meat, egg, and their products from healthy animals
- Protection of feed from rats and flies

5.9.6. Listeriosis

In man, it is characterized by meningitis and ruminants and swine by encephalitis. Abortion in the sheep and cattle has been reported. The causative organism is *Listeria momsytogenes.* Conjunctivitis is occasionally observed in ruminants. A lot of research is needed to discover the mode of transmission, prevention and control

5.9.7. Glanders

The causative organism is known as the Actinobaccilus mallei. Horses, mules and other member of the solipede family are very susceptible to glanders. Man though less susceptible, these solopede can readily contract the disease. Nasal discharge, enlargement of lymphaties, lymphnodes and the presence of nodules etc are the symptoms in animals.

5.9.7.1. Symptoms

Fatigue, loss of appetite, jaundice, headache, rheumatic pain in the legs, then physical signs develop like erysipelotous swelling on face and limbs and painful nodules and phlegmonous inflammation

5.9.7.2. Transmission

- People caring the glandered animals. Occupational contact, treatment or autopsies of glandered animals
- Laboratory workers dealing with experimental animals and culture
- Through aberration of skin either by nasal discharge or secretions pustules of infected animals
- Possible from eye, nose, and mouth when animal snorts

5.9.7.3. Prevention

- Elimination of all the infected or suspected animals
- Disposal of infected horses and routinely malein test
- Workers education, also the laboratory workers
- In case of human glanders, person should adopt all the necessary precaution

5.9.8. Rabies

The etiologic agent of rabies is a filterable virus. Rabies is a disease to which all the warm blooded animals are susceptible. Disease has three stages:

5.9.8.1. Prodourmal

- Rise in temperature
- Dilation of pupils
- Sluggish control reflex

5.9.8.2. Excitement

- Increasingly irritable
- Restlessness and nervous
- It may shun people and hide dark places show exaggerated response to sudden light and sound

5.9.8.3. Paralytic

- Dropped jaw
- Paralyzed
- Drooling of saliva

5.9.8.4. Signs in human beings

- Difficulty in swallowing
- Heavy rapid salivation or frothing

5.9.8.5. Transmission

- Open wound
- Biting by infected animals
- Air

5.9.8.6. Prevention

- Vaccination prior to disease both in man and other animals
- Shooting the affected ones
- No treatment

5.9.9. Milk nodules

Milker's nodules or milker's warts occur in most instances in persons who have milked cows suffering from a disease which is commonly called cow pox

a) Cat scratch disease (viral)
b) Contagious ectheyma of sheep (sore mouth of sheep and goat)
c) A filterable virus remain infected for years

5.9.10. Mad cow disease

It is also called as sub-acute spongiform encephalopathy or bovine spongiform encephalopathy. This fatal and noxious disease has caused a loss of a billion pounds in Europe. More than 11 million cattle have been affected by this disease. The animal said to be safe are still at high risk. The disease is said to have the origin from Kuru disease in New Guinea hills. Pathological changes brought by the disease are cerebellar cortices. Encephalitis with sever nervous signs has been found to be the main symptom of this disease. Frothy saliva and yellowish fluid with marked smell emitting from the mouth and nostrils are also a common feature.

5.10. Diseases Transmitted through Milk

Milk is a good medium for the growth of variety of organisms. Pathogenic as well as saprophytic forms may multiply in the milk. Spread of disease through milk and milk products is the most important problem. Therefore, prevention of milk borne diseases is of utmost important for public health. The abnormal changes in milk are easily detected by appearance, taste and smell. However, milk, containing pathogenic bacteria with normal taste and appearance, gives no warning to the consumers (Bilal and Ahmad 2004)

5.10.1. Diseases of Bovine origin

Animal health is important as several diseases may be transmitted to man through milk. Disease germs find their way into milk directly from the udder or indirectly through infected discharge from the body.

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Chapter 6

Agricultural Marketing and Risk Management

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Abstract

Pakistan is a developing country which draws most of its strength from agriculture sector. This sector contributes 21% to the Gross Domestic Product (GDP) of Pakistan; employs 45% of the total labour force of the country; and shares a significant amount in export earnings. Over the years, this sector has shown mix trends regarding production of crops and livestock yet significance of this cannot be underestimated. Sustainability in growth and development of this sector needs a condition where concerns of stakeholders are met in a satisfactory manner but current scenario poses a different picture. Stakeholders, particularly farmers, are facing risks in production and marketing of their production. Sometimes, they have to bear value reduction in the production and sometimes poor infrastructure and post-harvest practices cause losses. Further, frequent food surpluses and shortages have shown that distribution and marketing system needs to be modernized to handle the situation. Growth of agriculture sector heavily relies on the development of efficient and effective agricultural marketing system providing useful services to the stakeholders.

Keywords: Risk management, Sustainability, Stakeholders, Value Reduction, Effective Agricultural Marketing

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6.1. Agricultural Marketing System: An Overview

The present agricultural marketing system in Pakistan is characterized with numerous market players who perform different functions in transferring the farm production to the consumer. It is observed that an agricultural commodity changes seven to eight different hands before reaching its ultimate consumer. Functions performed by various market functionaries (especially the middlemen in the market chain) remain one of the most controversial issues in Pakistan's agricultural economy. It is argued that middlemen exploit marginal farmers and hamper their legitimate share. Infrastructure plays vital role in facilitating and ensuring smooth functioning of agricultural marketing system. Wholesale markets for instance, act as a cardinal link between the producers and the consumers, and are operated by the public and the private sectors. Most of the wholesale markets in the country, however, give a poor look-lack basic infrastructure (efficient logistics, storage and other marketing facilities), putting farmers at a disadvantageous situation while selling their production. Currently, in Punjab, there are 152 wholesale grain markets, 95 fruit and vegetables markets, 81 feeder markets and 11 markets are working in the private sector. There is a limited storage capacity (6-7% of total agricultural production) in the public domain and that, too, is limited to a few commodities. Existing cold storage facilities are unevenly distributed across the country with Punjab dominating with 512 units followed by Sindh (25 units), KPK (16 Units) and Baluchistan (2 units). Most of these facilities are not compartmentalized causing odor transfer between different commodities placed within cold stores. Another unfortunate fact about existing status is limited processing (3 percent of fruit, vegetables and milk) in the country. There are 121 known pack houses in the country for horticulture crops. DALPMG has made grades and standards for 42 agricultural commodities, but there still exists a need for framing grades for other commodities besides updating the existing ones. Post harvest losses are huge which amount to 35-40% of the total fruit and vegetable production in the country. The present length of farm to market roads (60,000 km) is crucially less than potential requirements (Govt. of Pakistan 2009).

The legal framework, for agricultural marketing system, in Pakistan has developed over time. The basic legal document is the Agricultural Production Markets Act, 1939. The market committees were established under the provisions of above act which were assigned noble pursuit i.e., safeguarding interests of growers. The Act of 1939 was replaced by the Punjab Agricultural Production Markets Ordinance, 1978. The rules to regulate working of wholesale markets were, however, framed during 1979. All agricultural marketing activities (especially the working of wholesale markets) in the province of Punjab are legally controlled under this ordinance. Grading and quality certification in the domestic markets is legally controlled under the Punjab Agricultural Production (Grading and Marking) Act 1972.

6.2. Concepts of Agricultural Marketing

Definition: Agricultural products differ from industrial products due to their perishable nature and special requirements during various farm and marketing operations. But, this does not imply that the field of agricultural marketing is something entirely different from marketing of industrial and other products. It is simply the application of the basic principles of marketing in agriculture sector.

Agricultural marketing covers the services involved in moving farm products from the farm to the consumer. Several activities are involved in the process, like planning, sowing, producing and harvesting, grading, packing, transport, storage, agro and food processing, distribution, advertising and sales. Such activities cannot take place without the exchange of information and are often heavily dependent on the availability of suitable finance. Marketing has to be customer oriented and has to provide the farmer, transporter, trader, processor etc. with a profit. This requires those involved in marketing chains to understand buyer's requirements, both in terms of product and business conditions by using shorter channels with minimum marketing costs.

A comprehensive definition of agricultural marketing is as; "Agricultural marketing includes all business activities involved in production planning, transformation, grading, storing, transported to agriculture as desired by agricultural producers (farmers) and consumers."

6.3. Sources of Marketing the Agricultural Products in Pakistan

There are three systems of marketing the agricultural products in Pakistan:

1. **Sale in Villages:** Most of the farmers (especially small farmers) sell major share of the surplus products to the local traders and shopkeepers in their own villages. Normally, the price they get for their products is below the market price. This is practiced in case of food grains, vegetables and fodder.
2. **Sale in Feeder Markets:** The second method of selling the surplus products is in the scattered markets near the villages. These markets are not well established, hence, deficient in basic requirements for trading. Fruit and vegetables, cotton, pulses and oilseeds are common examples in this case.
3. **Sale in Wholesale Markets (Mandis):** Another method of selling agricultural products is through wholesale markets (mandis) where wholesalers buy the products at competitive price and sell further to the other stakeholders. In these markets, commission agents and brokers, mainly help in selling the products of the farmers. They offer numerous services and deduct their fee/commission. Almost all of the agricultural products are traded through these markets.

6.4. Agricultural Marketing System and Associated Risks

Agricultural marketing system in Pakistan is characterized with numerous market players who perform their role in transferring farmers' products to the consumers in the urban areas. It is observed that on an average, an agricultural commodity changes seven to eight different hands before reaching the ultimate consumers. Wholesale markets act as cardinal link between the producers and the consumers. These markets are operated both by the public and the private sectors. Despite variance in the size of such markets, there exists a relatively standardized model of transactions with precisely defined roles for key players in the supply chain and a largely uniform set of rules.

In Pakistan, most fruit and vegetable markets are privately owned in the smaller towns and many cities. Particularly in the Khyber Pakhtun Khwa mandi owners are characterized as commission agents who charge a fixed sum from the growers for the usage of their facilities and services. Wholesalers buy fruit and vegetables in lots through an auction conducted under the supervision of mandi owner or his designated deputy (sometimes called a Munshi). Having auctioned the goods, the mandi owner (Ardi/Arti) pays off the growers after deducting his commission. The wholesaler (Pharia) then sells to individual retailers--ranging from fruit and vegetable vendors to the shopkeepers in retail markets. In bigger cities like Karachi and across the Punjab, wholesale markets for fruit and vegetables are controlled by the Agricultural Marketing Department through market committees set up at the district level (Aftab 2007).

Functions performed by middlemen in the wholesale markets have remained one of the most controversial issues in Pakistan's agricultural economy. It is generally argued that middlemen exploit marginal farmers and handicap them from their legitimate share. This allegation may not be ignored as many commission agents, bypassing the provisions of Agricultural Products Market Acts, have been found charging higher commission rates than the prescribed ones. Pre-harvest contractors dominate the marketing system of fruits in Pakistan. They are often allegedly labeled to over utilize their power. However, despite all these allegations, importance and role performed by middlemen cannot be underestimated.

The performance of agricultural marketing system is generally judged by the market margin approach which shows relative share of different stakeholders involved in the supply chain of agricultural commodities. It has been observed that the share of the farmer in consumer rupee is relatively low in case of perishable commodities as compared to non-perishables. In the case of fruit, pre-harvest contractors and retailers get more profit as compared to other stakeholders (Khushk and Sheikh 2004). Vegetables and other agricultural commodities are no exception to above mentioned observation.

Risk may be defined as the divergence between the estimated and the actual outcomes. While this deviation may be positive or negative, a negative outcome has greater importance from a practical point of view and is usually the focus of decision-makers.

Farmers face a number of risks which are often interconnected. Six types of risk (according to their sources) are generally considered in agriculture:

1. Production risks, concerning variations in crop yields and livestock production, affected by a range of factors: weather conditions/climate change, pests, diseases, technological changes as well as management of

natural resources such as water. Damage caused by the cotton Leaf Curl Virus or floods/ droughts are the most important examples.

2. Price and market risks, associated with variability in output price (mostly), also input price variability and integration in the food supply chain (with respect to quality, safety, new products, etc.). A sudden rise in prices of fertilizers due to shortage that caused escalation of cost of production in the past in Pakistan or decline in prices of maize or poultry products are the important examples.
3. Regulatory risks connected with the impact of changes in agricultural policies (e.g. subsidies, regulations for food safety and environmental regulations) or trade policies: a change in governmental actions, which is at odds with what farmers expected, may have a negative impact on their income. A direction by the government to sow a specific variety of sugarcane is another example.
4. Technological risks associated with the adoption of new technologies. A specific harvesting technique may be taken as an example.
5. Financial risks resulting from different methods of financing the farm business, subject to credit availability, interest and exchange rates, etc.
6. Human resource risks, associated with unavailability of the personnel. This is particularly true in case of shortage of labour during harvesting times.

6.5. Management of Risks

Management of risk starts with decisions on the farm and at the household level: which outputs to produce, how to allocate land, which inputs and techniques to use. Diversification of activities on and off-farm normally contributes to reducing risk. The level of the farmer's integration in the food supply chain also affects the level to which the farmer is impacted by price volatility. Vertical integration – when the farm controls a commodity across two or more levels of activities, typically reduces risks associated with a variation in quantity and quality of inputs (backward integration) or outputs (forward integration). Vertical integration is more common in the livestock sector (integration backward into feed manufacturing) or in the fresh \vegetables sector (integration forward into sorting and assembling).

6.6. Evolution and Stages of Development of Agricultural Marketing in Pakistan

After independence of Pakistan, government laid emphasis on food production whereas distribution and marketing were generally assigned low priority. As such, development of agricultural marketing took place at a slower pace. The first five year plan (1955-60) identified many weaknesses in agricultural marketing system. Amongst others inefficiencies in the methods of buying and selling, assembling and processing, transportation of farm production and utilization of market resources were the key factors affecting development of agricultural marketing system in the country. In order to cope with various challenges, some policy measures (proper implementation of grades and standards for agricultural commodities, grant of agricultural loans by Agricultural Development Bank (ADB) of Pakistan to farmers for the purchase of fertilizers, High Yielding Variety Seeds (HYV), farm implements and pesticides, training of stakeholders in post-harvest management and grant of subsidy for construction of cold storages in different production areas etc. were undertaken to ensure reasonable price to the stakeholders and improve the efficiency of the agricultural marketing system in the country. Although government focused its attention in strengthening agricultural marketing system by bringing improvements in marketing infrastructure and post-harvest management, noteworthy progress was not achieved in the implementation of proposed measures.

The second (1960-65) and third (1965-70) five year plans underlined the need for removing various weaknesses (such as malpractices of middlemen, inefficient handling of produce during marketing, inadequate storage space, improper processing, non-compliance to standardization and grading, inadequate supply of packing material etc.) in the agricultural marketing system. Government adopted some measures to enhance efficiency of agricultural marketing on the recommendations given in the second and third five year plans. Some of the measures undertaken by the government for the rehabilitation of agricultural marketing in the country included promulgation of Weight and Measures Act in major areas of Pakistan, implementation of grades and standards for major exportable agricultural commodities and up-gradation and improvement of existing markets and development of new regulated agricultural markets under the provisions of Agricultural Produce Market Act of 1939.

The plans identified hoarding, price manipulations by the middlemen and insufficient supply of agricultural loans as some of the major impediments in the development of agricultural marketing system. High priority was assigned to overcome various obstacles in the system. Incentives were provided through grant of subsidies and by fixing floor prices of agricultural products and by strengthening the institutional framework for agricultural markets. Along with these measures, government approved Agricultural Produce Marketing Regulation Bill to envisage the newly emerged regulated markets. Despite these measures, lack of cold storages/warehouses for perishable commodities, improper grading and standardization, poor infrastructure (farm to market roads) continued to be the major obstacles in the smooth working of the agricultural marketing system in the country.

The policy measures of the government in 1970s' remained primarily focused on the evolution and implementation of support price mechanism and making necessary arrangements for export of agricultural products keeping in view the trends and requirements of international markets. Support price programs for food grains (wheat) were successfully implemented. Adequate machinery for procurement operations was provided and storage capacity for agricultural commodities, especially for food grains was enhanced. In order to improve terms of trade, government increased export quotas and reduced import tariffs. The policy was further expanded to secure sanitary safeguards against the import of pesticides through provisions of Pesticides Act.

The fifth five year plan (1978-83) emphasized the need for strengthening market infrastructure. Based upon recommendations outlined in the plan, government undertook measures to develop market infrastructure and ensure timely availability of agricultural inputs (chemical fertilizers, pesticides and farm machinery) at reasonable prices and supplement imports when necessary. Pakistan Agricultural Storage and Services Corporation (PASSCO) was established in 1973 to ensure better returns to producers as well as reasonable prices to consumers. In addition, improved marketing and processing technology was adopted through collaboration between local entrepreneurs and reputed firms in the international markets. Marketing institutions (market committees, trading/export houses, commodity stabilization funds, support price cover, grading/quality standards through various institutional mechanisms) were established. Some progress was witnessed in improving infrastructural facilities (such as grain silos, warehouses, cold storages, product quality testing laboratories, grading and primary processing plants, transportation systems for handling and speedy clearance of perishable agricultural commodities etc.) Air-freight arrangements for promoting export of perishable products were improved. The development of food processing industry (through availability of cheap packing material and chemicals supported with other incentives such as packaging, tax concessions, import of machinery for modernization etc.) remained an important component of government policy. In short, agricultural marketing system received boost as a result of establishment of new processing plants, better procurement measures and improved transportation and distribution systems. Notwithstanding achievements, little progress was made in the construction of new storage facilities for major food grains and for perishable commodities and in improving management skills of the stockholders/market functionaries.

The last decade of the century was characterized with government's focus in promoting and diversifying exports and ensuring price stability. This era witnessed the emergence of WTO and globalization of international trade. These developments changed dynamics and requirements of agriculture. Pakistan, like many other developing countries, had to undertake structural and institutional reforms to cope with the changing environment. As a result, government assigned priority to establish and develop various institutions for boosting exports of high value crops. Pakistan Horticulture Development and Export Board was created to develop the horticulture Sector and to boost exports of various horticultural commodities (e.g., mango, kinnow, apples, dates etc.) and to cope with the emerging challenges encountered in international trade due to implementation of various WTO agreements (e.g. AoA, SPS, TRIPS etc.). Export targets for various agricultural crops were not achieved due to poor compliance to the requirements of various developed countries.

Pakistan is a developing country and overtime agriculture has proved its central importance in uplifting and supporting the economy of the country but still its real potential needs to be realized. After independence, various governments took measures to improve agriculture sector, particularly on productivity enhancement, however, agricultural marketing remained a neglected area as little attention was paid to the development of marketing infrastructure and post-harvest management of agricultural commodities.

Agricultural marketing infrastructure plays an important role in facilitating and ensuring smooth functioning of agricultural marketing system. An efficient logistic system is critically important for efficient performance of the marketing system. If the transport services are infrequent, and if quality is poor or expensive, then farmers will be at a disadvantageous position in selling their crops as an expensive service that will lead to low farm gate prices (the net price the farmer receives from selling his products). Seasonally impassable roads or slow and infrequent transport services, coupled with poor storage, leads to the enormous losses of many agricultural products, especially the perishables (milk, fresh vegetables, and fruit) as they deteriorate quickly resulting in lower prices to farmers. As such, all weather roads play crucial role in enhancing market surplus for many of the agricultural products.

Improper post-harvest handling of agricultural production in Pakistan results into quantitative and qualitative losses causing rise in consumer prices. These losses are enormous particularly for perishables. Such losses cost billions, which if avoided can ensure abundant supply of food at all times. Post-harvest losses of cereals, fresh fruits and vegetables are the results of many disorders during the handling, packaging, storage and transportation of the products and infectious diseases, which vary greatly among commodities, production areas and seasons. Other reasons for losses include excessive or insufficient heat or cold, improper mixture of environmental gases (such as oxygen, carbon dioxide and humidity) and inadequate storage and transportation facilities. Further, the losses are caused by mechanical damages (such as bruising, cutting, excessive pooling or trimming). In the developed countries, the post-harvest losses of agricultural commodities are nominal, whereas about 10-30 percent losses have been recorded in developing countries. However, world-wide post-harvest losses in the case of horticulture crops ranging between 30-35 percent are comparatively high (Hanif and Khan 2004).

6.7. Approaches to Understand Agricultural Marketing System

Agricultural marketing is a process of facilitating stakeholders that include suppliers, farmers, market agents, processors, retailers and consumers. These marketing practices are performed in different ways in Pakistan and in order to understand these market practices, a complete exploration of processes is necessary. For the sake of this, following section describes the different angles by which we can understand marketing system of agricultural products in Pakistan. This system can be studied by observing different functions performed or by analyzing the role of various agencies/ institutions involved in the agricultural marketing process or taking a commodity as case study.

6.7.1. Functional approach

The functional approach is one of the methods used in classification of activities that occur in the marketing processes by breaking down the processes into functions. A marketing function is defined as a major specialized activity performed in accomplishing the marketing process. The activities involved in agricultural and food marketing processes are generally classified in three sets of functions as under;

1. Exchange functions

2. Physical functions
3. Facilitative functions.
4. Exchange functions

Exchange functions refer to those marketing activities which are related to the transfer of ownership of goods and are mainly related to price determination process in the marketing chain. The exchange function has two sub-functions i.e. buying and selling. The primary objective of both buying and selling functions is the negotiations of favorable terms of exchange.

5. Physical functions

The physical functions include all activities related to the movement, handling and physical transformation of agricultural commodities. These functions are useful in solving the issues related to what, when and where in marketing.

6. Facilitative functions

The facilitating functions contribute in ensuring the smooth performance of the exchange and physical functions. These functions don't directly take part in the exchange of title or the physical handling of the products.

6.7.2. Institutional approach

Another method of market analysis is to study the various agencies and business structures which perform the marketing processes. Where the functional approach attempts to answer the "what" in the question "who does what," the institutional approach to marketing problems focuses attention on the "who." Marketing institutions are the wide variety of business organizations that have developed to operate the marketing machinery. The institutional approach considers the nature and character of various middlemen and related agencies and also the arrangement and organization of marketing machinery. In this approach, the human element receives primary emphasis.

Middlemen are those individuals or business concerns who specialize in performing the various marketing functions involved in the purchase and sale of goods as they are moved from producers to consumers. Our concern, here, is within the place in the marketing processes which the middlemen occupy. There is no limitation as to the way in which they are organized for doing business. They may operate as individual proprietors, partnerships, or cooperative or non-cooperative corporations. The middlemen of particular interest in agricultural marketing can be classified as follows:

1. Merchant middlemen (wholesalers, retailers)
2. Agent middlemen (commission agents, brokers, auctioneers)
3. Speculative middlemen
4. Processors and manufacturers
5. Facilitative organizations
6. Merchant middlemen

Merchant middlemen normally take title to, and therefore own, the product they handle. They buy and sell for their own gain and derive their income from the margins arising from the sales (i.e. difference between buying price and selling price). Unlike other classes of middlemen, they hold uncertainty to a minimum i.e. know what the buying and selling price in going to be. They are not risk takers.

i. Wholesalers

Wholesaler is any merchant who does not sell to ultimate consumer in any significant amount. He, therefore, can sell to other wholesalers or to industrial users or retailers. Wholesalers make a highly heterogeneous group of varying sizes and characteristics.

ii. Retailers

A retailer is any merchant middlemen who buys goods / services for resale directly to ultimate consumers. They represent the most numerous types of agencies involved in the marketing process. In terms of undertaking marketing functions their role in not easier as compared to the wholesalers. In fact, a retailer may have to do all the functions of marketing and thus this thing makes his job complex. Retailer is the producers' representative to the consumer (Hussain et al. 2003).

7. Agent middlemen

All agent middlemen of marketing don't own what they handle i.e. they do not take title to the goods. They derive their income from the fees they are paid by their clients or commissions given. Agent middlemen in reality sell services to their principals, not physical goods to customers. There are three categories of agent middlemen:

i. Commission agents
ii. Brokers
iii. Auctioneers

Their main stock in trade is their knowledge of market in which they participate. They use the knowledge in bringing together potential sellers and buyers. Their services will be retained either by buyers or the seller who feels that he / she does not have knowledge or opportunity to bargain effectively for him / herself.

iv. Commission agents

The difference between the brokers and the commission agents is on one degree.They are given power to handle the product that is being sold i.e. discretionary powers to assist their principals in ensuring that marketing process is accomplished one. Commission agents are given more discretionary powers over physical handling of the product, arrangement for terms of sale / purchase, and the collection of revenue from sales. They are allowed to deduct their commission before remitting the difference to their principals.

v. Brokers

They are not given any physical control over the product. They ordinarily follow directions from their principals. Usually, they have little power over terms of sales or revenue collection. They bring seller and potential buyer together.

vi. Auctioneers

They do not own what is handled, rather they may be involved in a number of activities. Theyhave places for physical displayor space where participants meet, announce the date of auction, and facilitate in price formation. During the bidding process, the main role of auctioneer is to announce the price offered by various participants such that it is heard and the highest bidder gets the good subject to the price being equal or greater than reserved minimum price. Prices closely conform to a competitive market price.

8. Speculative middlemen

These are those who take title to goods / products with a major purpose of profiting from price movement. They are specialized risk takers. They take uncertainty asis given. They are also called traders, scalpers and spreaders. Important distinguishing feature is that even though speculative middlemen involve themselves in movement of goods that is not their goal. Speculative middlemen are interested in short term price fluctuations. Speculators derive their income from short term price fluctuations in goods they handle. The emergence and growth of speculative middlemen is due to the fact that merchant middlemen are not willing to engage themselves in added risk involved in purchasing and storing of goods for longer period of time. Speculative middlemen play important role in marketing process in ensuring that commodities are available from time to time.

9. Processors and manufactures

Their role in marketing is to undertake some action on the products in order to change their form. Form changing is basically a marketing service. Manufactures and processors may take active role in other institutional aspects of marketing e.g. they may act as own buying agents in the producing areas, wholesaling of finished products and promotions. Processing and manufacturing are only the part of activities they get involved in.

10. Facilitative organizations

Their main function is to facilitate the activities of the other middlemen of marketing. They ensure that the activities take place in smooth manner and do not directly participate in marketing process either as merchants, wholesalers etc. They, basically, establish the rules that the other participants have to follow. Others may get involved in establishing the terms of sales and standards which must be followed, assist in grading of the product, and do actual arrangements of payment for the transactions. Some of the organizations provide physical facilities for the handling of the product. Others are involved in enforcing /policing the practices of their members.

6.7.3. Commodity approach

Increasing attention is being given to the development of theory in marketing. Theorists have used functional, managerial, and institutional approaches with relatively little emphasis on the commodity approach during the past decade. In this topic, the role commodities might play in formulating hypotheses which could lead to better theory in marketing. While the commodity approach is perceived as obsolete with few marketing journals or textbooks referring to it as a marketing research method, commodity based papers are still prominent in the marketing literature. This topic expounds sources and conditions of supply, storage, transportation and standardization and demand of agricultural commodities. It also explains the role of middlemen in commodity marketing. While the sources of supply may refer to the geographical location of the agricultural commodity or the different stages of the marketing system, conditions of supply refer to the form of the product which may either be in its raw or processed form. Storage refers to the logistical, technical and economic considerations during the process of storing agricultural commodities. Transportation and standardization refer to the process of ensuring requisite quantitative and qualitative standards. They also refer to the physical movement of the commodity-- from the point of purchase to the point of sale. Demand of agricultural commodity tries to capture the preferences of consumers of the commodity in its various forms, while the role of middlemen in the movement of agricultural commodities from the point of purchase to the point of sale is also explained.

6.8. Agricultural Marketing Problems and thier Solutions

Major problems in agricultural marketing system of Pakistan are as under;

1. Low quality of produce

The production of agricultural goods is generally of low quality due to the lack of grading, use of uncertified seeds, low quality of pesticides/weedicides and conscious adulteration etc. The agricultural producs like cotton, and rice, do not enjoy good reputation in the foreign market due to the lack of observance of SPS measures. As a result the cash returns to the producers, are low. The quality of rice is affected by presence of mixture of different varieties at various stages including its high broken percentage.

2. Lack of proper and modern wholesale markets

Many wholesale markets were built years ago and are unable to cope efficiently with increased transactions of today. Serious traffic congestion, insufficient space for efficient movement of products in and out, inadequate storage and improper management are some of the major factors for increased marketing costs and physical losses of farm products. Hygene conditions particularly in case of fruit, vegetables and livestock are quite dismal (Ali 2000).

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Although market committees have been constituted under the provincial statutory laws and are responsible for smooth administration, operations, management and development of these markets in respective province, their activities are much influenced by political interests. Most market committees are unable to discharge obligations. The sole concern of market committees is to regulate marekts. Unfortunately, enforcement of regulations is mostly defective and is to the disadvantage of entire marketing system.

3. Lack of 'farm to market roads' and poor transporation facilities

Poor farm-to-market roads is a common feature of agricutlural marketing system. These roads are often unusable during rainy months and in some cases during chilly winter. Current length and status of farm-to-market roads is not satisfactory. The present length of farm-to-market roads (60,000 km) is crucially less than potential requirements.

Poor condition of farm-to-market roads is also a stumbling block in introducing innovations and new teachnology some time (replacement of wooden crates with fiberboard boxes in spite of their positive impact on net returns to farmers).

High freight is charged by transporters due to poor condition of roads, which ultimately increases marketing costs, largely shared by the consumers and farmers. Non-existence of good roads limit the use of economical mode of transporation (e.g. trucks). As such, farmers and traders have to rely upon relatively less efficient mode of transportation (eg carloads, small vans etc.).

4. Inappropriate storage facilities

Inappropriate storage facilities (both in the public and private sector), register highest losses during handling operations. The perishable farm products (fruits and vegetables), due to their specific nature and characterstics, require variable storage conditions. In most of the cases, products (especially the perishable products) is stored in shallow pits covered with farm wastes without ventilation, without proper sanitation and preventive measures for insect and disease control. These conditions usually exist in on-farm storage houses.

This becomes more important in the light of recent food crisis (for commodities like wheat, sugar, milk, maize and meat). As stated earlier public storage facilities are not sufficient for maintaining stable supply of agricultural commodities to the stakeholders. The investment by the private sector is nominal and can be enhanced by offering special incentives (subsidy in the construction of storages). Additional storage facilities can be established at farm level and also at market levels to avoid shortages (and handle surpluses) of food stuff.

5. Lack of Post-Harvest Technology and Management

Post-harvest losses still remain as one of the most pressing problems particularly for perishables. Despite advances in research, enormous quantitative and qualitative losses still occur. The extent of loss depends on how the commodity is handled from farm to the market. Studies reveal that post-harvest losses are greater than production losses. These losses are not due to a single contributory factor but associated with different factors in post-harvest operations. Lack of farmer's awareness about scientific handling of farm produce especially the perishables, aggravates this situation. High post harvest losses if avoided can contribute in marketed surplus thus increasing returns to farmers and adding to supply, bridging gap for any shortages.

6. Lack of modern cool chain infrastructure

Modern cool chain infrastructure is prerequisite for an efficient agricultural marketing system. However, Pakistan lacks an integrated network of facilities in this regard. Post-harvest losses, loss in foreign exchange earnings, price destabilization, and quality deterioration (reduced shelf life of the products) are outcomes of absence of cool chain net-work in the country.

The existing cold stores do not have blast freezers that enable to bring down temperature of the products to a level that can be maintained within the cold store. Its absence causes the products to be taken directly into the cold store which loses heat within the store and deteriorates the temperature of the commodities already present in the store.

7. Processing and value addition of agricultural commodities

Processing of agricultural commodities is performed to add value and prolong life. This is another good option to make existing supply of agricultural commodities more sustainable. Some types of fruit are processed into products like jams, jellies, squashes, juices and pulp. Even many vegetables are processed by extracting moisture/water to prolong their shelf life (eg dry vegetables, cutlets and essence etc). There exists enormous potential forvalue additionin various agricutlural commodities especiallly perishables in the country which can be exploited by inculcating entrepreneurial skills among stakholders by offering special incentives by the government to the agribusiness entrepreneurs (Arifeen 2009).

8. Poor physical handling of perishable products

The typical farm products change hands from four to ten times. Initial handling is done in the field during harvest where the product is subject to various handling operations viz picking, piling, sorting and packaging. During this process, significant loss of products occurs. Careless loading and unloading of perishable farm products also cause heavy losses. As such, while analysing marketing costs, significant part of total marketing costs is comprised of produce handling cost.

9. Inappropriate packing and packaging

The types of containers used for transporting and storing products (e.g fruits and vegetables) vary from place to place. The most popular containers for fruits packing are wooden crates. Irrespective of the structure and properties of the farm products, a common practice is to use whatever container is available. As a result, product is pressed hard in the crates or carried in oversized containers causing huge loss. Currently, the private sector enjoys an exclusive monopoly in the packaging material industry in Pakistan.

10. Non implementation of grades and standards

By its very nature, agricultural product is characterized by variation in its quality. The specifications for classifying various fruits and vegetables vary and depend upon the nature of the product and requirements of the marketing system. DAPLMG and PSQCA are entrusted with the task of setting of grades and standards and their enforcement. Pakistan Horticultural Development and Export Company (PHDEC) has recently taken up the responsibility of setting grades and standards for various horticultural products. Although grades and standards for the exportable fruits, such as, mango, apple and kinnow have been established but not enforced in true letter and spirit. Not only the existing grading system covers few fruits but also their enforcement is poor.

11. Lack of agricultural marketing information system (AMIS)

Availability of accurate and timely marketing information plays an important role in fascilitating the process of transactions. In addition, this infromation helps in negotiating and establishing prices for the stakeholders. Farmers are handicapped by lack of reliable information on prices and market conditions. Many farmers take the price dictated by the traders or their informal financiers. Even the traders who operate in rural areas are not well informed about the prevailing prices in the wholesale markets. Even if the information is available, it is either too late or inaccurate. Information on daily prices and market arrivals are vital for farmers and village traders in planning shipment of their products, and in negotiating prices.

Possible Interventions

The importance of wholesale markets in the agricultural marketing system of Pakistan needs no emphasis. These markets confront many problems in the sphere of their operations, management and control. There is strong need to address various problems hindering, proper functioning and development of these markets. As stated most of the wholesale markets in the country were established long ago to cater to needs of population of given time, over years these markets have outlined their utility due to their location and many other inherent problems (size, design etc) markets to perform as cardinal link between producers and consumers. As such, there is need to establish new model markets fully equipped with requisite facilities. In this context role of market committees needs to be redefined and various implementation of clauses of Agricultural Produce Markets Acts ensured. Private sector successfully operates the wholesale markets for poultry and its products. This model may be carefully reviewed and adopted for other commodities with the involvement of private sector.

Recent food crisis (wheat flour, sugar, maize, rice and milk) has highlighted weaknesses in two areas i.e. storage and market information system. Available capacity and condition of various storage houses in the country is not satisfactory and consequently results into higher losses of the produce. An effective policy for creating new storage capacity is the need of time. As such, new storage facilities at farm and market levels be created. Besides, measures be adopted to establish cold storage facilities on scientific footings. The private sector should be encouraged to invest in this area by offering special incentives (e.g. zero rated imported equipments and tax exemptions). Government should further chalk out a comprehensive plan for establishing cool chain network for perishables. Punjab Agricultural Marketing Company (PAMCO) has already established one cold storage house at Lahore airport. More facilities on this pattern may be offered after carefully reviewing the merits and limitations of this experiment. Cool chain network for other perishable commodities (eg milk, meat, fruits and vegetables) and a plan in this respect be clearly chalked out. The recent food crisis in the country has underlined the need for preparing a comprehensive plan to cope with the surplus and shortages cycle manipulated by the stakeholders or created due to disequilibrium in the supply and demand equations. Amongst others, lack of market information available to stakeholders makes them dependent on market players who exploit under one or the other context. An effective Agricultural Market Information System (AMIS) be established by linking wholesale markets with the major producing areas through internet and other electronic media.

Proper infrastructural facilities are the backbone of an efficient agricultural marketing system. Current farm-to-market road network is not in a good condition. As such, full coverage of rural areas of the country is not ensured. Existing farm-to-market roads length is 60,000 Km which should be expanded to at least 350,000 Km. In addition, existing roads should be renovated to improve their workability.

The bulk of agricultural commodities in Pakistan is traded in its fresh/raw form. There is a need to change the mindset of stakeholders. New agri-business can be promoted for adding value to various commodities through processing at farmers' door steps. In this context, the PAMCO and PHDEC may be assigned the task to accomplish this objective.

The present status of human capital especially in the agriculture sector is not satisfactory. Farmers and other stakeholders in the supply chain are not fully equipped with technical know-how and skills required for performing various marketing functions efficiently. New agricultural marketing and post-harvest management institutions should be established with the mandate to impart technical training to the stakeholders, on various aspects of agricultural marketing and post-harvest management. The role of TEVTA needs to be redefined in this regard. Special training programs in the area of agricultural marketing and post-harvest management should be entrusted to TEVTA with a supervisory role assigned to the agriculture universities of the country in this regard.

In addition, department of agricultural extension in all provinces should be reorganized and new mandate must be assigned, keeping in view the emerging challenges in the field of agriculture and international trade of agricultural commodities.

Commodity boards were established for various agricultural commodities in the past but were dissolved due to mismanagement and malfunctioning. Commodity boards for major agricultural commodities may be re-established with the participation and involvement of private sector. Keeping in view the past weaknesses in the conduct and operations of such boards, emerging problems should be tackled and the new institutions must be run on sound business footings for the welfare of farming community and other stakeholders.

Farmers' cooperatives were established in various spheres of economic activity but experience with their working in agriculture sector did not yield good results. Nevertheless, the idea still holds its validity in many countries having almost similar socio-economic and cultural traits. It is suggested that farmers' cooperatives may be organized avoiding past mistakes.

There is a need to analyze various impediments coming in the way of various supply chains of agricultural commodities. Research may be undertaken at various agricultural universities to develop appropriate feasible supply chain models for agricultural commodities which enhance interaction among stakeholders and improve their working efficiency.

There is lack of effective coordination between various institutions entrusted with the role of strengthening the operation of agricultural marketing and post-harvest management systems in the country. For instance, three institutions (DALPMG, PSQCA and PHDEC) have the mandate of establishing grades and standards for agricultural commodities. Policy measures should be adopted to enhance coordination between these institutions and to avoid any duplication and overlapping of tasks assigned to each organization.

The planning commission, Government of Pakistan seeks to establish Agro Processing Centres, for supplying farm inputs to stakeholders and to undertake the task of marketing of their produce. It is sound proposal. 200 Agro processing centres as proposed should be established across the country. PAMCO along with PHDEC may be assigned task of establishing these centres in collaboration with private sector. In this regard, Pilot projects can be started at district level after reviewing potential requirements of stakeholders in the production areas.

There is dire need to introduce market-oriented agricultural practices. This necessitates for inculcation of entrepreneurial skills among stakeholders. Federal government in collaboration with respective provincial governments should establish Entrepreneurship Centres for Agribusiness and Rural Development (ECARD) in various agricultural universities of the country. Furthermore, Agribusiness Incubators be established at different agribusiness clusters to provide farming community and stakeholders with required information and new business ideas. The incubators should offer necessary technical advice managerial know-how, information and training in marketing management, advertising and sales promotions, branding and labelling etc. to enable the stakeholders to earn more profit.

There is strong need for undertaking research on current and emerging problems in the field of agricultural marketing infrastructure and post harvest management. Agricultural universities in the country may be entrusted with this task. Private sector be involved to make research efforts undertaken at universities result oriented and close to reality. Private sector be motivated to invest in research on these areas.

Diversification of agriculture is inevitable given the emerging trends, challenges, and requirements of international trade in the context of WTO. New agriculture ventures (floriculture, agriculture along with new avenues for value addition of agricultural and livestock products etc) identified and priorities assigned in National Plans in this regard.

The livestock sector has huge potential which may be exploited if proper investment is directed towards this sector. Policy measures be introduced to strengthen dairy industry in the country. Punjab Dairy Development Company is already performing a good task by establishing Model Dairy farms in the province. There is a need to extend this initiative in other provinces too. In this regard, import of machinery and breeds should be declared zero rated in the upcoming Tenth Five Year Plan. There is also a need to reorganize wholesale cattle and buffalo markets keeping in view the emerging market requirements. The hygienic conditions of various Abattoirs need improvement. There is a need for establishing Abattoirs on scientific footings.

A great export potential of agro-based products, particularly fruits, vegetables and livestock products exists in Pakistan, but stringent application of international standards hamper realisation of their real potential. In particular, Pakistan is constrained in its ability to export agricultural and food products to developed countries under SPS requirements. In certain circumstances, SPS requirements are incompatible with prevailing systems of production and marketing in Pakistan. The problems, Pakistan has in complying with SPS requirements, reflect its wider resource and infrastructure constraints that limit not only its ability to comply with SPS requirements, but also its ability to demonstrate compliance. A particularly acute problem is access to appropriate scientific and technical expertise. Indeed, in Pakistan knowledge of SPS issues is poor, both within government and the food supply chain, and the skills required to assess SPS measures applied by developed countries are lacking. There is a need to impart training to stakeholders and prepare them to comply with SPS measures in the production and export of agricultural products.

6.9. Future Challenges

Under the WTO regime, there is an urgent need to educate growers. They need to concentrate on improving the quality of products by adopting proper grading, standardization and storage. The Government both at the Federal and Provincial level shall have to develop efficient and strong marketing infrastructures for timely availability of the goods at the right place, at the right time, at the right price and in the suitable form needed in the domestic and international markets.

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Chapter 7

Economics of Risk Management

Muhammad Ashfaq, Syed Asif Ali Naqvi and Javaria Nasir*

Abstract

The standard method of dealing with abnormal events is defined as risk management. Risk is the chance of loss or hostile consequence related with an action. It is logical procedure for the quantification of possible costs of risks in contradiction of the possible benefits of permitting the risks said to stand uncontrolled. For the sake of much better recognizing the risk management, the terms hazard and risk must be discussed. Prior is basically existing situation, event, or object that could cause or pay to an accidental or undesired event. However, the latter is future impact of a hazard that is not controlled or eradicated. It can be considered as future uncertainty due to the hazard. If it comprises skill sets, the same situation may yield different risk. Risk assessment involves its identification, investigation, and prioritization. This process includes planning, mitigation and monitoring of risk. On the other hand, the risk is extent or degree of uncertainty.

Keywords: Risk management, uncertainty, risk assessment and economics

7.1. Introduction

Quantification of risk management gives several definitions, but it is a practical method to manage uncertainty, or it is a quantitative value assigned to a task, action or event. In the agriculture sector the farmers hire a variety of market based and informal tools to cope risk relevant with cost and production. A noteworthy volume of work has been available about these risk management approaches, for example,

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on farm risk management, purchase and sale of financial tools (such as future contracts), manipulation of government policies (such as price stabilization and underwriting schemes), drought relief strategies and agricultural management securities (Chambers and Quiggin 2004). Therefore, it can be said that risk management is the scheme used to control, eliminate or reduce the hazard within parameters of acceptability and it is exclusive to each and every individual as there are no two people exactly alike in skills, knowledge, training and abilities. In many cases, one distinguishes that his or her level of risk competence is in fact more than their ability, thereby, it is dangerous. It is the decision making process intended, to recognize hazards systematically, assess the degree of risk, and control the finest course of action. Once risks are identified, they must be estimated. Assessment determines the extent of risk whether these are negligible, low, medium, or high. Once the planned activity is started, attention must, then, be given whether to continue or not. So, it can be summed that hazard and risk are the two significant features of risk management. The risk management process includes four levels identification, assessment, evaluation and monitoring as has been shown in fig 7.1.

Fig. 7.1 The iterative framework for risk management

The economics of risk management specially deals with the costs of risk management; whereas the cost of control must be less than the cost of loss. It can be evaluated on the basis of pain and gains, Cost of compliance (pain) must be less than cost of circumvention (cost of gain).

7.2. Identification of Risks

The leading stair in the process of managing risk is the recognition and classification of potential risks. There are five basic sources of risk classification, production risks, marketing risks, and financial risks, and legal and human risks. These are briefly discussed in the following diagram. The profit or returns and costs are affected by all these risks as is shown in the diagram (Dana 2010).

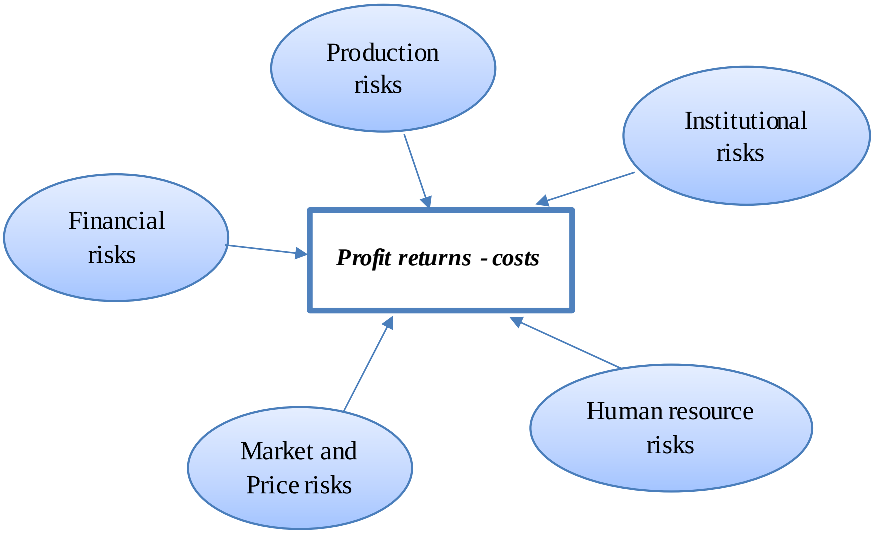

Fig. 7.1 Contributing factors diagram of market price risks

7.2.1. Production risk

Expected outcome or yield reflects farm production. Unpredictability in the outcome poses risks and variation in capability to attain financial goals. Any action (that has a diversification in the yield), tdirectly or indirectly interrelated to the process of production is the production risk. The main reasons of these risks are environmental variability, pest attack, diseases, cropping technique and their quality, and the quality of inputs. Other natural disasters like fire, wind, theft, and casualties could also be the causes of production risks as well.

7.2.2. Marketing risk

Marketing is a process or channel through which farmers take their produce to end user or middlemen in the market by a sophisticated pattern. Buyers, in a global market and other unexpected forces such as weather or government actions, are the potential marketing risks. The risk in any market is a related action or happening (that results in the change of prices that the farmers obtain for their output or pay for farm inputs).

7.2.3. Financial risk

This type of risk can be caused due to the financial health of the trade. There are following fundamental constituents of financial risks, price and affordability of capital, capability to meet cash flow requirements in a well-timed means, and the ability to preserve and produce equity and ability to absorb short-term financial jolts.

7.2.4. Legal risk

Many of the repeated events of all agriculturists include commitments that have legal insinuations. Proper understanding of these subjects can result superior risk management. Sometimes, legal risk issues overlap other than the other areas of risk. Likewise, acquisition of agricultural credit shows financial as well as legal implications, if not repaid in the stipulated time. Farm production events (comprising the application of chemicals) have also legal implications if suitable safety protections are not adopted. Marketing of farm products can encompass agreement legislation as well. Human issues connected with the farming sector could also have consequences like these.

7.2.5. Human risk

In the business venture, the individuals are both a source of business risk (for example non-technical agricultural labor and ill-mannered farms mangers) and an integral portion of the approach for coping with risk (farm owners). At its core, human risk management is the capability to retain all those who are involved in the business and it can be divided into four types, Human health and wellbeing, family and business contacts, human resource management and transition planning. Table 6.1 summarizes the sources and management, and the controls of risk management.

7.3. Strategies for Accelerated Economic Growth

Here in this section economic review of some of the strategies used for accelerated economics growth are given.

7.3.1. Yield and production trends

The need for agricultural growth is crucial for the development of the economies. It is essential to preserve a sustainable agricultural growth regardless of how fast the nonagricultural sector is growing over time. Frequently, it is an accepted fact that agricultural growth is not only an important part but also a prerequisite for the progress in the rest of economy. For the purpose of smooth economic growth, quantitative calculation of the contribution of certain indicators to growth of agricultural output is vital. There are several parameters liable for the farm sector development; area and yield are also among these (Singh 1981). Sources of growth are very important for development programs and for investment significances (Ranade 1980). Knowledge of difference in growth rates is significant to eliminate the blockages in attaining the fast growth of this sector (Sikka and Vaidya 1985). Growth decomposition in agriculture output has remained serious problem for policy makers. To help output project with substitute policies the collapse of growth into certain parts such as area, yield and cropping pattern is significant (Jamal and Zaman

1992). The pattern of farm production in the past and the quantification of its growth rates can fetch a foundation for future forecasts of farm production.

Table 7.1 Risk management sources and management control

Risk	Defined	Sources	Management Control
Production	Uncontrollable events such as weather, climate, disease and pest make the yield unpredictable. Changes in technology make the producer antiquated and the availability of inputs is also problematic, and the quality of input is not good.	Weather, Extreme temperature, pests, disease, technology, genetics, inputs (availability, quality and prices) equipment failure, labor etc.	Diversification, insurance buildings, storage, vaccines, extra labor, production contracts, new technologies
Marketing price	The input and output prices change after the production planning. Price fluctuations are due to changes in demand	Product quality (genetics, disease, handling, input feed) product price (quality, timing, global market, weather, government policy contracts.	Future and options, forward contracting, retained ownership, quality controls, storage, cooperatives, niche/ value added marketing
Financial	Stem from the way a business is financed. Borrowed funds leverage business equity but increase business risks.	Market, production, legal, interest rate changes, natural disasters, land market changes, foreign exchange, loan calls	Cash reserves, equity, borrowing capacity, reducing other types of risks
Institu-tional	Government or other institutional rules, regulations, and policies affect profitability through costs or returns.	Taxes, contract disputes, regulations, government policies, lawsuits, ambiguous and unwritten agreements, neighbors, environmental program	Estate planning, tax planning, contracts, bonds (environmental liability) research and education about local laws
Human resource	The character, health or behavior of people introduce risk. This could include theft, illness, death in the family, loss of employ, and divorce etc.	ambiguous and unwritten agreements, poor planning, miscommunication, health or other family problems	Family planning, including labor planning, clear contracts, training and goal setting, communication, estate planning

Source: Dana (2010)

7.3.2. Yield gap

Since last few decades the term ‘yield gap’ has been broadly used in the literature. It is defined as the difference between potential and actual yield over some specified spatial and temporal scale of interest (Ittersum and Rabbinge 1997). Actual yield is the average production taken by the growers. But yield potential can be described and quantified in many ways, which has resulted due to inconsistency in yield gap analysis in the literature.

7.3.3. Certified seed coverage

Pakistan’s economy heavily relies farming sector and in this regard seed is one of the strategic inputs for this. Quality seed carries inherited production potential and confrontation against the diseases and pests and tolerance of biotic and a biotic stresses. So, it is one of the significant indicators for attaining sustainability in agriculture. Private sector is playing a key part in multiplication and promotion of quality seed. Many private seed companies are working in the Pakistan in this field. But now instead of increasing number of companies, improvement of the mechanism is needed. Registered cultivar is the offspring of organization or certified seed handled so as to conserve acceptable genetic identity and is approved by the certifying agency (WSCS 2013). The cause of seed registration is to reserve and make accessible to the public through certification. Certification is also designed to attain agreed standards. Certification of complete quality shows seeds as to variety, varietal purity and mechanical quality. Certification of varietal purity only shows seed as to the variety and varietal purity and it does not substantiate mechanical quality.

7.3.4. Balanced use of fertilizer

Although fertilizer use can pay to ecological adulteration if not managed properly, it too plays a vital role for attaining potential yield and provides nutrients to crops. Unless the deficient nutrients are substituted in plausible proportion crop production cannot be sustained (soil will become despoiled). World fertilizer outlook is viewed from the perspective of the economic growth. In order to achieve the challenges of food security and environmental protection in developing countries, there is limited scope for area expansion alternative options, and to progressively depend on science based agriculture. In environmental friendly agriculture, mineral fertilizer combined with other modern chemical inputs, plays a critical role. Balance fertilizer use has pivotal role in green revolution technologies (Bumb and Baanante 1996). Progressive growers cannot be realized with the natural reserves of nutrients in most soils, these reserves should be augmented through synthetic or organic fertilizer application and this fertilizer use needs proper management. Because there only goal is to attain maximum production. Improper and overdose can damage the environment.

7.3.5. Farm mechanization

The productivity of farms depends greatly on the accessibility and proper application of farm power. Agricultural implements and machines enable the farmers to apply the power wisely for the sake of farm production. Farm machinery enhances the productivity of land and labor by meeting timeliness of agricultural activities and increase efficiency. Except its dominant influence on the multiple cropping and modification of agriculture; mechanization also facilitates efficient utilization of inputs like seeds, fertilizers and irrigation water. Agriculture is a sequence of planned procedures carried out by man on his natural environment, particularly affecting the soil and vegetation, for the purpose of systematically producing foodstuffs for subsistence and raw materials such as fibers. Agriculture is above all, a process of coordinating the preparation, care, maintenance and harvesting of crops, it also involves considerable handling and transport operations. Agriculture by definition involves the use of various implements (many of which must be mobile or transportable) and the application of directed force. Equipment must be suited to a particular treatment of the soil, crops and animals. Considerable progress in agriculture has only been made possible through improvements in implements and the means of propelling them. A change, from the use of draught animals to tractors as the source of motive power in agriculture, is brought because of perceived economic and human benefits.

7.3.6. Water for irrigation

Irrigation is key input for farming. It lessens suffering, conserves life, prevents famine, and upgrades the stability of the economy. Sometime, it is more valuable than land as water is applied to land it boosts up its usefulness up to six folds (Dhawan and Dass 1988). Research, in this field, has delivered security of life, increased the yields and value of land and revenue derived from it. In an agrarian economy like Pakistan, irrigation may be a good source of employment as well. Irrigation can raise both employment and income content of land and thus adds to capital formation. The productive irrigation enables rising of second and third crop in the lands. While, the protective aspect helps in stabilizing agricultural production against droughts, irrigation has the third aspect too. Irrigation improves and maintains the property of the land by sustained and adequate water supply. The growth of the agricultural sector aided by technological change has a comprehensive and a broad impact on the poverty alleviation of the people of the rural areas. As it reduces poverty in rural areas, it also reduces inequalities (Desai 2002). The future strategies of poverty reduction largely rely on irrigation. In addition, irrigation benefits are more to the population living in the low income quintile as compared to the upper income quintile, because irrigation generates employment and other feed backs in the rural economies. Increasing access to irrigation strategy helps the pro poor by reducing the severity of the poverty. Among all the variables selected for analyzing the poverty measures, irrigation has a crucial role in the reduction of poverty. Compared with rural literacy, irrigation has a much bigger marginal impact on the poverty reduction.

Agricultural productivity in Pakistan is still below its potential level as compared to the other developed countries as well as some other developing countries of the world. Lack of irrigation water is from one of the most serious problems being confrontedby the field of agriculture in the country. Although the agriculture sector of Pakistan mostly relies on canal irrigation, it still needs an efficient and sustained system of irrigation to increase the agricultural productivity. This efficient and sustained system will in turn increase the cropping intensities and cropping patterns. It is also a fact that Pakistan has the best network of canal irrigation, but still a great amount of water gets wasted (GOP 2003).

7.3.7. Diversification and value addition

Diversification is a business approach to move in a new market or industry which the business is not currently in, whilst also creating a new product for that new market (Ansoff 1957). It is a risk management tool that integrates a large diversity of investment within a portfolio. However, the value addition is the modification in the physical state or shape of theproduct or the production of a product in a way that increases its price, as validated through a business plan. Developing countries are being stimulated to diversify their food exports by developing new products and adding additional value to prevailing products. In case of food items, value and diversifying food exports rest not only on changing production and processing systems but likewise on connecting into suitable marketing systems. A value chain viewpoint is used to detect certain routes by which the value of food exports can be augmented. Keeping in view the approaches like providing fresh products, such products are offered for which consumers pay a price premium and also play active role in the development of branding activities.

7.3.8. Post-harvest losses

In the agriculture sector losses (quantitative and qualitative) occur in crops between harvest and consumption. These losses differ significantly among commodities production areas and seasons. Organic reasons of spoliation contain respiration rate, ethylene production, rates of composition of all changes, mechanical injuries, water stress, and pathological breakdown. Although the biological and environmental factors that are causing these losses are well known and certain techniques have been established to decrease these losses but they have not been implemented due to one or more of socioeconomic factors. Major socio-economic indicators are inadequate marketing systems, inadequate transportation facilities, government regulations and legislations, unavailability of needed tools and equipment, lack of information, and poor maintenance. Often, answers to existing problems require use of existing knowledge and use of available methods at suitable scale rather than conducting new research or developing new procedure (Kader 2005). Over whelming the socioeconomic constraints is necessary for attaining the goal of decreasing these losses.

7.4. Risk Management Frameworks

The risk management framework can integrate food security and market growth policy on long term basis. It could comprisethe following,

7.4.1. Weather insurance

It is comprised of the use of an index based weather derivative, contract to transfer the risk of severe national drought to the international markets. It can help achieve the financial risk linked with the exposure to intense weather conditions. It is crucial to any business or event whose revenues are vulnerable to weather.

7.4.2. Contingent import agreement (Call Option)

Contingent import agreement, or call option is a tool that provides the buyer the rights but not the obligation to buy stock for delivery later in the season. This is predefined agreement to purchase, if required at ceiling price at a pre-agreed time in the future. It also offers safety against upsurges in market price levels and elasticity about supply when the country is uncertain regarding the production sizes in the market.

7.4.3. Contingent export agreement (Put Option)

This type of arrangement is completely in contrast to the prior agreement. It is specified agreement to sell the products at minimum price in the future that was pre agreed. This is constructed on a put option, which bounces the buyer the rights but not the compulsion to sell for delivery later in the season. These options fetch security in response to falling prices and provide elasticity which is essential for a country when it is in short supply in its home market. If the stocks are needed in country, then it is not applied, export deals do not take place, and the stock remains in the country. Alternatively, if inventories are not required in the economy, this option would be practiced. This agreement safeguards the value of government held inventory until it is allotted to the domestic markets. The programming of obligations essential for this agreement would akin to that used one, for a call option.

7.4.4. Trade finance and call option

In this method, the private sector banks or local agents would procure the government's surplus inventory with a contract to sustain them in the economy and sell back to the government at a pre-agreed price if it is required. This is beneficial for the cash flow of the public's budget. Here, the first part of the contract is for financing for supporting collateral management of stocks held in the country, and second part is a call option. Stakeholders will be concerned in financing stocks held in national locations where warehouses are in sound condition and can be operated privately, based on collateral management agreements. Banks and local agents will finance the stocks and take responsibility for the collateral management function. All the other functions (such as procurement, handling and storage) stay with the government. This type of procedure offers government the guarantee of the quantity as well as quality of stocks to remain within country.

7.4.5. Crop or enterprise diversification

Diversification is an operational procedure of decreasing income differences. Effective diversifications take place when lesser income of one can be replaced by higher income of another enterprise. It, classically, decreases considerably in each year. Change in income may guarantee reasonable cash flow to overcome variable and fixed production costs over the time, debt obligations and household necessities. Getting information regarding the substitute business, expertise on new crop production procedures or information on equipment for a new crop may be costly. Growing into new areas or testing with new product will enhance the capital investment requirements. It involves diversed plant types, altered mixtures of goods (crops) and services, and diversed end points in the same production procedure.

7.4.6. Disaster payment

The Disaster Recovery Payment (DRP) is a payment for the individuals who have been adversely affected by a major disaster. This payment is made in the days of high impact and less probable disaster to the people who are unable to fulfil basic and immediate requirements for temporary lodging, food, essential clothing and medication.

7.4.7. Supplemental agricultural disaster assistance

In this type of assistance, financial support is provided for farm revenue losses due to natural disaster.

7.4.8. Emergency loans/Deficiency payments

These are governmental payments done to the farmers or producers for all or portion of a difference between the government-guaranteed value and the market price of commodity. These could be the direct governmental payments made to the farmers who contributed in the commodity programs for crops.

7.4.9. Hedging/ Forward contracts

This contract is basically an agreement between two parties to purchase or sell an asset at a specified price on a future date. This could be used for hedging or speculation although its non-standardized nature sorts it mainly apt for hedging that is the process of protecting oneself against risk. Hedging decreases the insecurity by buying something in a future market. These types of agreements could be customized to any commodity, amount and delivery date. Any financial market carries risks for its users, but the main function of some markets is redistribution of the risk. This is exactly what forward markets and derivative markets do (Djenic et al. 2012).

7.5. Food Security Strategies

Food security is considered a complex phenomenon, and with the passage of time the concept of food security has been taken as more convoluted form than before. Despite this difficulty the researchers have been successful in grasping the concept in some way. The notions of food availability, accessibility and consumption seem popular among the researchers as the pillars of food security (Andersen 2009). Hunger is omission- prohibiting from the land, from income, jobs, wages, life and citizenship. According to Josue de Castro ‘when a person gets to the level of not having anything to eat, it is due to the fact that the rest has been deprived of it. This is a modern form of exile. It is a sort of death in life’. The issues of preference and acceptability of food, on the part of the consumers, are also considered as key factors in this regard. If the ability to acquire food, which has consumers' preference and social acceptance, is uncertain and/or unacceptable, then the situation may be termed as food insecurity (Bickel et al. 2000). Food security is a state that occurs when all people, at all times have physical, social and economic access to the adequate, safe and nutritious food that fulfills their dietary requirement and food preferences for an energetic and healthy life (WHO 1996). Economic development comes in turn to reduce poverty, hunger and food insecurity that are also vital components of MDGs. Food security and economic together jointly interrelate and strengthen each other in the development process. Food security is thus important for national security, which is usually ignored. If a nation is unable to produce the requisite food demand and has not resources to afford from elsewhere (i.e. buy from international market to meet its demand-supply gap), that is not a food autonomous economy (Fullbrook 2010). Food inflation, in first decade of 21st century, elevated an apprehension on food security.

7.5.1. National food security policy

Notable features of Pakistani food by adequate production through enhancing the average productivities of farm products are:

- Lessen farm production cost for better returns to farmers
- Targeted subsidies and socio-economic safety nets for subsistence farmers
- Free movement of farm inventories by a viable food distribution network
- Increasing investment to build grain storage space through public and private sector participation
- By evolving an effective and reasonable system of food procurement, storage and distribution in the country
- By making better access of the poor household to food by implementing pro-poor growth framework and fetching non-agricultural employment on a substantial scale
- Structuring apparent and well-organized structure of safety nets income support provision to ultra-poor households

7.5.2. Institutional and legal framework for food security

There are several strategies to deliver basic values and strategies to attain food security and nutrition. These comprise World Food Summit (WFS), Rome Declaration on World Food Security, and all other international laws about food security. Particularly subsequent structures are important,

a) Millennium Development Goals (MDGs)

The United Nations MDGs offer a context in corporation, eight inclusive and precised improvement goals to be attained by 2015 to tackle life-threatening poverty and severe hunger. Millennium Development Goals comprised the goals and targets to eliminate life-threatening poverty and hunger, to achieve primary education, to promote gender parity and strengthen women, to reduce child mortality, to improve maternal health, to combat HIV/AIDS, malaria and other diseases, to guarantee environmental sustainability, and to grow worldwide corporations for the development. These all goals are interdependent. A major contribution to achievement of all above MDGs is to reduce the quantity of people who grieve from starvation.

b) The Voluntary Guideline to Support the Progressive Realization of the Right to Adequate Food in the Context of National Food Security (VGRTF)

This delivers a general outline to attain food security and food objectives. The fore most objective of food security policies is the right of provision adequate food to all. Programs, policies and regulations; that human rights principles should guide actions were designed to increase food security. These all should necessitate the empowerment of targeted population and the answer ability of right-providers.

c) The Five Rome Principles for Sustainable Global Food Security

These were agreed in November 2009 by the WFS in Rome, providing a commanding strategic reinforcement for synchronized act by all stakeholders, while implementing the twin track tactic to fight hunger.

i. Investigation's plans, aimedchanneling resources to well-designed and resultbased programsand partnerships.
ii. Raisestrategic coordination at all levels (national, zonal and worldwide) to developgovernance, stimulatebetter and equitable distribution of resources, evade duplication in efforts and trace out response gaps.
iii. Trying a comprehensive twin track approach for the sack that consists of; direct action to immediately challenge hunger for the most susceptible, andmedium-term and long-term sustainable agricultural growth, food security and balanced diet, andrural support programs (RSP's)to eradicatehunger and poverty root causes, and include theprogressive understanding of the rights to attain the satisfactory diet.
iv. Ensuring the strong role of institutions by continued improvements in efficiency, responsiveness, coordination and effectiveness.
v. Ensuring continued and considerable obligation by all stakeholdersthat investin agriculture and food security and nutrition to provide essential

resources timely and reliable way, aimed through multi years plans and programs.

d) UN Updated Comprehensive Framework for Action (UCFA)

It is a United Nations approach for international nations to support its action that yields viable rural livelihoods. It is not a multidimensional or trans-national tool.

e) Other Frameworks and Documents

There are many supplementary documents, instruments, strategies and programs for the provision of principles and strategies that may be relevant to achieve these objectives. For example, ILOConventions87, 98 and 169, the final Declaration of the International Conference on Agrarian Reform and Rural Development (ICARRD) and the UN Declaration on Rights of Indigenous People(UNDRIP).

7.5.3. Food procurement and storage

Procurement and storage secure the food and other goods required for supporting the comprehensive combat against hunger. Basically, grain storage i.e. wheat increases the holding capacity means smooth availability of commodity round the year. In this way, the price of grain stables in the country. It also gives the confidence to the farmer that government will buy their output. In Pakistan, due to inadequate procurement and storage capacities, the Punjab Food Department – the biggest wheat buyer in the country- is confronting the uphill task to store abundant in every year. Transport and storing of food as well as timely delivery to the consumers is vital in order to protect the procurement of food. This stored food is used for several purposes, like supply to consumers and permitting a better balanced diet through the year.

7.5.3.1. The global food security index

This index studies the issues of affordability, availability, and quality across a set of 109 countries. It is a dynamic quantitative and qualitative benchmarking model; based on 28 unique factors. Economist Intelligence Unit (EIU) has placed Pakistan on 77^{th} position among 109 countries in the Global Food Security Index 2014.

7.5.4. Social safety nets

These are also known as socio-economic safety nets and these are non-contributory transfer programs looking for those who are exposed to jolts and the lack of resources and they are falling below a certain poverty level. These programs can be offered by the government, aid donors or by the private sector like NGOs, private business and these include Cash transfers, Food-based programs such as additional feeding programs, In-kind transfers such as school supplies and uniforms, and Conditional cash transfers.

On an average, spending on safety nets accounts for 1 to 2 percent of GDP among developing and transition countries (Grosh et al. 2008) though sometimes much less or much more.

7.6. Role of Economic Research in Risk Management

Economists, for many years, have been concerned with gaining an understanding of individual behavior when confronted with risk, and with developing tools to address decision-making under risk. The factors like the variability in weather, uncertainty in markets for both outputs and inputs, and various other risks confronting agricultural producers, are not something surprising. This area of research has recently gained renewed attention due to certain reasons (Anderson and Mapp 1996). As realities of risk management in the present and future are confronted, it is reasonable to look back at what have been learned regarding agricultural risk management and to consider where risk management research efforts would be most productively utilized in coming years.

Past research into agricultural risk management issues has made a significant contribution to understanding producer risk management. Theoretic developments have donated much more to understand the portfolio trade-offs, optimal input and output decisions, and the use of instruments such as future and insurance. Improvements in the capabilities to calculate risk with more robust methodologies also contribute to the information available for producers. Research has also carried out for developing new techniques and provided evaluation of alternatives which confront producers (Coble and Barnett 1999). There are many areas in need of further research. This stems from issues that have not been fully addressed in the past and because new issues continue to arise. Some of the tools often used in the risk analysis are given in the following lines.

7.6.1. Feasibility studies

It is about the analysis of the viability of an idea. It is the evaluation of a proposed project to determine if it is technically feasible, within the estimated cost, and will be profitable. These types of studies emphasize on helping response the important inquiry of the question, ‘should the proposed project idea be preceded?’ All happenings of the investigation are focused for answer this question. These studies can be employed in certain techniques but basic emphasis is on projected business risks (Justis and Kreigsmann 1979). Farmers and others with a business idea should carry out a feasibility estimation to achieve the feasibility of idea earlier continuing. Further, it will not work to save time and money. A feasible business venture is one where the business will generate suitable cash-flow and returns. The project could be a start-up business, the purchase of prevailing business or a new enterprise for the present corporate.

7.6.2. Benefit-cost ratio (BCR) analysis

BCR analysis is a technique of assessing economic capability of projects. It relates the total benefits of a project with its all costs, and recommends the project implementation if the costs are less than benefits. The cost and benefits of a public project are evaluated from social perspective (Boardman 2006). First we determine the useful life of the project: the number of years over which the benefits and costs of the project need to be evaluated. Let the useful life be T years. Secondly, estimate in physical units all benefits and all costs of the project for each year of its useful life, irrespective of whether they are monetary or non-monetary in nature and whether they are associated with the use or nonuse value of resources. Third convert physical units of benefits and costs into dollars, using appropriate prices and values. Forth, once the monetary values of benefits and costs are compiled for each year; calculate their present values, using an appropriate discount rate. Fifth, present values of annual benefits are quantified to determine the total benefits (B) of the project. Similarly, the present values of annual costs to determine the total cost (C) are added. Then we calculate the total net benefits, called the net present value (NPV), by subtracting the total cost from the total benefit, i.e., NPV = B – C. Also, calculate the benefit-cost ratio, dividing total benefit by total cost, i.e., B/C ratio

The decision rule is then,

a. If NPV ≥ 0, implement the project. Else, do not implement it, or

b. If $\frac{B}{C} \geq 1$, implement the project. Else, do not implement it.

Results may be sensitive to choice of discount rate. Conclusion of a benefit-cost analysis may be sensitive to the choice of discount rate. At a certain discount rate, the project may be considered feasible, but at some other discount rate it may not be feasible.

7.6.3. Internal rate of return (IRR)

Benefit-cost ratio usually quantifies the IRR and it is the discounted rate at which the net present value (NPV) of project becomes zero. Generally, the NPV decays as discount rate increases. A project that has IRR ≥ social discount rate is considered a good project. IRR is a measure of risk associated with the project, as to how high the discount rate can go, without making the project infeasible (i.e., without making the NPV negative).

7.7. Conclusion

The risk management process includes four levels identification, assessment, evaluation and monitoring. The risk can be production risks, marketing risks, financial risks, legal risks or human risks. The risk management framework can integrate food security and market growth policy on long term basis. The economics of risk management specially deals with the costs of risk management; cost of control must be less than the cost of loss. It can be evaluated on the basis of pain and gains cost of compliance (pain) must be less than cost of circumvention (cost of gain). In risk management, we can perform in a better way by feasibility studies, BCR analysis and IRR.

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Glossary

Age of Maturity: The age of majority is the threshold of adulthood as recognized or declared in law. It is the moment when minors cease to be considered children and assume legal control over their persons, actions, and decisions, thus terminating the control and legal responsibilities of their parents or guardian over them.

Agricultural marketing: Agricultural marketing is inferred to cover the services involved in moving an agricultural product from the farm to the consumer. It is also the planning, organizing, directing and handling of agricultural produce in such a way as to satisfy the farmer, producer and the consumer.

Allogamy: Fertilization by transfer of pollen grains from stamen of one flower to the stigma of another flower present on another plant is called allogamy (cross pollination).

Alloploids: It refers to hybrid individual/cells possessing two or more sets of chromosomes derived from varying ancestral species.

Aneuploids: It refers to an individual/cell not having exact multiple of haploid number of chromosomes of that species.

Animal Power: The production of food and fiber to meet the needs of the population is a basic requirement of any civilization. The application of power in agriculture sector other than human muscles has been a matter of great importance. Animals have been used in agriculture for farming operations well before the recorded history. Egyptians first used the ploughs and animals to perform different agricultural activities. Later on, the people of Indus Valley used such animals for power requirements. They were amongst the pioneer of the agriculture at that time. The most common animals that are used as a source of power are oxen and buffalo. Horses, donkeys, mules and camels are used in many countries for transportation purposes.

Autogamy: Fertilization by transfer of pollens from the stamen of one flower to stigma of same flower or stigma of another flower present on same plant is called autogamy (self-fertilization).

Autoploids: It refers to a hybrid individual/cells possessing two or more sets of chromosomes derived from same ancestral species.

Axle pressure: It is total weight or pressure that is applied on a unit volume of soil by all wheels of a tractor/wheeled vehicle by all wheels connected to axle. Or it is fraction of total weight or pressure of tractor/wheeled vehicle lying on an axle (axle load) and pressure exerted by it on a soil surface.

Blocky and sub-angular blocky: Peds in blocky structure are usually are cube shaped with flattened surfaces and sharp edges. While, peds in sub-angular blocky are cube shaped with flattened surfaces and round edges. These are rich in clay and exist in B-horizon.

Calving Cow: Young and small heifers have a greater chance of calving difficulty than mature cows. Heifers must be old enough and large enough. · Mature cows require less attention at calving. Generally, cows which have had at least one calf already, have fewer problems.

Catastrophic: A sudden event that causes very great trouble or destruction. An unchecked increase in the use of fossil fuels could have catastrophic results for the planet.

Chewing Insects: By feeding in the leaves, they reduce the area available for the photosynthesis. They attack on the stem and interrupt the flow of sap. These insects also destroy the growing points of plants. Their attack on roots causes the disruption in the absorption of nutrients from the soil. They also reduce the seed production and germination after attacking on the fruits. Examples of biting and chewing insects are armyworm, grasshoppers, beetles, crickets.

Climate Change: The climate change phenomenon refers to seasonal changes over a long period with respect to the growing accumulation of greenhouse gases in the atmosphere.

Climate Change Mitigation: Climate Change Mitigation refers to efforts to reduce or prevent emission of greenhouse gases. Mitigation can mean using new technologies and renewable energies, making older equipment more energy efficient, or changing management practices or consumer behavior.

Columnar: Peds in columnar structure are rectangular, with long vertical dimension and rounded top. Soil particles are separated by minute but definite plain vertical cracks that exhibit poor drainage.

Combustion Engine: Transition from animal power to mechanical power started early in the twentieth century. The first tractor used in agriculture was steam powered. Steam engine was invented in the mid of the 19th century and efforts were made to use it for farming operation.

Conservation tillage: Conservation tillage is an umbrella term that encompasses any type of tillage that minimizes soil disturbance and leaves residues of previous crops on soil surface as mulch taking soil health into account. It can be divided into zero tillage or direct seeding and reduced or minimum tillage.

Crumb: Soil structure containing spheroidal shape peds/aggregates, it often depicts more porosity than granular structure and thus maintains aeration. The peds are mainly comprised of clay particles, while, silt and fine sand particles might also be present. The shape of peds is round while size is larger compared to granular structure.

Development: A deliberate series of action.

Disaster payment: The Disaster Recovery Payment (DRP) is a payment for the individuals who have been adversely affected by a major disaster. This payment is made in the days of high impact and less probable disaster to the people who are unable to fulfil basic and immediate requirements for temporary lodging, food, essential clothing and medication.

Disease: A disorder of structure or function in a human, animal, or plant, especially one that produces specific symptoms or that affects a specific location and is not simply a direct result of physical injury.

Diversification and value addition: Diversification is a business approach to move in a new market or industry which the business is not currently in, whilst also creating a new product for that new market. It is a risk management tool that integrates a large diversity of investment within a portfolio.

Dominance: It is relationship between the alleles of one gene whereby the phenotypic expression of one allele is masked due to presence of another allele at the same locus. The first allele is called recessive while the second allele is dominant.

Drought: A prolonged period of abnormally low rainfall, leading to a shortage of water.

Electrification of Farms: Electrification is done to create the pleasant farming environment. Electrification on farms will also encourage the installation of tube wells.

Epistasis: It is a type of interaction between the non-allelic genes whereby one combination of non-allelic genes dominates over the other combinations.

Erosion: It is detachment, transfer and deposition of soil particles from one place to another under the action of erosive agent (wind, water, gravity).

Euploid: It refers to an individual/cell having chromosome number that is exact multiple of haploid number of chromosomes of that species.

Exploitation: The action or fact of treating someone unfairly in order to benefit from their work.

Facilitative functions: The facilitating functions contribute in ensuring the smooth performance of the exchange and physical functions. These functions don't directly take part in the exchange of title or the physical handling of the products.

Farm Mechanization: Farm mechanization means replacement of animal and human power with machines; and performing different farming operations by means of different machines. It includes hand tool, animal and tractor drawn equipment's, processing equipment and machinery, irrigation equipments or any other farm equipment.

Financial risk: This type of risk can be caused due to the financial health of the trade. There are following fundamental constituents of financial risks, price and affordability of capital, capability to meet cash flow requirements in a well-timed means, and the ability to preserve and produce equity and ability to absorb short-term financial jolts.

Flood: An overflow of a large amount of water beyond its normal limits, especially over what is normally dry land.

Food Security: Food security exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food which meets their dietary needs and food preferences for an active and healthy life.

Functional approach: The functional approach is one of the methods used in classification of activities that occur in the marketing processes by breaking down the processes into functions. A marketing function is defined as a major specialized activity performed in accomplishing the marketing process.

Genetic diversity: Total number of genetic characteristics in genetic makeup of a species which act as an indicator of plant species to adapt in varying environmental conditions.

Genetic Potential: Genetic potential means that theoretical optimum performance capability which an individual could achieve in a specific activity, after an ideal upbringing, nutrition and training.

Genetic recombination: It is process of developing new combinations of alleles as a consequence of exchange of genetic material i.e. exchange of DNA sequences and crossing over between homologous chromosomes during meiosis.

Genetic variability: It refers to the ability of a plant species to vary its genetic characteristics under prevailing environmental conditions.

Granular soil structure: It refers to the excessive gravel, sand and silt with little or no clay. Thus, granular soil depicts low cohesiveness, unable to be molded when moist and crumble easily when dry. While peds usually have round surface.

Heterozygous: Heterozygous refers to a gene containing non-identical alleles on both homologous chromosomes for a particular trait whose phenotypic expression is being controlled by that gene.

Homozygous: Homozygous refers to a gene containing identical alleles on both homologous chromosomes for a particular trait whose phenotypic expression is being controlled by that gene.

Human Power: Human power is still used for performing different tasks on farm. The main tasks performed by human beings include, preparation of land (ploughing, levelling, formation of bunds and drainage system), sowing and planting activities, spraying application for plant protection, harvesting and threshing of crops, transportation of good to the storage structures, processing of grains to get by-products.

Human risk: In the business venture, the individuals are both a source of business risk (for example non-technical agricultural labor and ill-mannered farms mangers) and an integral portion of the approach for coping with risk (farm owners). At its core, human risk management is the capability to retain all those who are involved in the business and it can be divided into four types, Human health and wellbeing, family and business contacts, human resource management and transition planning. Table 6.1 summarizes the sources and management, and the controls of risk management.

Inbreeding depression: Reduced biological fitness (capability of an organism to survive and sustain its genetic makeup and diversity) of an individual in a population due to repeated inbreeding.

Institutional approach/analysis: The term institutional analysis is used by several academic disciplines, and has several meanings and connotations. One meaning of institutional analysis refers to actual formal institutions.

Integrated Pest Management: This technique can be applied to agricultural and non-agricultural practices. Its mechanism laid stress upon the healthy growth of a crop with least disturbance to the ecosystem and by utilizing natural control to protect the plants.

Invertebrate Pests: Invertebrate pests belong to the class Insect of animal kingdom. They are not only harmful to the human beings in causing many diseases but also responsible for dramatic damages in agricultural crops.

Legal risk: Many of the repeated events of all agriculturists include commitments that have legal insinuations. Proper understanding of these subjects can result superior risk management. Sometimes, legal risk issues overlap other than the other areas of risk. Likewise, acquisition of agricultural credit shows financial as well as legal implications, if not repaid in the stipulated time. Farm production events (comprising the application of chemicals) have also legal implications if suitable safety protections are not adopted. Marketing of farm products can encompass agreement legislation as well. Human issues connected with the farming sector could also have consequences like these.

Livestock Production: Livestock are domesticated animals raised in an agricultural setting to produce labor or commodities such as meat, milk, leather, and wool. Originally, livestock were not confined by fences or enclosures, but these practices have largely shifted to intensive animal farming, sometimes referred to as "factory farming".

Livestock Risks: The increase in livestock related accidents and deaths are attributable to inadequate handling facilities on farms, poor set up or taking risks when dealing with livestock, less contact between farmer and livestock and inadequate attention given to breeding animals for docility.

Management: The process of dealing with or controlling things or people.

Marketing risk: Marketing is a process or channel through which farmers take their produce to end user or middlemen in the market by a sophisticated pattern. Buyers, in a global market and other unexpected forces such as weather or government actions, are the potential marketing risks. The risk in any market is a related action or happening (that results in the change of prices that the farmers obtain for their output or pay for farm inputs).

Marketing System: A market system is the network of buyers, sellers and other actors that come together to trade in a given product or service.

Methemoglobinemia: Methemoglobinemia is a blood disorder in which excessive amount of methemoglobin is synthesized due to which ability of haemoglobin to release oxygen reduces severely.

Mites: They look like insects but they have four pairs of legs and also very minute in size. They belong to the order ACARINA and the class is ARACHNIDA. They are mostly red or yellow in color. They cause the damage to the crop by sucking the sap.

Nitrogen use efficiency: The ratio of amount of nitrogen applied to the nitrogen taken by a crop is called nitrogen use efficiency.

Oxidative stress: It is a type of secondary stress that results due to excessive production of reactive oxygen species in other stresses (temperature, water and nutrient stress).

PAMIMA: Pakistan Agricultural Machinery and Implements Manufacturers Association (PAMIMA) need to be encouraged to play its due role of upgrading manufacturer's premises facilities, creating their own R&D and producing quality products at competitive prices to meet WTO challenges.

Pests: Noxious organisms detrimental to humans, his possessions and cause economic losses, are called pests. They are also responsible for causing many epidemic diseases associated with high mortality rate.

Phytochromes: Blue green pigments in plant that are sensitive to red and far red light and regulate various developmental processes (seed germination, biosynthesis of chlorophyll, growth rate, flowering etc.) in plants.

Platy: Platy soil structure has rectangular shape with long horizontal dimension. Soil peds combine horizontally to form plates that overlap with each other and thus impair drainage. These usually exist in A-horizon.

Pleiotropic effects: It is single gene triggered phenotypic expressions of several unrelated phenotypic traits in the same plant/ organism.

Pollutants: A substance that pollutes something, especially water or the atmosphere.

Polygenic traits: Traits that whose phenotypic expression is controlled by multiple genes.

Polyploids: Polyploids are organisms/cells possessing more than two paired (homologous) sets of haploid chromosomes. Diploid refers to the two paired (homologous) sets of chromosomes that are inherited from each parent. Polyploids can be auto or alloploids.

Prismatic: Peds have long vertical dimension with flattened top. The vertical axis is more prominent compared to horizontal to produce a pillar shape. These are usually found in sub horizons of arid and semi-arid areas.

Problem of Land Tenure: The availability of land is an important factor in the production of different agricultural produce. The land tenure refers the owned land in a country by individuals. The prevailing land tenure systems reduce the possibility of agricultural machinery use for farming operations.

Production risk: Expected outcome or yield reflects farm production. Unpredictability in the outcome poses risks and variation in capability to attain financial goals. Any action (that has a diversification in the yield), directly or indirectly interrelated to the process of production is the production risk. The main reasons of these risks are environmental variability, pest attack, diseases, cropping technique and their quality, and the quality of inputs. Other natural disasters like fire, wind, theft, and casualties could also be the causes of production risks as well.

Quantitative trait loci (QTL): Quantitative trait loci are a section of DNA/ chromosomal region/ genetic locus on which sequence of bases are present that controls the phenotypic expression of a quantitative trait. These QTLs are located on different chromosomes and control the phenotypic expression of polygenic trait.

Residual toxicity: Sum total of all adverse effects caused by remains of fertilizers, pesticides and other synthetic substances that sustain in soil, air and water, build to the toxic level and finally find their way to the food chains of living organisms.

Retailers: A retailer is any merchant middlemen who buys goods / services for resale directly to ultimate consumers. They represent the most numerous types of agencies involved in the marketing process. In terms of undertaking marketing functions their role in not easier as compared to the wholesalers. In fact, a retailer may have to do all the functions of marketing and thus this thing makes his job complex.

Risk management: The forecasting and evaluation of financial risks together with the identification of procedures to avoid or impact.

Risk: A situation involving exposure to danger.

Rodents: Rodents are regarded as major vertebrate pest of field crops as they destroy food quality more as compare to consumption. They also eat away large amount of human food and are also responsible for the losses of stored grains. Rodents cause loss in all cereal and grain crops as well as too many fruits and vegetables.

Scope of Farm Mechanization: The scope of farm mechanization in Pakistan is quite encouraging as the population of country is increasing very rapidly which would need huge quantity of food and fiber in near future.

Scope of Farm Power: Farm power has wide scope in the field of agriculture. The major application of farm power includes: i) use of cultivable waste land ii) to solve water problems iii) timely field operations iv) to address the labor shortage problems v) the electrification of farms vi) increased productivity through farm machines vii) the use of multiple horsepower tractors for different jobs viii) the use of farm implements to increase farm productivity ix) the possibility of better land leveling x) improved weed eradication xi) better plant protection practices.

Soil aggregate stability: Capability of soil to resist against the disruptions triggered by external forces (wind, water, gravity, mechanical operations etc.).

Soil compaction: Physical rearrangement of soil particles at microscopic level in response to the applied pressure which results into decreased distance between soil particles and increased bulk density. Or it is ratio of actual bulk density of soil to the bulk density that results after application of 200 K Pa pressure on a wet soil.

Soil sickness: Faulty agronomic practices trigger disturbances in soil ecosystem that consequence into imbalance of beneficial and harmful microbial populations and thus result into accumulation of toxic substances in soil harmful for rhizosphere of crops. This condition is called soil sickness.

Soil strength: Capability of a soil to bear the magnitude of shear stress applied is called soil strength. It is function of shear resistance of soil particles and types of bonds between them.

Sources of the Farm power: The farm power is one of the most reliable and useful input source to perform different agricultural practices using machines. For production of agricultural products, the sources of power such as humans, animals and tractors etc. are being utilized. During different farm operations, different working activities required to fulfill these tasks. These activities require a suitable and reliable power source. Power is defined as the rate of doing work and is expressed in horsepower or kilowatt (kW). Apparently, 1 hp is equal to 0.75 kW.

Sucking Insects: Their attack causes the plant to wilt if they suck the sap in excessive quantity. These are responsible for the low seed production and damage floral organs. If the insects having these types of mouth parts attack, then infestation cause by these invite the fungal, bacterial and pathogen attack as well. Many of the sucking insects also inject toxins which may induce abnormalities like premature falling of leaves, formation of galls, leaf deformations.

Sustainability: The ability to be maintained at a certain rate or level.

The global food security index*:* This index studies the issues of affordability, availability, and quality across a set of 109 countries. It is a dynamic quantitative and qualitative benchmarking model; based on 28 unique factors.

Value Reduction: Value Reduction' Reducing the value at which an asset is carried on the books because changes in the asset or market conditions have reduced its current market value. Book value reduction is a non-cash charge that is reported as an expense and thus reduces net income.

Vertebrate Pests: Mostly the focus is given only on the damage by insect pests but one cannot forget the losses by various vertebrate pests like rodents, birds, weeds, mites, mollusks, and nematodes. These can be pests in many cropping system and situations. They cause damage not only to crops but also to the livestock.

Water use efficiency: Ratio of water used by plant in metabolic processes to the water transpired is called water use efficiency. Water use efficiency of productivity (integrated water use efficiency) typically refers to the ratio of biomass produced by plant per unit of water consumed in transpiration process.

Weather insurance: It is comprised of the use of an index based weather derivative, contract to transfer the risk of severe national drought to the international markets. It can help achieve the financial risk linked with the exposure to intense weather conditions. It is crucial to any business or event whose revenues are vulnerable to weather.

What Is Climate Change?: Climate change is a change in the usual weather found in a place. This could be a change in how much rain a place usually gets in a year. Or it could be a change in a place's usual temperature for a month or season.

What is insurance: A thing providing protection against a possible eventuality. An arrangement by which a company or the state undertakes to provide a guarantee of compensation for specified loss, damage, illness, or death in return for payment of a specified premium.

Wholesalers: Wholesaler is any merchant who does not sell to ultimate consumer in any significant amount. He, therefore, can sell to other wholesalers or to industrial users or retailers. Wholesalers make a highly heterogeneous group of varying sizes and characteristics.

Yield gap: The term ‘yield gap’ has been broadly used in the literature. It is defined as the difference between potential and actual yield over some specified spatial and temporal scale of interest.

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