THE UNIVERSITY OF READING

PARTICIPATORY RESEARCH APPROACHES IN THE DEVELOPMENT OF IMPROVED MANAGEMENT PRACTICES IN INDIGENOUS CHICKENS PRODUCTION SYSTEMS WITH SMALLHOLDER FARMERS IN KENYA

by

JOSEPH MUTITU NDEGWA

B.Sc. (Hons), M.Sc.

Thesis submitted for the degree of Doctor of Philosophy

Department of International and Rural Development, and School of Applied Statistics

October 2006

DECLARATION

I confirm that this is my own work and the use of all material from other sources has been properly and fully acknowledged.

Signature

ABSTRACT

This thesis is concerned with development of improved management practices in indigenous chicken production systems in a research process that includes participatory approaches with smallholder farmers and other stakeholders in Kenya. The research process involved a wide range of activities that included on-station experiments, field surveys, stakeholder consultations in workshops, seminars and visits, and on-farm farmer participatory research to evaluate the effect of some improved management interventions on production performance of indigenous chickens. The participatory research was greatly informed from collective experiences and lessons of the previous activities.

The on-station studies focused on hatching, growth and nutritional characteristics of the indigenous chickens. Four research publications from these studies are included in this thesis. Quantitative statistical analyses were applied and they involved use of growth models estimated with non-linear regressions for the growth characteristics, chi-square determinations to investigate differences among different reciprocal crosses of indigenous chickens and general linear models and covariance determination for the nutrition study. The on-station studies brought greater understanding of performance and production characteristics of indigenous chickens and the influence of management practices on these characteristics.

The field surveys and stakeholder consultations helped in understanding the overarching issues affecting the productivity of the indigenous chickens systems and their place in the livelihoods of smallholder farmers. These activities created strong networking opportunities with stakeholders from a wide spectrum.

The on-farm farmer participatory research involved selection of 200 farmers in five regions followed by training and introduction of interventions on improved management practices which included housing, vaccination, deworming and feed supplementation. Implementation and monitoring was mainly done by individual farmers continuously for close to one and half years. Six quarterly

visits to the farms were made by the research team to monitor and provide support for on-going project activities. The data collected has been analysed for 5 consecutive 3-monthly periods. Descriptive and inferential statistics were applied to analyse the data collected involving treatment applications, production characteristics and flock demography characteristics.

Out of the 200 farmers initially selected, 173 had records on treatment applications and flock demography characteristics while 127 farmers had records on production characteristics. The demographic analysis with a dissimilarity index of flock size produced 7 distinct farm groups from among the 173 farms. Two of these farm groups were represented in similar numbers in each of the five regions.

The research process also involved a number of dissemination and communication strategies that have brought the process and project outcomes into the domain of accessibility by wider readership locally and globally. These include workshops, seminars, field visits and consultations, local and international conferences, electronic conferencing, publications and personal communication via emailing and conventional posting. A number of research and development proposals were also developed based on the knowledge and experiences gained from the research process.

The thesis captures the research process activities and outcomes in 8 chapters which include in ascending order – introduction, theoretical concepts underpinning FPR, research methodology and process, on-station research output, FPR descriptive statistical analysis, FPR inferential statistical analysis on production characteristics, FPR demographic analysis and conclusions.

Various research approaches both quantitative and qualitative have been applied in the research process indicating the possibilities and importance of combining both systems for greater understanding of issues being studied. In our case, participatory studies of the improved management of indigenous chickens indicates their potential importance as livelihood assets for poor people.

ACKNOWLEDGEMENT

This thesis has been written under very difficulty circumstances, which by all means looked insurmountable, occasioned mainly by a lack of requisite funding for the purpose. Inevitably, it has taken a longer time than originally anticipated. However, despite the difficulties, it has been possible to produce it largely due to the support I received from many people. Their sympathy, understanding and forbearance were beyond my expectation. They sustained my determination and kept me going even when it seemed a hopeless endeavour. I will never forget their great gesture of kindness that was beyond measure.

Just to mention a few of these people, I would like to extend my gratitude to first of all my supervisor, Professor Roger Mead at the school of Applied Statistics who through sheer happenstance, made arrangements for me to be registered for the PhD study. I met Professor Mead in Kenya during a workshop on statistical methods in on-farm experimentations and we managed to visit one of my indigenous chickens project groups together. Much appreciation is also extended to my supervisors at the department of International and Rural Development, Dr Patricia Norrish (now retired) and Derek Shepherd, my great mentors. These were my ‘guardian angels’. Without them, I doubt if I might have lived the dream.

Many thanks to other people, so many to mention, at both the Applied Statistics and IRDD for their great support and encouragement. I also thank the many friends I met along my long journey for their company and support in many different ways.

I would also wish to thank the Director, Kenya Agricultural Research Institute and my Centre Director, KARI, Naivasha, and the staff at both the headquarter and Naivasha, for their support and great understanding. Special mention is deserved for my colleagues at Naivasha with whom we executed the on-station and on-farm experimentation. Special thanks to my former colleague, Catherine Kimani for her contribution. Many other colleagues at KARI and all the extension friends in all the locations we visited are greatly acknowledged for their contributions and enthusiasm.

I cannot forget my long-suffering family who had to remain in Kenya all the time I stayed in UK doing this study. My wife Lucy Muthoni, our kids Elizabeth Gathoni, David Ndegwa and Faith Mukami, as well as other family members, were all a great source of strength, hope and encouragement. They have been very understanding and patient. My mum is remembered in a special way for her constant prayers and concern. I have no words to thank them all.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PHOTOGRAPHS

LIST OF BOXES

LIST OF APPENDICES

APPENDICES FILES ON CD:

Appendix 4.1: Body weights of individual birds from three indigenous chicken lines and one cross of Rhode Island Red with Nyeri line

Appendix 4.2: Body weights of individual birds from six indigenous chicken reciprocal crosses.

Appendix 5.1: Names of regions and villages where the study was done.

Appendix 5.2: Treatment uptake - housing, vaccination, deworming and supplementation, in five regions in periods1 - 5.

Appendix 5.3: Treatment uptake totals for 5 periods for each farm in five regions.

Appendix 5.4: Demography characteristics – flock size and dynamics (addition, loss, sale, gift and consumption as recorded in each farm in region 1 over 5 periods.

Appendix 5.5. Demography characteristics – flock size and dynamics (addition, loss, sale, gift and consumption as recorded in each farm in region 2 over 5 periods.

Appendix 5.6. Demography characteristics – flock size and dynamics (addition, loss, sale, gift and consumption as recorded in each farm in region 3 over 5 periods.

Appendix 5.7. Demography characteristics – flock size and dynamics (addition, loss, sale, gift and consumption as recorded in each farm in region 4 over 5 periods.

Appendix 5.8: Demography characteristics – flock size and dynamics (addition, loss, sale, gift and consumption as recorded in each farm in region 5 over 5 periods.

Appendix 5.9: Flock demography dynamic factors - total addition, total reduction, controlled reduction (sales, gifts, consumption) and unplanned reduction (losses) in each farm in region 1.

Appendix 5.10: Flock demography dynamic factors - total addition, total reduction, controlled reduction (sales, gifts, consumption) and unplanned reduction (losses) in each farm in region 2

CHAPTER 1

INTRODUCTION

1.1 Context and Objectives of the Research

In Kenya, as elsewhere in sub-Saharan Africa, about 80% of the population live in rural areas eking out a living from subsistence farming, often under very difficult climatic and economic conditions (Ndegwa, *et. al*., 1998a), to meet household food requirements. Often, this is only a pipe-dream and many rural folk are dependent on food handouts from their governments or non-governmental relief organisations. They lack access to external inputs of production to improve output and their local resources are poorly managed and over-exploited, leading to environmental degradation and further impoverishment. This gives rise to a vicious cycle of dependency among millions of impoverished people in rural areas.

Improvement in agricultural output in rural areas could be greatly enhanced by the proper harnessing and utilisation of local resources. Indigenous chickens are among the many local resources available in rural areas which, if well managed, could ease the burden of the people. Over 90% of rural households keep and rear indigenous chicken in small flocks of about 20 birds (Ndegwa *et. al*., 1999; Mbugua, 1990; MOLD, 1990; Stotz, 1983). Usually, the birds are left to scavenge for food around the homesteads. Hardly any attention is given to the birds as they have a very low rating among the rural men who are usually the households heads. The chickens are mostly regarded as a woman's domain, hence the low status (Ndegwa and Kimani, 1997; Ndegwa *et. al*., 1998a). Several factors then are at play contributing to the low productivity often associated with indigenous chickens. They include poor management, inadequate and poor feeding regime, poor (or lack) of disease control measures, poor hygiene, inappropriate housing, negative attitudes, lack of technical knowledge and lack of institutional support in terms of policy and infrastructure (Ndegwa and Kimani, 1996; Musharaf *et. al*., 1990). Poor and haphazard breeding practices also contribute to low productivity associated with high inbreeding pressure. Low productivity is manifested in terms of very high mortality, low growth rates, small mature weights and low egg production.

Despite the low productivity among the indigenous chicken flocks, the birds play a very significant role in rural livelihoods. In Kenya, and indeed in sub-Saharan Africa, indigenous chickens comprise over 70% of total poultry populations (MOLD, 1991; Ibe, 1990). They produce about 50% of the total eggs and over 80% of the poultry meat produced in many countries in sub-Saharan Africa (Ndegwa *et al*., 1998a). Although the indigenous poultry production is not market-oriented, despite the huge contribution of poultry meat, its products (eggs and meat) are preferred and often fetch higher prices than the exotic commercial poultry products. That is the potential of indigenous chickens. The contention is that there is a potential for a local resource like indigenous chickens to turn around the misery that is the lives in rural areas, if properly harnessed. This calls for a concerted effort by all stakeholders coupled with a change of attitude and policy focus. Infrastructural and institutional support are hence required in research and development activities aimed at improving productivity at farm level.

Many people in sub-Saharan Africa have very precarious and vulnerable livelihoods. Any adverse change in situations surrounding them, whether environmental, socio-economic or political either at local or global level, will almost certainly impact negatively on their lives. Their livelihoods are not in any way sustainable. According to DFID (1999) and Scoones (1998), a livelihood comprises the capabilities, assets and activities required for a means of living. A livelihood is said to be sustainable when it can cope with and recover from stresses and shocks and maintain or enhance its capabilities and assets both now and in the future, while not undermining the natural resource base. Farrington *et al*., (1999) have given a perspective on early experience in implementing sustainable livelihoods as a new approach in poverty alleviation. This approach draws on improved understanding of poverty not just in terms of income and consumption, but also in terms of absence of basic capabilities to meet physical needs (health, education, clean water and other services). According to Chambers (1987), the poor people themselves describe poverty not just in terms of income but in terms of a whole range of aspects that include insecurity and vulnerability, lack of a sense of voice, levels of health, literacy, education and access to assets. The sustainable livelihoods approach also draws on other streams of analysis, relating for instance to households, gender, governance and farming systems that bring together relevant concepts that allow poverty to be understood more holistically. Farrington et al., (1999) mention that a sustainable livelihoods framework assumes that people pursue a range of livelihoods outcomes (health, income, reduced vulnerability, etc) by drawing on assets or resources (human capital, natural capital, financial capital, social capital and physical capital) to pursue a range of activities. The activities they adopt and the way they reinvest in asset building are driven in part by their own preferences and priorities as well as the types of vulnerability, including shocks (such as drought), overall trends (in, for instance, resource stocks) and seasonal variations. Structures (such as the role of government or the private sector) and processes (such as institutional, policy and cultural factors) which people face determine options. In aggregate, these conditions determine their access to assets and livelihood opportunities, and the way these can be converted into outcomes. In this way, poverty and opportunities to escape from it depend on all of the above.

The World Development Report by the World Bank (WBDR, 2000), describes poverty not just in terms of lack of cash but in terms of poor people's perception of it as hunger, lack of shelter, being sick and not being able to go to see a doctor. Poverty is also not being able to go to school, not knowing how to read, not being able to speak properly. Poverty is not having a job, fear for the future and living one day at a time. Poverty is losing a child to illness brought about by unclean water. Poverty is powerlessness, lack of representation and freedom. Poverty has many faces, changing from place to place and across time. Most often, poverty is a situation which people want to escape from. So poverty is a call to action – for the poor and the wealthy alike – a call to change the world so that many more may have enough to eat, adequate shelter, access to education and health, protection from violence, and a voice in what happens to their communities.

With more than 1,200 million people or one in five of the world's population living in absolute poverty, condemned to short lives stunted by malnutrition, ill-health, and illiteracy, the world's attention is now focused on eliminating poverty with a general acceptance of the fact that it is in every one's interests to eliminate poverty (Blair, 2000; Wolfensohn, 2000; Al-Sultan, 2001). Accordingly, mass poverty hurts not only the poor but claims everyone as its victims. Problems such as war and conflict, international crime and trade in illicit drugs and the spread of health pandemics like HIV/AIDS are caused or exacerbated by poverty. That the world community seems now, more than ever before, fully committed to fighting poverty in all its manifestations and to bring down the number of people living in absolute indigence in the coming years is a heartening happenstance. The millennium development goals (UNDP, 2003) have set the target of halving the number of people living in absolute poverty by the year 2015.

Proper harnessing of local resources of the poor people and their involvement in the research process can help bring about development of sustainable livelihoods and contribute to the fight on poverty alleviation in rural areas where the majority of the poor live. The largest proportion of the poor is mainly composed of women (Blair, 2000; Al-Sultan, 2001) who engage in subsistence agricultural activities as they struggle to survive and feed their families under often very hostile environments (Ndegwa *et al*., 2000, 1999, 1997; Gueye, 2000a).

A comprehensive participatory approach is necessary to develop a means of sustenance that guarantees the people a sustainable livelihood and freedom from being adversely affected by those conditions that have hitherto contributed to their perpetual indigence. Marilee (2000) has noted that participation can take many different forms at different stages of a project cycle ranging from contribution of inputs in predetermined projects and programmes, to information sharing, consultation, decision-making, partnership and empowerment. Participation as a means is a process in which people and communities cooperate and collaborate in development projects and programmes. As an end, it is a process empowering people and communities through acquiring skills, knowledge and experience, leading to greater self-reliance and self-management. Marilee (2000) has also offered some common objectives and expected benefits of participation in development, for example improving efficiency, effectiveness, sustainability and coverage of projects and programmes and promoting stakeholder capacity, self-reliance and empowerment. According to Adato *et al*. (1999), community participation in projects also offers prospects of lowering the costs of anti-poverty interventions.

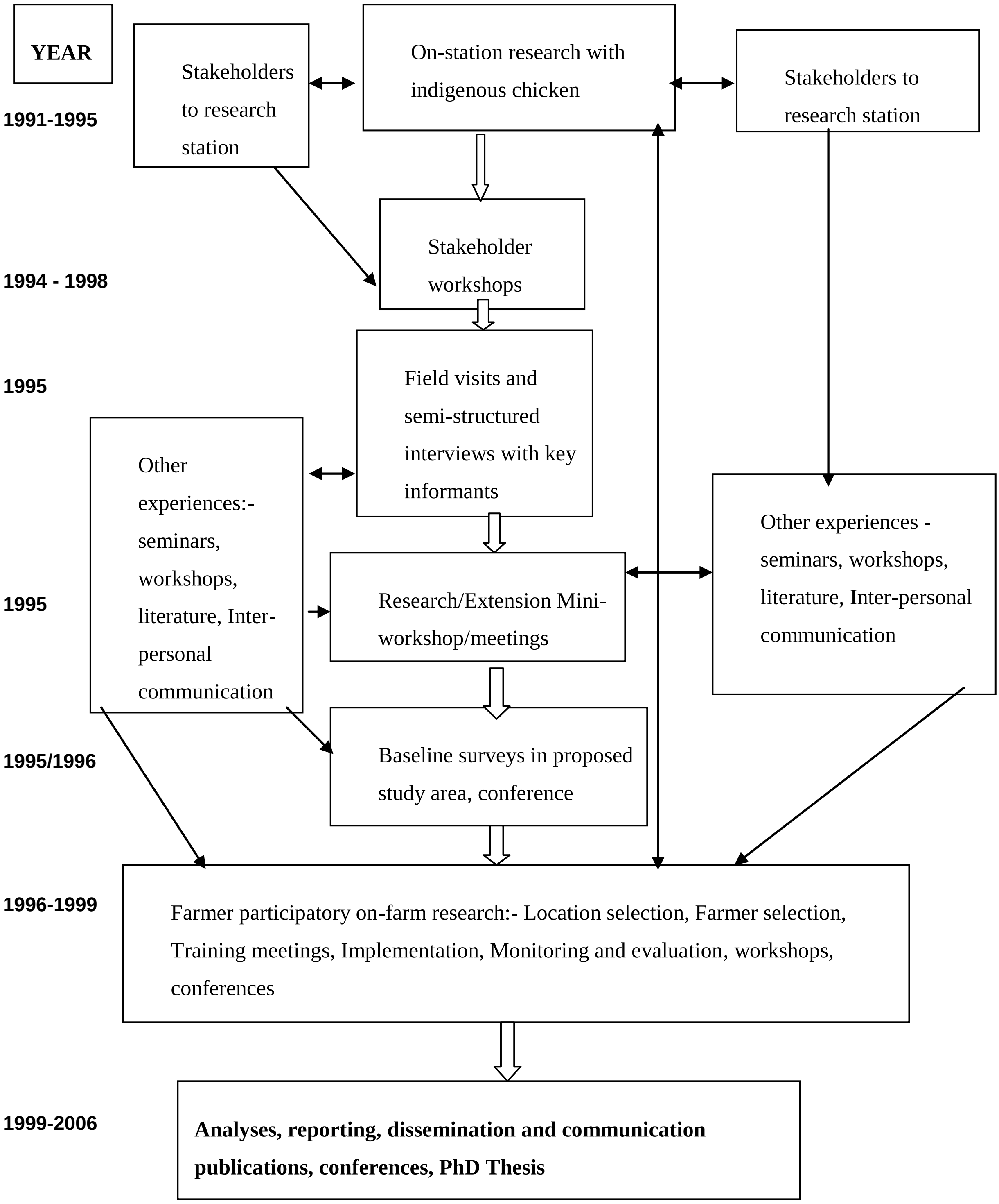
Outside interventions are obviously needed to create the opportunities and impetus necessary to realise these goals and to empower the people. According to Nyong'o (2000), empowerment entails creation of opportunities for people to acquire decent standards of civilised living.

In line with the above goals and strategies, research on indigenous chickens has been undertaken in the recent past in Kenya under the Kenya Agricultural Research Institute's Poultry Research Programme. The research has been largely directed and coordinated by the author of this thesis. It has been an attempt to mainstream this sector in various domains and to realise its potential to contribute to poverty alleviation and development of sustainable livelihoods for the poor. This study details a research process on indigenous chickens from on-station to on-farm carried out in Kenya at the National Animal Husbandry Research Centre of the Kenya Agricultural Research Institute for over a decade (1989-1999). The aim was to evaluate growth and production characteristics of indigenous chickens and subsequently improve their production performance at farm level through a process that encompasses the various participatory modes described by Biggs (1989) namely, contractual, consultative, collaborative and collegial. The on-station research was of the contractual mode without any participation of farmers although they were the main clients. From on-station, the research process moved into another phase of field survey in the consultative mode of participation. The third phase of the research process was the on-farm studies with a strong farmer and extension participation. This phase had a collaborative and collegial mode of participation.

This thesis looks at the whole continuum of the research and development endeavour in a chronological sequence and describes and analyses in detail.

The different phases range from on-station researcher-controlled experimentation to the interactive experimentation with smallholders. The thesis is also a description of an attempt to focus critically on, and to bring to the fore, a local resource readily and 'abundantly' available and affordable in rural areas. Marginalised and most vulnerable groups in the rural communities, who are mainly women, have complete access to, and control over this resource. It is a resource with untapped potential to turn around the misery that is the life in rural areas. It may be of little significance to many people as exemplified by lack of any meaningful research and development investment in this sector over the years, but can contribute a great deal to eradication of poverty among many rural communities and groups especially in marginal areas. The thesis also highlights involvement of farmers in the on-farm research process where they (farmers) are left to choose interventions/technologies from a basket of options and either adopt and adapt them at their own pace and according to each individual's ability and capacity. It is therefore a description of two different research approaches, one being the conventional 'laboratory-type' controlled process and the other being a non-conventional on-farm research process in the hands of the farmers and wholly dependent on their participation. The thesis is therefore a description of a research process involving a set of inter-related activities that followed one another. The methodology section in chapter three describes these steps in more detail. However, an outline of the importance of each step of the process is summarised briefly in section 1.2 and in Figure 1.1.

Figure 1.1. Research process and methodology of the study with indigenous chickens



1.2 Research process outline

The on-station research (Fig 1.1), carried out in 1991 – 1995, helped create the necessary impetus towards on-farm research by raising interests of many stakeholders who had been sceptical about focusing on indigenous chickens. The research involved studies on hatching, growth and nutritional characteristics of indigenous chickens and generated some useful insights of potential performance of indigenous chicken. Researchers started to have more confidence and to focus more on the need for an in-depth study on the characteristic performance of indigenous chickens.

Because of the preliminary studies, the raising of awareness about the importance of indigenous chicken then started in earnest. The on-station studies also helped to bring about a change in orientation within the Kenya Agricultural Research Institute's management and more resources were hence sought and directed towards the sector.

An approach for a more extensive study of indigenous chicken involving the stakeholders was then developed. Generally, it comprised stakeholders' workshops and field visits to key informants, which took place between 1994 and 1995. These were meant to further the message on the importance of the indigenous sector within the whole poultry industry. They also offered a forum for learning from other people with divergent views, experiences and knowledge and importantly, forged strong linkages for collaboration. These were followed by farm-level field baseline surveys in 1996 to establish farmer practices. Subsequently, the on-farm farmer participatory research was set up and carried out in the period 1996 - 1999.

The experience from baseline surveys, like that of the on-station research, informed the subsequent on-farm research activities. This gave the researchers an insight on the real situation at the farms and an understanding of how to interact with farmers and the extension personnel. The walls were beginning to fall. Formulation of the on-farm research proposal was done following a completely different approach from the ones envisaged in the priority-setting workshops held earlier, where farmers, the real stakeholders, were grossly under-represented. In our approach, we strongly felt it would be more prudent to involve farmers in the whole research process from selection through implementation to monitoring.

Farmers' own resources were to be the main inputs. This was a radical change of attitude on the part of the research team by leaving the pace and direction of the research process to the control of the farmers. This change of 'heart' and 'style' in conducting research came about due mainly to information gathered from the field visits and from the survey experience.

1.3. Thesis outline

The thesis is organised into eight main chapters as follows:

- Chapter one:

This includes the introduction and some background information on the Kenyan situation in the poultry industry with specific emphasis on indigenous chickens, livelihoods and participatory research. The chapter also provides a chronology of activities and events carried out for about a decade and covering the whole continuum of research involving indigenous chicken, from researcher-led and managed on-station research, to farmer-managed on-farm participatory research. The chapter sets out the justification and objectives of, the thesis discussed more elaborately in chapter three.

- Chapter two:

This chapter looks at the theoretical framework of the research process and highlights concepts underpinning the participatory research and development paradigm. Emphasis is given to the evolution of farmer participatory research as an effective tool for technology development and transfer. The chapter also traces the activities and events of the research with indigenous chickens, in the perspective and orientation of these concepts.

- Chapter three:

This chapter describes aims and objectives of the PhD study, focusing on research methodology and processes. The chronological events highlighted in chapter one are here provided in greater details and justification. Various outputs of the many activities in the research processes are also highlighted in this chapter.

- Chapter four:

This specifically deals with the research activities done on-station and highlights studies carried out to understand potential production performance of indigenous chickens and other characteristics. Two research studies focusing on growth characteristics are described in detail here, one of which awaits a decision for its possible publication in peer-reviewed journals while the other has been accepted for publication in the Tropical Agriculture Journal. Two other studies, one on nutrition and the other involving hatching characteristics both of which have recently been published (2001 and 2002), are also given here in summary form, while the full papers are included in the appendices at the back of the thesis.

- Chapter five:

This chapter focuses on the on-farm farmer participatory research data analysis which involves descriptive statistics for the treatments, demography and production characteristics. It highlights the selection of project location and farms. The treatment characteristics data was obtained from 173 farms and involved housing, vaccination, deworming and supplementation totals observed over five 3-month long periods. The flock demography characteristics data was also obtained from the 173 farms and included flock size at each of the 5 periods, total flock additions, total flock reductions, total unplanned reductions and total controlled reductions. The production characteristics includes predicted egg production per hen-cycle, egg production differences between cycles 1 and 3, (both of these had data from 107 farms), eggs set per hen-cycle (data from 127 farms) and hatchability (data from 121 farms).

- Chapter six:

The chapter deals with the inferential statistical analysis on the production characteristics – eggs laid and hatchability - using data obtained from 107 and 121 farms respectively, and recorded in three consecutive typical hen-cycles. The analysis investigates the effects of farm, cycle or hen on the production characteristics in 20 villages covered in the farmer participatory project. Effects of treatments and flock demographics on the production characteristics are also investigated. General linear models are used to assess and compare levels of variation while regression analysis is used to investigate the treatment and demographic effects on the production characteristics.

- Chapter seven:

The chapter analyses the farmer participatory research data on flock demography to identify clusters or groups of farms with similar flock size patterns using dissimilarity index calculations and inferential statistics. Comparisons are then carried out to identify similarities and differences between the identified groups based on the demographic, treatment and production characteristics. Hence, 173 farms are categorised into a small number of distinct farm groups, each defined by a number of characteristics to represent the general feature of indigenous poultry system in rural areas in Kenya.

- Chapter eight:

The chapter includes a general overview of the thesis, makes conclusions on major observations from various issues covered on the research processes, and highlights values of both the on-station and on-farm research. The challenges involved in the participatory research processes dealing with livestock compared to crops are also highlighted and suggestions made on how these might be addressed.

CHAPTER 2

THEORETICAL CONCEPTS ON FARMER PARTICIPATORY RESEARCH

2.1 Development context – a general overview

Development is a dynamic concept referring to a change in, or a movement away from, a previous situation. Development entails a positive transformation in the condition and circumstance of individuals or societies. According to the UNDP (1994) development is defined as a furthering of human choices that involves a change in economic, social and human aspects from one point to another. Such choices are neither finite nor static. Yet, regardless of the level of development, the three essential choices are to have access to the resources needed for a decent standard of living, to lead a long and healthy life, and to acquire knowledge (UNDP, 1997). Goulet (1971) quoted by Thirlwall in Desai and Potter (2002) state that true development involves three elements: life sustenance concerned with basic needs such as housing, food, education and clothing; self-esteem entailing self-respect and independence; freedom which is the ability to determine one's own destiny.

According to Kambhampati (2004), development is progress in economic, social and political spheres, a fulfilment of basic needs - material, emotional and cerebral. Hence, development requires the growth of output as well as structural, social and possibly, cultural change. But there has recently been a shift from a 'Eurocentric' development model (economic – maximum growth, structural change towards industry; social – change from rural to urban living; political – democratisation) towards a more comprehensive appropriate model that includes environmental sustainability (Kambhampati, 2004). Chambers (1983) suggests that biases within the notion of 'normal' development – eurocentrism, positivism and top-downism are disempowering and sideline local people.

The United Nation Millenium Summit (UN, 2000) put forward the Millenium Development Goals (MDGs) hence extending the definition of development. The aim of the goals is to halve extreme poverty by 2015, achieve universal primary education, promote gender equality and empower women, reduce child and maternal mortality, combat AIDS, malaria and other diseases, ensure environmental sustainability and develop global partnership for development.

To bring about this progress or changes in human conditions, actions need to be taken that seek for solutions, develop understanding, generate resources and knowledge, among other issues necessary to actualise the desired change. An important aspect that is now widely accepted as a necessity for change is people's participation. UNDP (1993) states that people today have an urge – an important urge – to participate in the events and processes that shape their lives. Participatory research and developments have evolved to be main avenues for enhancing societal transformation.

2.2 Participation –concept, evolution and application

2.2.1 The concept of Participation

Greater interest in the concept of participatory development emerged in the 1980s (Mayoux, 1995) after it was realised that the benefits of the centrally planned rural development approach did not reach the intended targets, the poor people (Oakley, 1991 and Uphoff, 1991). This led to a shift from a state planned and controlled development process to one where people are active participants. Participation has been conceptualised differently by different people and within the field of development, it is defined as a means of increasing control over resources, a process that empowers people to actively control their lives, a mechanism to identify needs and find solutions to problems or a voluntary contribution (Misturelli and Heffernen, 2003). According to Pretty *et al*. (1995), the degree of participation varies from passive participation where the communities are just objects of the process to self-mobilisation, where the communities take action independently of the outsiders. Participation within the context of development is taken to mean both process and outcome/product (Misturelli and Heffernen, 2003). Active participation of rural people in the development agendas increases their empowerment and ensures project ownership and sustainability. Thus, participation is a way of empowerment enabling people to hold the 'stick[1]' of development.

Thus, there is no universally accepted definition of what the term participation entails. Several authors have different wording defining participation but they all point at one thing: "active involvement of beneficiaries in a development project or programme". Other related development paradigms currently in fashion include, bottom-up, putting people first, taking target beneficiaries as partners, seeing them as hard working, ingenious and resilient, listening to the voices of the rural poor and their felt needs.

The key elements in the participatory paradigm include implementation, people's involvement, and decision-making process, distribution of benefits, institutional capacity building, and control over resources, self-reliance, transformation, people's primacy, indigenous knowledge, destiny, empowerment and sustainability. Some advantages of people's participation in development programmes and projects according to Oakley (1991) and Mwaniki, (1993), include:

- cost-effectiveness
- efficient use of local resources
- self-reliance (empowering)
- higher coverage/adoption
- increased sustainability
- gender consideration
- value for indigenous knowledge and usage

---

[1] 'Stick' of development is a metaphor which means active contribution in decision-making process in the development process. The metaphor is currently being used by development practitioners that advocate for participation in development (A. M. Muia – Personal Communication).

2.2.2 Participation in historical perspective and application

Mohan and Stokes (2000), as quoted in Desai and Potter (2002), assert that over the past 20 years, a wide range of organisations have started involving local people in their own development. For instance, GTZ (1991), in Nelson and Wright (1995) as quoted by Desai and Potter (2002), adopt participation as involvement of external and local agencies in a project activity. The World Bank's Learning Group on Participation involves stakeholders who 'influence and share control over development initiatives, decisions and resources which affect them' (World Bank, 1994:6 in Nelson and Wright, 1995:5, quoted by Desai and Potter, 2002). The World Bank Learning Group has also developed a scheme (Paul, 1986), identifying indicators of participation as being information-sharing, consultation, decision-making and initiating action. The concept of participation and its application is therefore not standard. There are wide differences in both opinion and practice.

The notion of participation has a strategically well-founded multi-dimensionality as reported in Roseberg, (1993) and according to some authors (Oakley and Marsden, 1984 and Davis-Case, 1989), is conceptualised in a multitude of overlapping and/or contradictory definitions. To other authors (Korten, 1990 and Mulwa, 1987), participation is a way of harnessing the existing physical, economic and social resources of rural people to achieve the objective of development programmes and projects meant to benefit them. It is a welcome, feasible and an alternative approach towards a more people-centred development, replacing conventional top-down approaches that have failed to achieve stated objectives. In this case participation is viewed as a way to influence operations and increase the chances of success in rural development, through the involvement of beneficiaries in a project.

Cohen and Uphoff (1977), report that participation includes people's involvement in decision-making processes in implementing development programmes, their sharing the benefits of the development programmes and, their involvement in efforts to evaluate such programmes. Pearse and Stiefel (1979), regard participation as being concerned with the organised efforts to increase control over resources and regulative institutions in given social situations on the part of the groups and movements of these hitherto excluded from such control. Paul (1987) defines community participation as being an active process by which beneficiaries or client groups influence the direction and execution of a development project with a view to enhancing their well-being in terms of income, personal worth, self-reliance or other values they cherish. According to the World Council of Churches (Mulwa, 1987), participation has been referred to as being peoples' initiative to assert themselves as the subjects of history. The people here include the poor, the oppressed and marginal groups. In the process, people discover their consciousness and identity as they regain control of their destiny and work for transformation of new knowledge by the people, including the appropriation and control of technology so that it serves the people.

Some authors (Oakley, 1991 and Korten, 1990) regard participation also as a means and an end, a means to achieve some predetermined goal or objective, an end because it is a process that unfolds overtime with a purpose to develop and strengthen the capability of rural people to intervene more directly in development initiatives. In his book, ‘Freedom and Socialism’, the former Tanzanian president, the late Nyerere says that "Rural development is the participation of people in a united learning experience involving themselves, their local resources, external agents and outside resources" (Nyerere, 1968).

A strong case to justify participation is argued for by Oakley (1991) that, in order to begin to tackle poverty in the rural areas, it is important to develop the abilities of rural people to have a say in, and to have some influence on, the forces, which control their livelihoods. In this case, participation will lead to a type of development more respectful of the poor people's position and interests.

Uphoff (1986), has however, expressed scepticism over many development projects purporting to be participatory and terms them as pseudo-participatory projects. Such projects are more rhetorical and illusory than real, a view that is also expressed by Okali *et. al*., (1994). They pay increasing lip service to participation and are less committed. Chandran *et al*, (1990) also views such projects as short-lived and exploitative.

Pound *et al.* 2003, have stated that involvement of stakeholders in research for development is crucial for identifying acceptable tradeoffs and reaching consensus about research findings and recommendations. It is also key to coping with the unpredictability of change and to sustaining variability, diversity and resilience in ecosystems.

2.3 Farmer participatory research – concept, evolution, and application

2.3.1 Farmer Participatory Research conceptual framework

Over the past decade, there has been a big debate over the concepts of farmer participatory research (FPR), an idea which has become a centrepiece of a worldwide movement (Long and Long (1992). These authors have described a rich intellectual discourse that explores the nature of knowledge and emphasises interaction and meaning at the interface between knowledge systems. FPR attempts to create a more fruitful interface between formal and informal agricultural research.

Ashby (1992) has described farmer participatory research as ''increasing devolution to farmers of major responsibility for adaptive testing''. Ashby (2003) in Pound *et. al.,* (2003) has also described participatory research as a collection of approaches that enable participants to develop their own understanding of and control over the processes and events being investigated.

Leedesma (1982) describes the elements of participatory research for action as being:

- Participatory in that data gathering, analysis and reporting is done by communities.
- Action-oriented - research findings utilised immediately by local communities to help solve their problems.
- Research done in a systematic way adhering to basic norms of social science investigation.

According to Gubbels (1992) FPR is a new scientific perspective that has recently been developed and is intent on:

- Stressing, illustrating and exploring the abilities of resource-poor farmers to experiment, adapt and innovate.
- Giving priority to farmers' agendas and knowledge.
- Developing practical approaches and methods for farmer participation.
- Understanding and advocating the respective implications for research extension and their institutions.

As noted by Okali *et al*., (1994), FPR also emphasises and focuses on cost-effective technologies, sustainability, indigenous knowledge, local resources and institutional support among others. It hence calls for radical changes that demand reversal of normal and expected roles on the part of outsiders. Many understand FPR to be one element of a "participatory" development agenda (as previously noted), that aims to not only generate, test and disseminate technologies, but also to change the orientation of existing research and development structures, develop a sustainable comity-based research capability and create new social and political institutions (Okali *et al*., 1994). However, the backdrop for FPR is based on realisation of the fact that innovations come from a number of different sources, including farmers, and that many agricultural producers actively seek, test, and pass on new ideas, technologies and materials.

People have different understanding and meaning for FPR (Okali*, et. al.*, 1994; Ashby, 1992; Biggs 1989; Probst and Hagmann, 2003). Some describe projects designed simply to carry out research in close collaboration with farmers. Others refer to broader activities carried out within a much broader agricultural research framework and include extension activities and institutions. It is also used to refer to activities that lie within, but subsidiary to, broader development programmes focused on, for example, community organisation, education or water. This gives a reason why FPR is intertwined with wider debates about empowerment, social justice and community development. FPR aims to operate at the interface between knowledge systems. It is a people-centred process of purposeful and creative interplay between local individuals and communities on one hand, and outsiders with formal agricultural and research knowledge on the other (i.e. a collegiate interface). Many FPR programmes target whole communities rather than individuals, focusing on poverty with emphasis on the involvement of the poorest especially women. Research in FPR programmes is considered essential particularly in difficult, fragile and low potential areas. These environments are characterised by low, unreliable rainfall, poor and easily degradable soils, hilly topography isolated from centres of communication, services and trade. Many descriptions of locations where FPR is being implemented emphasise their diversity, with the implication that standardised or blanket solutions are unlikely to succeed.

Issues of sustainability have also been addressed in a number of ways by many development programmes as observed again by Okali and colleagues (1994). The aim is to minimise dependence on the projects and just as with our approach in the indigenous chicken project, there is an emphasis on the use of local resources and less dependence on external inputs. Sustainability and other policy issues of poverty alleviation, empowerment and rural development that are a concern of Farmer Participatory Research uniquely distinguish it from Farming System Research.

2.3.2 Evolution of Farmer Participatory Research

Participatory research is based on the philosophy of 'conscientisation'[2] of Paolo Frere by addressing root causes of poverty and oppression and aiming at organising disadvantaged communities for increased self-reliance and bargaining power (Rahnema, 1992). Smallholder farmers are active experimenters (Richards 1985) but what rural people can and do achieve for themselves is hardly noticed by the outsiders. As reported by Rahnema, (1992)

---

[2] A situation in which individuals become aware of the conditions and situation around them and begins self dialogue where they question why they are what they are and so begin to desire for a positive change in their own circumstances and in the environment around them. They develop strong sense of awareness and begin to take actions to liberate and empower themselves to bring about new and improved situations of their lives.

a number of major international aid organisations came to accept at some point in time that development projects had often floundered because people were left out.

Farming Systems Research (FSR) preceded FPR, which, according to Sharner et al, (1982), is the first approach that looks at the interactions taking place within the whole farm setting and places emphasis on inter-disciplinality and on integrating rural people into research processes. It aims at improving small-scale farming through the development of appropriate technological solutions. On the other hand, farmer participatory research shifts focus to the central role of farmers and their priorities. Roseberg (1993) reports that, participatory research or action research avoids the widespread mistake of conventional research and planning methods to consider those concerned as mere reservoirs of information- passive and unable to analyse their situation, incapable of finding solutions to their problems.

Transformation in research processes is described by Sutherland (1998) where he observes that conventional research in the 1960s was based in research stations and was mainly supply driven and often unrepresentative of farmers' conditions. In response to criticism of this approach, FSR approach was developed in the late 1970s. It placed importance on demand identification via the diagnosis of farming systems, rationalisation of research resources through priority setting, testing new technology under farmers' conditions and developing strong linkages with extension. From the mid 1980s, FSR approach was criticised as being too linear and prescriptive both by academics and by non-governmental organisations (NGOs) involved in developing and testing new technology. From these critiques, the generic approach of FPR was developed. According to Okali *et al.*, (1994), FPR placed particular emphasis on farmer participation and incorporated ideas from related approaches such as participatory technology development (PTD), participatory rural appraisal (PRA) and low external input agriculture (LEIA). Farrington (1997) however, suggests that an FSR-type approach may work well for resource-endowed farmers in higher potential areas. FPR in contrast, would be more appropriate for resource poorer farmers in more marginal areas. Sutherland (1998), cautions not to confuse FPR with PRA. PRA describes an empowerment-oriented development appraisal with emphasis on participatory appraisal - i.e. one that is initiated by an external multidisciplinary team, using qualitative research methods, to help a local community conduct an efficient assessment of its own situation, including problems and potential. Again, according to Okali *et. al*., (1994) FPR is a new scientific perspective that has recently been developed and can be described in its simplest form as the involvement of farmers in a process of agricultural research. FPR emphasis and focus is on cost-effective technologies, sustainability, indigenous knowledge, local resources and institutional support among others. IFAD (2001), in its rural poverty report, reinforces the need for greater participation, especially of the poor, in deciding which technology to use otherwise they are unlikely to benefit from it.

Farrington and Martin (1987) report that although even in its earliest formulations FSR stressed the need to involve and learn from farmers in research, the purpose of such participation is merely instrumental. The status quo in relations between researchers and farmers remain unquestioned - the expert develops and the target group adopts.

There has been a considerable emphasis on the distinction between FPR and FSR. This is despite the fact that the two concepts share many common elements - farmer participation, multi-disciplinality and location specificity. On this issue, Okali et al., (1994), notes that the current interest in FPR follows two decades of interest and investment in both appropriate technology and FSR. FPR is associated with two often, distinct traditions, agricultural research on one hand, and community development on the other. A number of agricultural research programmes are concerned with 'technical' issues and less concerned with new social organisations although they are deeply involved in FPR.

The community development approach developed out of a realisation of weakness inherent in the 'modern' technocratic approach which had started to be seen as simplistic (Spicer, 1962). Instead, emphasis was placed on location specificity, grassroots involvement and 'felt needs' (Okali *et. al*., 1994). Interest was on appropriate technology, based on local materials and simplicity of production methods, operation and maintenance. Cliffe, 1973, has emphasised similar principles by stating that farmers should be provided with alternatives which they themselves have helped determine and among which they can choose.

Lipton, (1989) has noted that there has been a tendency for research to be focused on high yielding crop varieties and livestock breeds as well as on management strategies for high potential areas to produce surplus to feed an ever-increasing population especially in urban areas. This approach is associated with green revolutions and was carried out at the expense of traditional crop varieties, livestock species and production systems. This involved heavy reliance on external inputs. The approach has not been particularly useful in many instances to the majority of small-scale resource-poor, subsistence farmers in marginal environments. An alternative approach that is dependent on external inputs (Okali *et. al*., 1994) should be able to cope with uncertainty and diversity of poor people in low potential areas.

2.3.3 FPR application

Okali *et. al*., 1994, raise the question of how farmers should participate, for what purpose, stage and kind of programmes. Biggs (1989) cited in Okali *et. al.,* (1994), has described a framework of relationship between actors in research processes. This has four categories of participation that could be termed as 'Biggs’s four Cs'. These are, contractual, consultative, collaborative and collegial modes of participation. The framework is now widely used to classify types of participatory research and development activities. It also describes increasing degree of farmer involvement in decision making. From the accounts given by Okali *et. al*., (1994), most programmes characterise participation in terms of the point or stage at which clients are involved in decision making, such as diagnosis, research design, implementation, monitoring or evaluation. Others who have expressed similar views include, Ashby, (2003), McDougal and Braun (2003), Probst *et. al*., (2000), Lilja and Ashby (2000), Milne *et. al*., (2001) and Johnson *et. al*., (2000). Their sentiments closely resonates with the process used in our indigenous chickens research project. However, as noted by Okali and her colleagues, there is clearly no 'best' mode or level of participation. Many practitioners claim to operate as closely as possible to collegiate mode.

Okali *et al*. (1994), are sceptical about many FPR programmes and projects which they note to be little more than just controlled experimental or test plots in which crop varieties or production techniques are demonstrated and evaluated with little ‘drama and sense of negotiation’. That not withstanding, these workers note that the discussion about farmer participation in agricultural research has become a focal point for a number of debates rooted in a wide range of disciplines and intellectual traditions. They also revolve around subjects cutting across the academic disciplines. They are the touchstones of current development thinking: knowledge, participation, empowerment, sustainability, livelihoods, systems and institutions. They argue that although proponents of FPR are distancing themselves from FSR, they share common roots. While FPR is relatively recent, most of the themes with which it is associated are not new, but form part of a historical shift in opinion and practice. Most FSR programmes were and are implemented largely through research institutions while FPR is implemented through a wider range of institutions. Both FSR and FPR are said to share many common frameworks and activities.

Much of FPR takes place within the context of development activities and hence the heavy involvement of many developmental organisations and NGOs in FPR more than there was relative to FSR. Our own FPR project with indigenous chicken production in Kenya and which is the subject of this thesis, was conceptualised as part of both a research and development agenda. In addition to observing the different ways various farmers try out the available technological options and effects of the latter on production performance, there is also a focus on poverty reduction and the issue of empowerment especially of the disadvantaged section of rural population mainly the women. These are the issues central to most development organisations agenda. Carrying out FPR in the context of development activities is a significant shift from the conventional FSR approach.

Okali *et al.,* (1994) assert that FPR cannot be dissociated from increased awareness of and respect for indigenous or local knowledge. They note that the major interest is interface of local knowledge, experience and experimental skills and more formal agricultural research. FPR has clear advantages for the development of appropriate, environmentally sound or friendly and sustainable production systems.

Local innovations:

At a technological level, the aim of FPR is to understand the main characteristics and dynamics of agro-ecosystems with which the community operates, to identify priority problems and opportunities, and to experiment locally with a variety of technological 'options' based on ideas and experiences derived from indigenous (local) knowledge and formal science (Okali *et. al*., 1994). Probst *et al*., (2003) report that local people's perspectives need to be at the centre of research efforts for development and that innovations need to be 'owned' by local land users if changes in decision making and behaviour leading to impact are to be achieved. Martin and Sutherland (2003) provide a suggestion reported by Hagmann et al., (1999), that a joint learning process empowers and challenges both researchers and farmers to extend their knowledge and action into new areas. Warburton and Martin, (1999) have noted that application of new knowledge does not occur in a vacuum but has to be incorporated into specific social and ecological contexts.

Active farmer experimentation reported by several workers over the years (Richards, 1986; Brammer, 1980; Ghildyal, 1987; Dommen, 1975 and Kaimowitz *et. al.*, 1990), characterises agricultural technological systems into subsystems of basic, strategic, applied and adaptive research. The subsystems facilitate adoption and adaptation of technologies by the users. Basic research develops new knowledge. Strategic research solves specific problems. Applied research develops new technologies based on knowledge generated from basic and strategic research while adaptive research effects changes in the technologies to adapt them to specific regions and producer groups. FSR has its genesis from this kind of classification. It was more of a response to the Green Revolution experience (Okali *et al*., 1994). However, according to Chambers (1992), FSR was used by researchers to validate their own perspectives or actions which is both extractive and disempowering. Okali et. al., 1994, on the other hand, notes that FPR has much in common with FSR and that attempts to make the former be independent of the latter will yield little value. FPR therefore does not discredit the agricultural technological systems but rather tries to give them sense and purpose.

The importance of indigenous knowledge systems (IKS) is highlighted in a number of reports (Okali *et al*., 1994; van der Bliek and van Veldhuizen, 1993; Brokensha *et al*., 1980; Richards, 1978, 1985; Berlin, 1973; Howes and Chambers, 1979). Van der Blieck and van Veldhuizen define it as referring to ideas, experiences, practices or information that has been generated locally or is generated elsewhere but has been transformed by local people and incorporated in the local way of life. It incorporates local technologies as well as cultural, social and economic aspects. IKS however, has its shortcomings as expressed in several reports (Howes and Chambers, 1979; Swift, 1979; Salas, 1992; Uquillas, 1992 and Bell, 1979). Use of IKS (on herbs) was seen as complimentary to scientifically proven disease management strategies. The latter was however, to be modified and adapted to suit rural farmers' circumstances. This is a view shared by other authors (Chambers, 1992; Fairhead 1993; Bentley, 1991).

Several authors have noted that development of low external input sustainable agriculture is central to the future of resource-poor farmers in marginal areas (Woodhouse, 1992; Lightfoot and Noble, 1992; Parret et. al., 1983; Altierri, 1984; Harwwood, 1984). This approach is regarded as one of the major differences between FPR and FSR as the latter put more emphasis on technologies such as high yielding varieties, chemical fertilisers and pesticides. Hence, technical objectives of low external input sustainable systems are seen in terms of optimal use of locally available resources, maximum recycling of external inputs and a stable or increasing level of production (Okali *et al.,*1994). The main objectives or goals are to maintain or increase biological and economic productivity and, enhance efficiency of inputs used. High stability of production and increased resilience to environmental change, minimise adverse environmental impacts, and ensure social compatibility (Lightfoot and Noble, 1992.). One major weakness of the emphasis on local resources is a tendency to dichotomise resources and technologies for the rich and poor. But it has been noted that the dynamic between local and introduced crop varieties is not necessarily one of conflict (Okali *et al.,* 1994).

A basket of options offered for individual households to select technologies best suited to them has been suggested by a number of authors (Gibbon, 1981; Miles, 1982; Sumberg and Okali, 1988; Chambers, 1989; Versteeg and Kondokpon, 1993; Heinrich, 1993). They all emphasise the need for research and extension to focus on provision of options and choices rather than single recommendations.

Gender:

Boserup (1970), brought into limelight the issue of involvement and contribution of women in all aspects of agricultural production. According to Staudt, 1985; Cloud, 1987; Poats, 1991 and Ellerston, 1991, national governments and international development agencies have hence been incorporating women in their development agenda. Moser (1989) notes that men and women have different roles in rural production systems and consequently have different needs. As reported by Okali and colleagues (1994), translation of such understanding into practical programmes has been problematic. As noted by Meadows and Sutherland (2000) and Ndegwa et al (2001a), women are the majority of the rural poor and are heavily engaged in productive activities. However, as noted by Meadows and Sutherland (2000), there is an increasing gender inequality due to work and responsibility loads women have to shoulder in absence of their men-folk who mostly seek alternative engagements off-farms. This also creates a situation for potential gender conflict as gender roles start to change.

Active stakeholder participation in research is more likely to occur when the focus of the research is relevant to their priorities and roles (Martin and

Sutherland, 2003). According to Ashby, (2003), the way in which power relations among stakeholders are handled in a participatory research process is intimately related to the issue of research quality. For example, gender relations affect the distribution of power in a participatory research process and bias the result. McDougall and Braun (2003), highlights the importance of diversity analysis as an integral part of traditional and participatory research. As with gender, diversity refers not only to roles, but also to the dynamic aspects of power relations. According to McDougall (2001), societies ascribe roles, relations and power structures on the basis of gender in combination with other forms of diversity.

Empowerment aspect of FPR:

Allowing farmers more say in decision making (Bunch, 1982; Brown, 1991) is a means of empowering the rural farmers. This is given credence by the assertion from Okali *et. al*., 1994 that a research approach which starts with an analysis of local people, and clearly places greater emphasis on the farmers' own capacity to solve problems or seize opportunities, must be considered potentially empowering. Okali *et al*., (1994), Ashby, (1992), Biggs (1989) and Merill-Sands and Collion (1992), all are in agreement that FPR is not sufficient in empowering as it takes place in the field, at the level of farm families and communities, and between individual researchers and groups of farmers without institutional mechanisms coming into play.

Programmes:

A number of authors (Farrington and Lewis 1993; Bebbington and Thiele, 1993; Wellard and Copestake, 1993; Cromwell and Wiggins 1993) have noted that, few development organisations or programmes devote a significant proportion of their total resources to agricultural research. Most of FPR takes place in the context of agricultural research programmes. However, there is a limited number of NGOs with established research interests. Farrington and Lewis (1993) have reported on ATA in Thailand. This NGO has taken an extreme participatory approach of identifying existing examples of rice-fish technology. Operators of these systems were made resource persons and often share their experience with others. In Bangladesh, Friends in Village Development (FIVDB) has a duck-rearing programme involved in assembling farmers' knowledge for wider dissemination. According to Bebbington and Thiele (1993), most development NGOs involved in FPR deal more with processes than specific technologies. Processes include popular education, farmer organisation, farmer experimentation and participatory diagnosis.

Programmes with FPR within agricultural development and research could be categorised into two distinct groups as noted by Okali *et al* (1994):

- Programmes using farmer participation as a research tool for very specific problems.
- Programmes addressing agricultural research as a long term, community-based development process.

Other examples of projects within the first category include agricultural technology improvement project (ATIP) in Botswana, crop-fish systems in Malawi, Bangladesh and Ghana, and varietal selection programme in Rwanda and Nepal. In the second category, examples include, community-based management of tsetse control in Kenya, the Participatory Research and Extension project (PAREP) in India, the Farmers Research Project in Ethiopia, Farm-Link in Egypt, the Chivi food security project in Zimbabwe, Sustainable Agricultural Research Project (SAVE) in Sierra Leone and the Farmer Participatory Research Project (FPRP) in Uganda.

Some of these programmes use direct interventions and training strategies while others use less direct strategies. The participatory research and extension project (COOPIBO) in Rwanda is concerned with development and sustainability of a continuous process of group innovation. The groups (interest groups) are formed to address particular topics such as vegetable gardening or goat production similar to a Germany-supported GTZ poultry and dairy goats improvement projects in Central Kenya. Training in the Rwandese case involved group representatives who in turn passed on what they had learnt to the rest of the group members. The Rwandese project places considerable emphasis on exchange visits between farmers and researchers and amongst farmers themselves. Just as was the case with the indigenous chicken project, in the Rwandese project, seminars and workshops focusing on specific issues were organised where farmers freely discussed and exchanged ideas with researchers and amongst themselves. This allowed them to discover potential solutions existing and practised elsewhere. Farm Africa's farmer research project in Ethiopia is an example of a project linking non-governmental with government organisations and farmers. This works as a service organisation rather than a project-implementing agency. It aims at enhancing the flow of technical information in the hands of farmers and researchers. Training of farmers in the establishment of on-farm trials is done as a strategy to link farmers and researchers.

2.3.4 Methodologies and approaches in FPR

Methods associated with FPR have generated debate regarding the relative merits of qualitative and quantitative methods. This is also related to the widespread use of participatory rural appraisal (PRA). The use and form of field trials is also a major area of discussion and is related to FSR experience.

Three common methodologies or approaches in FPR have been mentioned by several authors (Goode and Hatt, 1952; Hoeper, 1990; Quiros *et al*., 1991; Long, 1992; Scoones and Thompson, 1992; Long and Long, 1992; Pretty and Chambers, 1992; Cornwall *et al*., 1992; Chambers, 1992; van der Bliek and van Veldhuizen, 1993). The first, is qualitative and quantitative techniques and approaches including PRA. The second concerns enhancement of self-awareness and analytical skills of farmers and attitude changes by researchers. The third centres on modes of experimentation with an emphasis on farmer participation and control.

Qualitative research is seen as aiming at describing and understanding more limited and local realms. Qualitative techniques are equated with an understanding and respect for others and hence seen as more empowering. They emphasise the use of case studies, situational analysis, analysis of interface situations and PRA. PRA tools are noted to be probably the most used in the FPR. On the other hand, traditional quantitative research is viewed as 'sterile', 'elitist' and 'empirical'. In other words, there is a distinction between qualitative and quantitative approaches. The first is non-statistical and the other is statistical. Lilja and Ashby (2000) quoted by McDougall and Braun in Pound *et al.,* (2003), suggest that one fundamental difference between traditional (conventional and quantitative *sic)* research and participatory research is the issue of 'who controls and makes decisions.

However, Barahona and Levy (2003), report that from their experience in Malawi, the dichotomy of the 'qualitative versus 'quantitative' research is a false one. They suggest that statistical principles are amenable to application in research using participatory methods and to generate numbers-based analysis that is 'representative' of a population. They also point out that, there are obviously major differences between research that uses surveys and the research using participatory methods. However, by adopting certain statistical principles and making some adaptation to participatory tools, these differences disappear in most cases.

The PRA techniques and tools have been criticised for being heavily focused on the farmers at the expense of researchers and extensionists (Okali *et al*, 1994). The role of the latter seems to be viewed as being insignificant. However, Galpin *et al*., (2000) have acknowledged the role of extensionists in developing farm management tools using PRA techniques.

In practice, FPR is undertaken by a variety of institutions and organisations with different ideological, institutional and operational orientations and objectives. Two categories of approaches could be identified as:

- Approaches defining steps in the process of technology development.

i) Farrington and Martin (1989) - defining researchable problems, conducting and evaluating research and dissemination of results.

ii) CIMMYT (1989) model as adapted by Amanor (1990)- diagnosis, planning, experimentation, analysis, recommendation and follow-up.

iii) ILEIA framework (ETC, 1992) adapted by van de Briek and van Veldhuizen (1993) - getting started, identification of options and making choices, improving and innovating, spreading out, sustaining the process.

iv) Approaches focusing on level, character or mode of participation in programme or activity. The framework by Biggs (1989) – contractual, consultative, collaborative and collegiate is a good example of these approaches.

Okali and her colleagues (1994) have also made a number of observations concerning many FPR programmes and which interestingly, fit the process and design of our own FPR with indigenous chickens described in detail in chapter three.

- Activities are carried out within more general development projects and there are relatively few activities involved solely with the FPR.
- Due to the development context in which FPR is taking place, some social and political concepts have become part of FPR.
- Some issues key to successful implementation activity include selection of participants, sustainability of the investigation process, consideration of an agro-ecological perspective, effects on research agendas and information needed prior to project implementation.
- working with groups rather than individual farmers is the preferred mode of most development agencies and that many programmes initiate new groups rather than work with existing organisations.

Okali and colleagues report a polarisation of debate among FPR programmes but there is generally agreement on steps in research processes. The most common of these being: identification of opportunities and constraints, identification of ideas and options for addressing these opportunities and constraints and testing and adaptation of ideas and options. They suggest a possibility of both farmers and researchers being involved at any or all points along a continuum of levels of participation. This should take cognisant of the research implemented by farmers alone, and that by researchers alone (on-farm and on-station).

Research activities in the past took place within a political, social-economic and agro-climatic context which, as noted by several writers (Biggs and Farrington, 1991b; Biggs, 1989; Gubbels 1992a, Bebbington and Thielle, 1993; Pretty and Chambers, 1992) do not support the FPR. The situation has obviously changed over time with wide acceptance and application of participatory approaches. Modernisation theory (Moore, (1963) as reported in Okali *et. al.,* (1994)) and technocratic approaches to development considered 'traditional' society and culture as unprogressive or stagnant. Little faith or none at all was given to abilities and capacities of farmers who were supposed to adapt the 'modern' technological packages which in many cases were not suitable to prevailing circumstances and environments. Okali *et. al.,* 1994, note that the modernisation theory has fallen from favour while traditional systems have taken the front stage.

The modernisation and technocratic approaches to development emphasised use of exotic hybrid poultry and a commercial production system and this, at the expense of local germplasm and traditional management systems. However, the use of local resources and knowledge is presently acknowledged as equally important in development approaches. It is highly intensive and expensive with a high external inputs reliance. According to Handwerker (1973) and Parkin (1972), rural farmers have been able to innovate and adapt in changing circumstances. An example of local peoples involvement in innovation processes is CIAT’s Local Agricultural Research Committees (CIALs) (Ashby *et. al*., 2000; Ashby and Sperling, 1995; Braun et. al., 2000, in Probst and Hagmann, 2003). In a field study on participatory research, 70% of researchers considered local people to be equal partners in a joint innovation process (Fernandez, 1999). Okali and colleagues (1994) note that ability of individuals to affect their situations depends on various political, cultural, social, economic and personal factors. Hence the need to pay attention to individual farmers.

In reviewing a number of specific programmes, Okali and her colleagues identify four categories of information vital for successful programme planning as being: institutions and patterns of social and economic relations; farmer experimentation; the flow of resources and information; and gaps in local technical knowledge. Different levels of farmer and research participation are likely to be appropriate in different contexts and with different types of research being undertaken. Problem identification and on-farm trials are the two most common participatory activities.

2.4 Evaluating participation

According to Oakley (1991), parameters and the content of evaluation of participation will necessarily be linked to the operational understanding of participation. If the understanding is limited to the notion of economic benefits derived from successful projects, physical attendance at project's activities or extended project coverage, then the evaluation will probably be largely quantitative. If the operational understanding is more closely linked to participation as a process with a series of qualitative objectives, then the evaluation will demand an alternative form, a qualitative method. It will be concerned with the analysis of a dynamic qualitative process and not merely the measuring of static, physical outcome.

Where participation is defined in terms of direct contributions to projects, sharing in the economic benefits or physical involvement in project organisation or decision-making procedures, evaluation of participation draws upon an enormous body of literature and practice already available. In projects with this understanding of ‘participation’, participation is evaluated as part of and in the same way as other project objectives. However, participation as a qualitative process deals with forms of change that have characteristics and properties not necessarily amenable to quantitative techniques (Imboden,1979).

Participation, like poverty, is an abstract concept (Oakley, 1991) that is concerned with results which are quantifiable, but more importantly, with processes that are qualitative in nature. A phenomenon occurs over time and cannot be measured simply by a single 'snap-shot' form of exercise. As a process, it unfolds throughout the life of a project and continues when a project formally ceases.

Hence quantitative analysis is used on material development and qualitative analysis used on development of peoples consciousness and their organisation (increasing level of awareness). In other words, evaluation of participation involves measuring tangibles and intangibles, quantitative and qualitative, as was noted earlier with Barahona and Levy (2003). Bhasin (1985) noted that material development and development of people's consciousness and their organisation go together. That is, quantitative and qualitative analysis cannot be exclusive of each other. The author further notes that when working with poor people, material well-being takes precedence. Their material conditions have to be improved first. The poor will not be interested in consciousness raising for its own sake. It must lead to an improvement in material wellbeing.

FPR as a participatory process is also amenable to both quantitative and qualitative analyses which offer good criteria to differentiate and categorise projects (Barahona and Levy, 2003). Evaluation of participation in such FPR projects helps better understand their effectiveness in meeting objectives for improving conditions of target beneficiaries**.**

2.5. Challenges in livestock focused participatory research

A crucial issue that calls for greater attention within the farmer participatory research discourse is the challenge posed when dealing with livestock. According to Morton *et. al*.,(2002) most of the farmer participatory research has tended to focus on issues dealing with crops rather than livestock science. Given the emphasis placed on use of local resources in participatory research processes, the expected outcome would very much depend on the nature of such resources and the way local people relate to them. The majority of farmers in Kenya are smallholders with less than 5 acres of land divided among competing interests of the household including growing of various crops and rearing of different livestock species. Livestock keeping is limited to the carrying capacity of a household plot of land and factors such as wealth, preference (due to culture or religion). Hence, most of these farmers would have only a small number of livestock heads either cattle, sheep, goats, pigs or indigenous poultry which are highly valued. With exception of poultry, women normally do not have mandate over livestock even though they are the ones who rear them. Despite the small number of livestock heads per household, they are highly valued and have always been seen as security and status symbols. They also provide a source of food and income by supplying hides and skins, wool, milk, meat (rarely), eggs, and labour.

Crops on the other hand do not excite similar sentimentalities and are mostly tended by women for food to feed their families. A number of different crops can easily be grown within the same plot and in different seasons, therefore providing more options for participatory and on-farm research activities. Crops are also viewed as being less risky to deal with as they can easily be replaced in case of a failure and in any case, only a small portion of plot might be required to be set aside for experimentation. The plot could even be segmented to allow factorial and replicated trials. Experimentation with livestock on the other hand presents a real challenge given their small number per household and the sentimentalities around them. Hence high risk trials might be too costly to a household if such trials result in the loss of the animal(s) or reduced production. Factorial and replicated trials with animals are therefore difficult if not entirely impossible to carry out at farm level. Farmer participation is also restricted by gender resource control in a household for research dealing with livestock compared to crop related research activities. An example would be when one is working specific with women groups and individual members have to make some animals available for experimentation. Unless it is a woman led household, participation of many women in this case will solely depend on a man’s decision and is not guaranteed.

Consequently, the challenges of dealing with livestock requires development of strategies that minimise the risks involved as well as allowing for multifactor and replicated trials to be carried out. Participatory research with livestock therefore is not as easily applicable as is the case with crops research. Animals are not sedentary, hence the difficulty of applying uniform treatments and the requirement for higher capital investment. They are more prone to theft, or loss from disease. Hence participatory livestock research should be applied with great sensitivity as farmers risk high loss from reduced output or loss of the animal.

2.6 Participatory research using indigenous chicken

Our experience with participatory research dealing with indigenous chickens gives credence to the assertion that gender control of a resource and type of livestock are important factors influencing research processes and outcomes. Women have greater control over indigenous chickens than other livestock species.

The nature of chickens as small animals, relatively larger numbers in a household, high fecundity, short life cycles, lower monetary value per head and low attachment to them by the people especially men, make them more easily amenable to participatory research approaches than would be the case with other larger livestock species. The risk of loss is much less and so are the other hindrances to dealing with the resource in a participatory research process. Though the numbers may not easily allow for a factorial and replicated trial in a household, this could be overcome by dealing with a large number of households in different localities and using specific statistical analyses such as regression and analysis of variation as we have done with our indigenous chicken project. This is described in greater detail in chapter 5.

One way of dealing with the challenges of livestock participatory research might be to establish some form of insurance that protects farmers from perceived potential loss. This could be an agreement to compensate them in case an animal dies or there is reduced production resulting from research activities. Farmers could also be provided with at least one input used for the research activities. These and other forms of incentives are imperatives to stimulating and sustaining a participatory research process with livestock. In our case, providing farmers with a few chicken would allow for many manipulations that a research process might demand such as slaughtering of birds to check for internal worm infestation.

The Farmer Participatory Research Project presented in this thesis focused on improved management of indigenous chickens systems. The project involved a wide spectrum of stakeholders and also encompassed many of FPR concepts as detailed later in chapter three. This study with indigenous chicken is of importance in contributing to the general understanding of challenges and opportunities of participatory research with livestock.

CHAPTER 3

METHODOLOGY, PROCESS AND RATIONALE OF THE FARMER PARTICIPATORY RESEARCH AND OTHER RESEARCH ACTIVITIES WITH INDIGENOUS CHICKENS

3.1 Introduction

There have been a number of attempts to understand the underlying principles of the indigenous poultry systems in Kenya and their role in livelihoods scenarios among smallholder poor farmers and to improve productivity as a means of enhancing these livelihoods through research and development programmes (Ndegwa *et. al*., 2000; Ndegwa *et. al*., 2001a).

This chapter describes the research process with indigenous chickens through the process of information gathering and consultations, on-station researcher managed studies and farm-level farmer participatory research carried out in Kenya from the National Animal Husbandry Research Centre of the Kenya Agricultural Research Institute within the past decade. The aim was to investigate production characteristics of indigenous chickens and the effect of improved management practices on production performance, both at the on-station and farm level, as well as examining their potential as a livelihood strategy among poor smallholder farmers.

Conventionally and as described, by Johnstone (1998), many research projects, trials or experiments follow a specific pattern of experimental intentions. Design involves decisions on the experimental unit, experimental site, and measurements to be made, description of measured response or modelling, and comparisons needed to be made, detecting differences between treatments, and experimental layout. After this comes planning and facilitation, management of experiment (implementation, measurement, recording), data analysis and reporting. There is therefore need to have clear experimental intentions before data is collected.

Research can be generally categorised according to three purposes; explanatory, exploratory and descriptive. In social science, the research purposes are achieved through one or more research methods or strategies; experiments, surveys, histories, analysis of archival information and case study (Yin, 1994). Conventionally, various research strategies are arrayed hierarchically thus; case study for the exploratory phase, surveys and histories in the descriptive phase and experiments for explanatory or causal inquiries. According to Platt, (1992), case studies were only an exploratory tool and could not be used to describe or test propositions but Yin (1994) suggests that each strategy can be used for all three purposes – exploratory, descriptive and explanatory. Thus, there may be exploratory case study, descriptive case study or explanative case study. The need for a case study arises out of desire to understand complex social phenomena, which allows the investigation to retain the holistic and meaningful characteristics of real-life events. According to Sieber (1973), there are huge areas of overlap among various research methods or strategies.

The present study with indigenous chicken involves a mix of different research strategies both empirical and non-empirical. The use of these mixed research strategies was necessitated by the need to explore as widely and deeply as possible, the indigenous poultry system and its implication in livelihood scenarios. Hence the strategies ranged from on-station experimentation to engagement of participatory and development principles.

The purpose of experiments according to Mead *et al.*, (2003) is to make inferences as unambiguously as possible about the effects of treatments applied to experimental units. The units are taken as representative of the population of units to which the treatments may in future be applied. Randomisation is used in experiments to remove biases in comparing treatments while blocking is used to control the effects of factors other than treatments that are known to effect the response measured. The same authors also describe the objectives of sample surveys as being to allow inferences to be made from a sample about the whole, but always finite, population from which it has been drawn. In this case, “there is no imposition of treatments”. Sample surveys should describe certain properties of the population as they naturally exist. In sample surveys, say of people, a population may be divided into strata according to social economic class, then sampled separately from each stratum. Stratification in sample survey is related to blocking in experiments, both being ways of controlling unwanted sources of variation.

As outlined in chapter 2, the farmer participatory research (FPR) is a new scientific perspective that has recently been developed and can be described in its simplest form as the involvement of farmers in a process of agricultural research (Okali, *et al.* 1994). This approach developed out of a realisation that the relatively more traditional farming systems research (FSR) developed in the late 1970s had major flaws in bringing about desired sustainable development achievements. It placed importance on demand identification via the diagnosis of farming systems, rationalisation of research resources through priority setting, testing new technology under farmers' conditions and developing strong linkages with extension. Hence FSR was viewed as being too linear and prescriptive. FSR itself had emerged out of the shortcomings of the conventional research of the 1960s based in research stations that was mainly supply driven and often unrepresentative of farmers' conditions (Sutherland, 1994). FPR on the other hand, focuses on cost-effective technologies, sustainability, indigenous knowledge, local resources and institutional support among others.

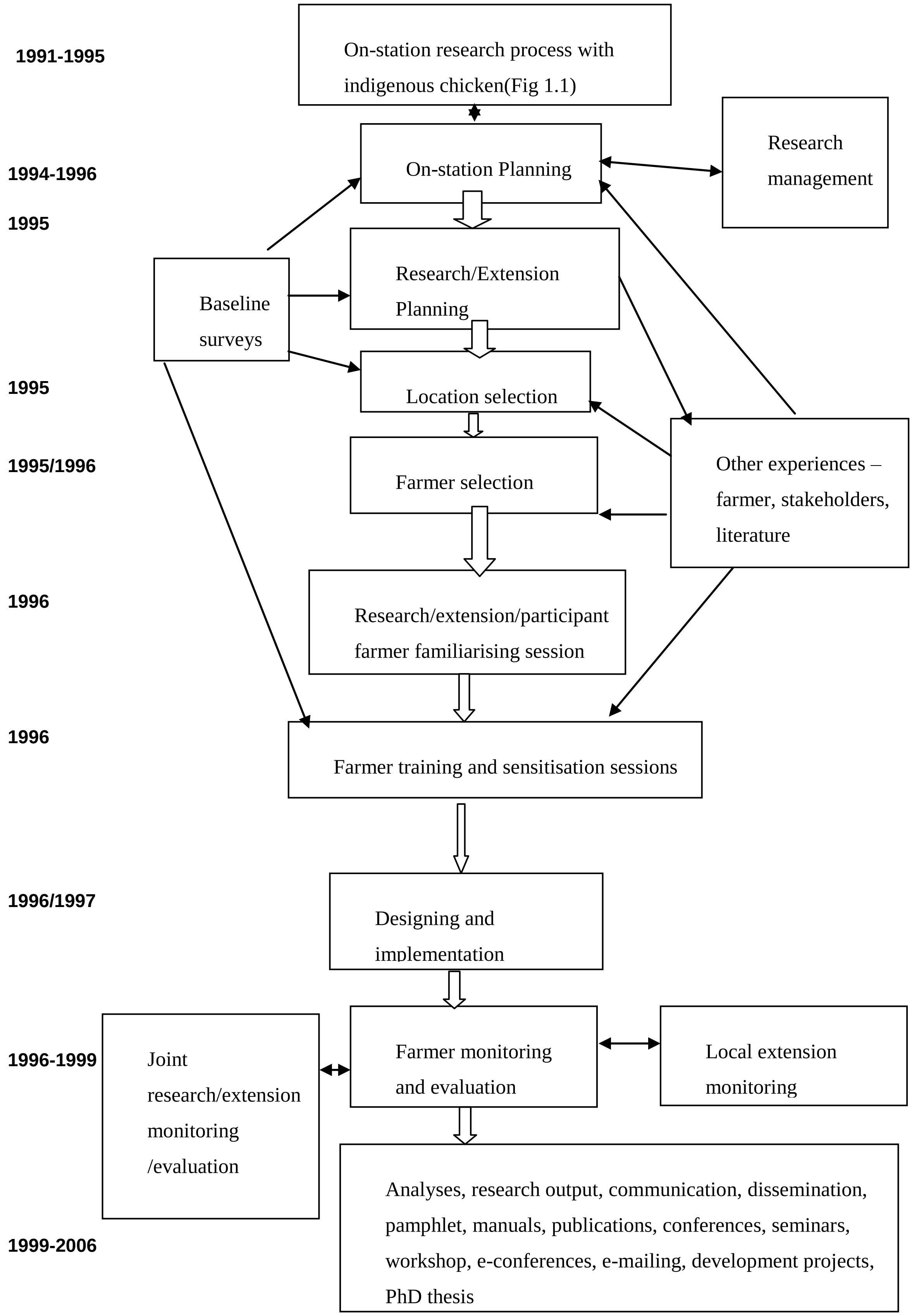
Ashby (2003) in Pound *et al*., (2003) reports that research for participatory resource management requires, but is not limited to, the use of participatory methods. A wide range of research methods, both participatory and non-participatory, are combined and need to be understood as a spectrum of methods and approaches from which stakeholders- not just researchers – can choose. McDougall and Braun (2003) in Pound *et. al*., (2003) argue that the desired improvements in natural resource management (NRM) demand that research institutions assess, more explicitly and thoughtfully than ever before, the multiple facets of traditional and participatory research approaches, and consciously craft appropriate and innovative combinations of approaches for each research initiative.

Research is useful only if it is taken up and applied by users of information and technology derived from it according to Garforth (1998). This is enhanced by dissemination to ‘end users’ (farmers, individuals, households, communities, companies, associations) engaged in productive activities, and ‘intermediate users’ (researchers in international agricultural research centres and national agricultural research systems, others concerned with research and development in non-governmental organisations, private sector, extension, and donors).

This research process has attempted to encompass the various participatory modes described by Biggs (1989) adapted by Okali *et al.,* (1994) namely, contractual, consultative, collaborative and collegial as pointed out in greater details in chapter two of this thesis. The on-station research was basically of the contractual mode without any participation of farmers although they were our main clients. This involved researcher-controlled experimentation using solely quantitative statistical methods. The research process also involved a phase of field surveys and visits in the consultative mode of participation using a mix of some quantitative and qualitative methodologies. The third phase in our research process was the farm level studies with more qualitative statistical approach and user perspectives. There was a strong farmer and extension participation falling within a collaborative and collegial mode of participation.

The process of our research studies with indigenous chickens involved a number of stages that have been summarised chronologically in the flow diagram shown earlier by Fig 1.1, section 1.1 and by Fig 3.1 in this section.

Figure 3.1. Farmer participatory research process and methodology with indigenous chickens in Kenya



3.2 The on-station, researcher-managed studies of indigenous chickens

3.2.1 General description

The objective of the on-station research activities was mainly to gain greater understanding of characteristics and nature of indigenous chickens. Apart from the information on the production of commercial poultry, there was a knowledge gap as far as the indigenous chickens were concerned. The technology that was passed on by extension and development agencies to the farmers relating to indigenous chickens was usually based on information meant for commercial poultry production, an entirely different system.

We conducted a number of studies at station level to understand the character and potential of indigenous chickens. The aim was to generate and disseminate relevant information on improved production management practices for use by farmers and support services. Previous development and extension activities had not done much to change prevalent negative attitudes and perception by various stakeholders on indigenous chickens' potential as a livelihood strategy, and hence failed to create enthusiasm in the rearing of these birds among majority of smallholder poor farmers. The on-station research hoped to bridge the knowledge gap. A number of research studies were hence carried out which generated valuable information and provided important experiences on the indigenous chickens reared under controlled standard management practices. The main studies included:

- Monitoring the growth performance of three lines of indigenous chickens obtained from three different regions in Kenya and their reciprocal crosses under a station management regime. This was done by monitoring the weight of individual birds on a weekly basis from the time of hatching through to maturity.
- Hatching characteristics of eggs from six reciprocal crosses of indigenous chickens. The eggs were artificially incubated in the research station.
- Nutritional experiments involving investigation of the growth performance of indigenous chickens fed diets with different protein levels. This was done from the time of hatching and up to 25 weeks of age.

- Nutritional studies to investigate the efficacy of various feedstuffs such as simsim seeds (*Sesamum indicum),* sorghum and grain amaranthus in poultry diets (Ndegwa, 1992a, 1992b; Tuitoek, *et al*. 1998; Okon'go *et al,* 1999)

Details on the on-station research studies are in chapter 4. The findings and experiences informed the subsequent farm level participatory studies.

3.2.2 On-station research outcomes

A number of on-station experiments were carried out to evaluate production performance of indigenous chickens under improved management and to establish their characteristics in terms of growth patterns, hatching of eggs artificially incubated and nutritional aspects. Information about these is reported in Ndegwa, 1992; Okong'o *et. al.,* 1998; Tuitoek, *et. al.,* 1999; Ndegwa *et, al.* 2001c, Ndegwa *et, al.* 2002; Ndegwa *et, al.* 2005a and Ndegwa *et, al.* 2005b - see appendix 3.1 - Box 3.1. Two of the publications are presented in greater details in chapter 4.

The research team gained confidence dealing with stakeholders including farmer and extension groups on matters relating to management of indigenous chicken. This was an important aspect to achieve impact in persuading farmers to adapt or adopt technologies to improve productivity of their flocks.

The on-station research also helped create awareness and generate interest and enthusiasm in indigenous chickens among stakeholders including researchers, extensionist, farmers, students from schools, colleges and universities, lecturers and teachers, government officials and dignitaries, members of general public and foreign visitors. Most important, the policy makers in research and extension became aware of these research endeavours. This resulted from stakeholders visiting the centre to see the research involving indigenous chicken. Farmer visitors were particularly impressed and desired to similarly improve the management of their indigenous chicken flocks. The visitors gave valuable advice concerning indigenous chicken management which was a great source of encouragement. This also sharpened our appetite and fuelled enthusiasm to experiment with farmers' local resources. The experience from these studies informed the subsequent farm-level participatory studies.

3.3 Information gathering and consultations

These processes involved stakeholder workshops and meetings, field visits to key informants and farm level surveys.

3.3.1 Stakeholder workshops

Process Description:

Stakeholders are individuals or organisations with legitimate interests in a project. Hence it was imperative to incorporate divergent views of different stakeholders in the indigenous chicken production systems in our research plans. Grimble (1998), suggests that many projects fail to meet their stated objectives because of non-co-operation and involvement of key stakeholders. He also states that stakeholder groups cut across society as a whole and range, for example, from formal or informal groups of men or women farmers to government bodies or international agencies and multinational companies. According to ODA (1995), a stakeholder is any person, group or institution that has an interest in an aid activity, project or programme. The key stakeholders in natural resource research are subsistence farmers and other small-scale natural resource users, but stakeholders may equally include development practitioners, policy makers, planners and administrators in government, commercial bodies or non-governmental organisations (NGOs).

Grimble (1998), further states that, the most fundamental division between stakeholders is between those who affect (determine) a decision or action – and those who are affected (whether positively or negatively). The distinction may not be absolute, however, some groups like local people may be involved in natural resource management in both active and passive ways. This is similar to the ODA (1995a) categorising of stakeholders into two very broad groups: those with some intermediate role – secondary stakeholders – and those ultimately affected, primary stakeholders, who expect to benefit from or be adversely affected by for example, ODA's aid. Stakeholders are groups of people who share a common interest. Again, stakeholder groups selected should be relevant to the research or activity being undertaken. This was the main criteria we used in selecting various stakeholders for the workshops. They were all in one way or the other involved or had interest in the poultry industry although we did not strictly follow the ODA (1995b) checklist for identifying stakeholders that argue for the following considerations:

- Have all primary and secondary stakeholders been listed?
- Have all potential supporters and opponents of the project been identified?
- Has gender analysis been used to identify different types of female stakeholders (at both primary and secondary levels)?
- Have primary stakeholders been divided into user/occupation groups, or income groups?
- Have the interests of vulnerable groups (especially the poor) been identified?
- Are there any new primary or secondary stakeholders that are likely to emerge as a result of the project?

Our stakeholder workshops were organised and conducted by the National Poultry Research Programme (NPRP) at the National Animal Husbandry Research Centre, Naivasha, one of the Kenya Agricultural Research Institute (KARI) centres, during Phase II (1994-1999) of the National Agricultural Research Programme (NARP II – KARI, 1994). We brought together individuals and representative of farmer groups, extension services, local universities, non-governmental organisations, animal feed industry, drug manufacturers, input suppliers, commercial poultry producers and chick multiplier/supplier. The status of poultry industry in Kenya, its challenges and opportunities were explored and suggestions for interventions made. Two stakeholder workshops were held in 1994 each attended by 32 people (Mbugua *et al*., 1994; Ndegwa *et al*., 1994). A mini-workshop in 1996 with research and extension teams discussed and arranged for baseline field surveys that we carried out as a prelude to the farmer participatory research.

The first workshop aimed at gathering available knowledge on:

- Major local production systems
- Production constraints
- Farmers' solutions to the constraints
- Researchable constraints at the farm level

The proceedings of this workshop formed the basis of a second workshop where on-farm adaptive research topics were explored and prioritised (Ndegwa *et al*., 1994). The main objective of the second workshop was to bring together stakeholders in the poultry industry to actively participate in discussions aimed at:

- Formulation of concrete goals to be achieved under NARP II.
- Formulation of project proposals to meet these goals and rank them on the basis of both priority of the topic and achievability of the project, and fitting in the setting of NARP II.

The 'SWOT' methodology (based on identification of Strong and Weak points and Opportunities and Threats of the research) was used to achieve these objectives. During the workshop, the participants (in working groups) were expected to explore, describe and prioritise, sessions the following:

- Strong and weak points of those involved in poultry research and development as a group.
- Opportunities and threats (constraints) for poultry research and development.
- Quantified goals (i.e. required/expected output) for the NPRP. These goals had to be specific, quantified, measurable and challenging.
- Research questions or questions of institutional, organisational and educational nature that have to be answered to meet the above selected goals.
- Write draft project proposals to handle the research questions, to serve as input for the Plan of Operations for the NPRP.

The purpose of this second workshop then, was to prioritise (research) questions and formulate actions to be undertaken, either in the form of research proposals or as activities of an organisational nature to solve specific weaknesses in or threats to poultry research.

Proceedings from these two workshops formed the main guidelines in the preparation of the National Poultry Research Programme (NPRP) Five Year (1995 -1999) Plan of Operation and detailed yearly work-plans (KARI, 1995). The workshops provided an analysis of the poultry industry in Kenya, its characteristics, constraints and opportunities (Mbugua *et al*., 1994; Ndegwa *et al*., 1994). The farmer participatory research project was developed within the framework of the NPRP.

One shortcoming of these stakeholder workshops was the lack of adequate representation of an important category of stakeholders, the poor rural subsistence farmers keeping a handful of indigenous chicken. This oversight could be attributed to a lack of understanding of the importance of participation of these stakeholders and probably also due to lack of interaction between the research team organising the workshops and the farmers. This also reflects the perception of researchers concerning the involvement of farmers in such activities and a lack of recognition of rural people's capacity, ability, knowledge, resources and aspirations. Were these workshops and activities to be undertaken now, it would be conditional on real and active involvement of the poor farmers in research process, given our current level of understanding and knowledge of the participatory perspectives.

Stakeholders workshops outcome:

During the first workshop, three principal poultry production systems were identified:

- The free range mainly indigenous chickens
- The semi-commercial system where small numbers are raised and its variants such as the mixed system with chicken, geese, ducks, turkeys and pigeons. Exotic commercial chicken breeds and their crosses with indigenous chicken are mainly reared in this system.
- The intensive system with mainly 'large-scale' exotic commercial breeds.

In the second workshop, characteristics, constraints and opportunities in the three poultry production systems were identified and included:

- Subsistence system - characterised by low input, minimal investments, small scale (<20), (semi-)scavenging, indigenous (crossbred) chickens, mainly meat production, irregular sales, and used as a 'bank-account' - controlled by and accessible to rural women where they could sell some eggs or a bird to meet some household needs.
- Small scale, commercial, 'garage-farming' system - characterised by, high input, low investments, small scale (<50), confinement, indigenous/crossbred/exotic, meat and/or eggs, regular sales, 'bank-account'.
- Large-scale commercial system - characterised by high input, considerable investments, exotic chickens, confinement, meat or eggs (specialised).

Major constraints in poultry production were listed as generally being:

- Socio-cultural factors (low regard for indigenous chicken production which was considered a domain of women and youth; eggs and poultry meat were not commonly consumed by members of a household but were rather reserved for important guests; lack of awareness about potential of the systems as a livelihood opportunity)
- Lack of appropriate technological know-how for different poultry systems
- Lack of capital
- Lack of Market organisation
- Lack of Institutional support

Specific constraints for carrying out on-farm research were mentioned as being:

- Logistics - on-farm research involves high capital investment as well as proper co-ordination and timing, due to involvement of different actors.
- How to handle results of farmers involved in a research project. Farmers cannot necessarily stick to strict research routines and hence expected outputs may not be achieved. This can be frustrating to a researcher used to controlled experiments with pre-determined outcomes.
- Skill of research personnel - lack of experience and inadequate training in on-farm experimentation.

Problems in poultry production system in general were identified as being:

- High mortality (caused by predation, infectious diseases and malnutrition).
- Shortage of feed ingredients and feed of guaranteed quality.
- Lack of knowledge on on-farm mixing of diets.
- Lack of knowledge on input-output relations.
- Unavailability of one day old chicks,
- Lack of knowledge on housing systems, hygiene, flock size management, genetic potential and inbreeding.

Following the consultations and focusing on the orientation in the national agricultural research strategic policy framework as at that time, a five-year Plan of Operation for the National Poultry Research Programme was put in place as the framework for research with more emphasis on indigenous chicken and on-farm research (KARI, 1995).

3.3.2 Field visits and consultations with key informants- Networking

Process Description:

The visits and intense consultations took place in mid-1996 with the objective of collecting more information on the general status of the poultry industry in Kenya and in particular that of the indigenous chickens. Consequently, a wide variety of views was collected on how best the industry could be improved to make it more responsive to challenges of poverty alleviation and enhancement of peoples' livelihoods. We also aimed to foster close linkages with the agricultural extension service, local universities, development and research projects, non-governmental organisations, professional organisations, international organisations and agricultural input suppliers among others. Our plans to undertake farmer participatory research were discussed and valuable suggestions were provided by majority of our hosts. This is what Starkey (1996) describes as networking. He defines networking as any group of individuals or organisations, which on a voluntary basis, exchange information or undertake joint activities in such a way that the interactive process of networking strengthens the individual autonomy of the members. Our visits and discussions therefore established good relationships through sharing experiences and information and where possible, arrangements were made to carry out joint activities. According to Starkey (1996), many of those involved in agricultural development are isolated from the wider experiences of others. Information flows are top-down and narrow, restricted to single disciplines, limited geographical areas and prevailing organisational persuasion. The same author suggests that networks are important as they allow people and organisations to exchange information and experiences and to cooperate with those outside their immediate environment. Whether formal or informal, national or international, networks are extremely valuable and cost-effective mechanisms for enhancing agricultural development.

These visits were therefore both elaborate and extensive. They covered universities, extension service, professional organisations, development projects, international organisations, non-governmental organisations and input suppliers as shown in Appendix 3.2 – Box 3.2.

Details of the outcomes from these visits and consultations are given in a report by Ndegwa *et.al.,* (1998b). Important insights into the state of the poultry industry were obtained as well as ideas of what others were doing and these contributed in the forging of close linkages and collaboration in our subsequent farmer participatory research activities whose planning was also shared with other stakeholders. Close working relationships were especially established between ourselves and the local universities and the agricultural extension service from the headquarters down to divisional and location levels in areas where the participatory research on-farm was planned to be carried out. A number of joint on-station research projects focusing on indigenous chicken have been carried out mainly as a result of the close links established with the stakeholders.

Field visits highlights:

Field visits with semi-structured interviews of key informants (networking), are reported in Ndegwa *et al*., (1998b). The following are highlights of some pertinent issues observed:

- Poultry industry is an important component in the rural farming system.

- Indigenous chickens are reared in all the places visited while commercial poultry production tended to be concentrated in urban and peri-urban areas.
- Both indigenous and commercial poultry production systems are constrained by poor management.
- Technical knowledge on poultry husbandry was deficient among extension personnel and farmers.
- Many stakeholders considered indigenous chicken to be of great importance in uplifting livelihoods of rural poor if well harnessed. There was a chance for economic gains from rearing indigenous chickens as witnessed by a chicken market at Chaperaria, West Pokot where over a thousand birds and thirty trays of eggs (30 eggs each) were sold in a day. The majority of those selling the birds and their products were Pokot women, a community that is traditionally pastoralist. We had not expected women to handle livestock which is regarded as mainly men’s domain.
- It was necessary to carry out a survey at the farm level to establish the state of poultry production as practised and viewed by farmers.

The workshops and visits to key stakeholders enabled establishment of close linkages and development of collaborative research with Egerton University and the University of Nairobi. Plans for collaborative research were also made with Baraton University. These research projects focused on indigenous chicken and two masters degree level projects were jointly carried out, one each with Egerton and Nairobi. A third on-station PhD research project with indigenous chicken is also due for completion as a joint venture between KARI and Egerton University (see Appendix 3.3- Box 3.3).

Collaboration with the NGOs did not go as far as expected. This could be attributed to the fact that most of these NGOs were not research oriented and might therefore have been less enthusiastic about joining our project. There was also no indication from them regarding their 'feeling' or willingness to participate. It is not certain why they did not participate but it was felt that they probably lacked qualified and interested personnel to take up the challenge. On the other hand, our team lacked financial resources to carry out follow-up visits to convince and persuade the would-be partners.

3.3.3 Research/Extension mini-workshop and meetings

A research and extension stakeholder mini-workshop was held late in 1996 at the National Animal Husbandry Research Centre, Naivasha, to discuss and set out modalities of conducting baseline field surveys to precede the farmer participatory research. Summary findings of the previous workshops and field visits were also discussed and informed decisions made on the baseline survey and planning of the farmer participatory research. The modalities of conducting baseline surveys were discussed at length and decisions made on selection of locations for the survey based on land size and agro-ecological zonations, number of farmers to be covered per location (cluster or village) and the information to be collected (status of poultry production at farm level and other household characteristics). A choice of some Participatory Rural Appraisal (PRA) tools specifically, checklist, transect walk and semi-structured interviewing of farmers to gather the required information in the baseline survey was made at the meeting. This was necessary to win the trust of the farmers and to collect more information from a large number of farmers easily and quickly. Further brief meetings were held over specific details about area and farmers to be covered as well as counter-checking the checklist at divisional agricultural extension offices in five different regions.

3.3.4 Baseline field survey

Process description:

The survey was carried out in five different regions and in four locations (villages or clusters) within a region and covering about 15 farmers per location. These regions were: 1) Njoro - medium-high potential; 2) Ol Kalou - cold and medium-high potential; 3) Ngarua - low potential arid and semi-arid area (ASAL); Naivasha – medium-low potential some arid segments; 5) Bahati – high potential. The four clusters covered in each region differed in agro-climatic zones, land sizes and other features like infrastructure. Sampling of farmers in a given cluster was done systematically along a transect walk through the cluster.

This clustering and transect can be viewed as a mix of the standard procedures in sample surveys described by Mead *et al.,* (2003). This was also a means of controlling unwanted sources of variation. “Transect” means a transverse walk in a given cluster so as to cover as many features within it as possible.

A checklist was used to collect the baseline information for every household including the situation of their flocks and the problems most experienced that hinder production. Farmers were approached and requested to state their willingness to participate in the planned farmer participatory research at their own farms and using their own local resources. This was an important criteria used in selecting farmers for the participatory research

This survey was a consultative mode of participation and was also an opportunity to develop partnerships between research and extension teams on one hand and with farmers on the other. This created mutual trust and an atmosphere for free exchange of information and ideas. Hence, the checklist used and the mode of collecting the information was devoid of the 'threats' farmers would usually experience from formal, conventional, questionnaire-type interviewing.

The survey then, was a mix of both qualitative and quantitative methods. Marsland *el at*., (2001), point out that there are areas where the 2 types of approaches can benefit from each other, leading in turn to improved quality of information which is required for appropriate decision-making at the various stages of research projects and programmes.

Detailed outcome of the survey is provided in a report by Ndegwa *et. al*., (1999) while a more generalised description of on-farm indigenous chickens studies and related research activities are reported in a paper presented at the symposium of the International Network for Family Poultry Development (INFPD) during the XIX World Poultry Congress held in 2000 in Montreal Canada (Ndegwa *et. al.*, 2000).

Baseline surveys - highlights of outcomes:

- The study revealed that the average flock size prior to the implementation of the on-farm participatory research process was 17.3 chickens per household, although Ngarua region had a higher flock size of 21 chickens per household. The general flock structure composition was 1-2 cocks, 1-6 hens, 1-5 growers and 1-10 chicks.

- Average number of broodings per year, number of eggs laid before a hen became broody, eggs set for hatching and hatchability were respectively 2.5, 16.5, 11.1 and 84.2%,.

- Average chick mortality during the first 8 weeks was 47.9%. Diseases, especially Newcastle, were cited as the main cause of mortality. Other diseases included fowl pox and fowl typhoid. Predators were also a serious problem. Adult bird mortality was mostly due to disease.

- About 50% of the respondents used different herbs to treat and control diseases. Conventional disinfecting, vaccination and deworming were not common practices. Cleaning of chicken houses was occasionally done. Ecto-parasites infestation was a serious problem in most farms and methods such as hot ashes, acaricide and burning of paper inside chicken houses were applied as control measures. *Aloe spp*. was the most commonly used herb (Siamba *et. al*., 1998). Other herbs included pepper and neem tree.

- Selection for genetic improvement was not a common practice but occasionally, farmers would purchase or exchange a cock, a hen or eggs to control inbreeding.

- On most farms, chicken were left to scavenge around the homestead and generally no housing was provided although there were some form of shelter where birds rested in the night. In some cases a run was used whenever there was a crop growing.

- All farmers reported supplementing feeding of their birds but the quantities offered were small. This was done particularly during the early cropping period.

The feed offered also depended on what was grown in a particular area. Mostly, supplementation was on kitchen 'left-overs' and a handful of grains.

- The purpose of rearing indigenous chicken was to have eggs and meat for home consumption, hatching, sale and use as gifts. Farmers in Ngarua region reported the highest sale of eggs and chicken meat.

- Generally, women looked after the chickens and had control and access over this resource, making decision on whether and when to eat or sell chicken or eggs. 78.4% of the respondents in the study indicated that women take greater responsibility and decision making in the production of indigenous chickens.

- Most households did not have off-farm economic activities. Farming was mainly for household food needs even though these would often be sold to raise cash for other needs.

The survey results demonstrated potential for and the need to improve rural poultry production through interventions with appropriate technologies to enhance people's livelihoods.

3.4 Inputting formal knowledge from on-station research, information and consultation processes to impact target beneficiaries livelihoods

The research processes discussed in the previous sections yielded much insight about the indigenous poultry system characteristics as well as indicating its potential for enhancing livelihoods of smallholder poor farmers especially women if it is well harnessed. These research outputs came mainly from professional stakeholders and would not be effective in transforming livelihoods among target beneficiaries, the smallholder farmers unless some mechanism was put in place to involve this category of people in a process that would bring the knowledge generated to impact their development enhancement. Hence a farmer participatory research was initiated evaluating improved management practices in production of indigenous chicken with complete involvement of smallholder farmers. This is described in more detail in the next section.

3.5 Farmer participatory research on-farm

3.5.1 Research rationale and objectives

The farmer participatory research (FPR) was carried out between 1996 and 1999 in partnership with the agricultural extension service and involved 200 farmers organised into 20 groups who were initially selected in five different regions in Kenya.

The objectives of FPR were to evaluate effects of improved management practices on performance of indigenous chickens at farm level and more importantly, the consequences of farmer participation in the implementation of the research activities. We were highly enthusiastic to work directly with farmers in their own surroundings, situations and circumstances in order to share our ideas and visions, and at the same time learn from their rich experiences and traditional knowledge. Other objectives of the on-farm research were:

- To improve knowledge of farmers in management of indigenous chicken.
- To improve farmers capacity and ability to participate in the research processes and to sustain tempo (involve them in design, implementation and monitoring activities).
- To improve productivity of indigenous chickens production systems in rural areas to enhance their real potential as livelihood resources.
- To enhance livelihoods of the poor especially the women farmers.

The project was monitored over a span of five, 3-months long periods. Monitoring was by a visit every three months to each farm to evaluate progress and confirm the farmer's records. This was also the time for more consultation and sharing of experiences. However, there was a six-months gap between visits 2 and 3 when there was no visit to the farms due to security concerns especially in regions 1 and 2. This coincided with a general election in Kenya and a number of farmers were forced to flee their homes abandoning the project due to the volatile situation. These factors might have therefore played a key role in the behavioural patterns with flock demography. For the purpose of this study, ‘periods 1 - 5’ refer to the records at the end of the period. The data recorded from the research activities has been categorised into three types of variables – treatment uptake, flock demography and production characteristics.

This research process has been reported in a paper presented at the International Community Development conference held in Rotorua, New Zealand (Ndegwa *et. al*., 2001a – see Appendix 3.4 - Box 3.4).

3.5.2 Method and Process

A total of twenty villages were selected where 200 farmers were selected from 5 regions (4 villages per region) for the project based on indication of willingness to participate. Ten farms were selected in each village. Training and sensitisation meetings were held with the selected farmers, their neighbours and extension personnel. This was followed by the introduction of intervention options, implementation by farmers, monitoring and evaluation by the main partners (farmers, extension and research).

The choice of this research design was influenced by the need to have a diverse representation of farmers participating in the project in order to collect information that might yield generalisable outcomes.

The methodology and the process of the farmer participatory part of our study with indigenous chickens therefore comprised the set of activities summarised in Fig 3.1 shown earlier in section 3.1. These activities included:

- Selection of locations – 5 regions in different Agro-Ecological Zones (aezs) and 4 villages per region. Each cluster has ten farmers and were based on land size as well as aezs criteria
- Farmer selection – along a transect in the cluster area and systematically sampled during baseline studies. Main criteria, was willingness of the farmers to

participate and carry out activities and have at least five indigenous chicken hens.

- Emphasis on use of farmer's own locally available resources and mobilisation of farmers in acquiring some external inputs jointly.
- Training and sensitisation seminars – done per cluster in farmers' localities.
- Design and plan of the experimentation was left to individual farmers to decide and to choose.
- Implementation of the research activities was entirely left to the farmers to decide which intervention/s to take up among the options available.
- Monitoring and evaluation – daily by farmers taking records, and periodically by extension and researchers' visits to individual farms.
- Reporting and dissemination – periodic reports. Publications and extension leaflets and manuals.

3.5.3 Location description

The project location cut across two provinces, Rift Valley and Central, and three districts Nakuru, Nyandarua and Laikipia. The study sites were:

Ol Kalou – low to high potential and cold with frequent frost and water logging incidences. Has impassable road network for transportation during wet seasons. The selected villages were: 1) Ol Kalou South with average farm size of 2.5 acres; 2) Passenga with 5 acres as the average farm size; 3) Mirangine with average farm size of 2 acres and 4) Kaibaga with average farm size of 1 acre.

Laikipia Ngarua – low potential semi-arid, poor infrastructure and frequent livestock theft incidences. Selected villages (with average farm sizes) were, 1 - Kinamba (2 acres); 2 - Sipili (2.5 acres); 3 - Cheleta (10 acres); 4 - Ol Moran (1 acre).

Naivasha – low potential, porous volcanic soils of high infiltration. Good to poor road network especially during wet periods villages (with average farm sizes) were, 1 - Karate (1.5 acres); 2 - Maraigushu (2.5 acres); 3 - Karai (5 acres); 4 - and Mirera (1 acres).

Bahati – high potential with adequate rainfall and good soils for agricultural activities, with land size ranging from 5 to 0.25 acres per household and relatively good road network and market opportunities. The selected villages (with average farm sizes) were, 1 - Munanda (2 acres holdings); 2 - Kabazi (1.5 acres); 3 - Scheme (3 acres); 4 - Wanyororo (0.5 acres).

Njoro –high to medium potential with good to poor road network and market opportunities. The selected villages (with average farm sizes) were, 1 - Njokerio (0.25 acres): 2 - Gichobo (5 acres); 3 - Piave (2.5 acres); 4 - Likia (1.5 acres).

3.5.4 Farmer participation

The project was based on the willingness of individual farmers to participate and their confirmation was sought when we carried out the survey reported in section 3.3.5 to characterise rural poultry production in the study area (Ndegwa *et al.*, 1999). Farmer participation and organisation as well as the attention to local resources aimed at affording sustainability of the process leading to livelihood improvement. Creation of ownership of the process among the farmers and extension workers was a priority and was done through a series of sensitisation and planning meetings pictorially shown on **Photograph 3.1**. The research strategies for active farmer participation and use of locally available resources were explored and mutually accepted by both the farmers and the research team.

Photograph 3.1. A sensitisation and planning meeting with farmers of Wendani women self-help group at a village in Njoro region Kenya

3.5.5 Farmer training and Knowledge sharing

Farmer sensitisation seminars and information exchange preceded implementation of interventions. The exercise as depicted in Photograph 3.2 focused on improved management practices and adaptability of various interventions according to individual farmer's ability. It was carried out in the villages at locations selected by farmers and local extension agents, but usually on one of the participant farmer's homesteads. The target for training was mainly the participant farmers especially women but the turn out was far above expectation and adjustments were made to accommodate all who came for the sessions. Over five hundred farmers were trained on improved management practices for indigenous chicken production, a figure 2-fold higher than the anticipated target.

Photograph 3.2. A research team member in one of the training and knowledge sharing sessions at a farmer's homestead at a village in Njoro region Kenya

The improved management practices involved feeding, housing, health, hatching and brooding and aimed at overcoming constraints that hinder productivity of indigenous chicken. Farmers were introduced to formal knowledge on each of the topics and ways were explored on the best mode of implementation of the project. This knowledge was based on a training manuals by Ndegwa *et. al.,*(1998c), information from on-station nutritional evaluation of feedstuffs (Ndegwa, 1992; Okong'o *et al.* 1998; Tuitoek *et al*., 1999) and booklets from the Ministry of Livestock Development (MoLD, 1989). The design was such that each farmer would be able to implement by adapting technologies to fit his or her resource restrictions while realising the benefits of improved productivity.

Information on local remedies for chicken diseases used by farmers and other type of farmers' knowledge was established and shared freely with others not previously aware of such knowledge. Such vital 'indigenous knowledge' was incorporated into the project as one of the options of interventions and many farmers adopted it.

Regarding feeding, farmers were informed about its importance and relevance, the aim being to meet requirement of the birds for protein, energy and other nutrients (vitamin and minerals) necessary for efficient production. The farmers could manage this using a variety of local ingredients including cereal grains, sunflower seeds, grain and vegetative part of amaranth plant, potatoes and their peelings (boiled), household kitchen leftovers, vegetables (cabbage, kale, pumpkins, carrots, tomatoes), *croton megalocarpus* ('*mukinduri'* in the local Kikuyu language), grass and a variety of weeds among others. Special attention was given to the feeding of chicks and was done separate from older birds. We gave recommendation to put feedstuffs in feeding troughs or just hang them inside the chicken houses. Clean and cool water was to be provided at all times.

Housing information focused on its importance in protecting chickens from a variety of hazards including extreme weather, diseases, predators and theft. Important features required in a house would include adequate lighting, ventilation, smooth walls and floor. Any local materials could be used to construct such a house. Again, special emphasis was given to the housing of chicks from hatch up to the age of eight weeks. This is the period they are most vulnerable.

Health management focused on disease control through a variety of means that included better hygiene, housing chickens in clean houses, vaccination against Newcastle disease, use of herbs mainly in drinking water, disinfecting chicken houses to kill and control ecto-parasites and deworming.

Hatching and brooding management aimed to increase the flock size by production of own chicks and better rearing. Synchronised and/or consecutive hatching and group brooding of chicks from different batches would provide an opportunity to realise large flock sizes faster and more easily.

3.5.6 Design and Implementation

The interventions were introduced as a basket of options and were taken up by individual participating farmers for adoption and/or adapting at their own pace and style. There were as many variations in the design and implementation as there were participant farmers. The basic aim however, remained that of improving management and enhancing productivity of their flocks as a means to realisation of a better wellbeing. The farmers used their own local inputs in implementing the project interventions and recorded various project activities and outputs including various aspects of management and production. In carrying out the implementation of the interventions, farmers made use of formal knowledge and the indigenous knowledge they already had and that learnt during the training sessions. This was a deviation from conventional methods of managing a poultry enterprise which assume farmers' only motive is profit maximisation. This is usually not the case with smallholder farmers (Galpin, *et al.,* 2000). For example photographs 3.3 – 3.6 provide a pictorial presentation of some of the adoptions and adaptations techniques the farmers made using a variety of resources available to them. Use of locally available resources and farmers' ingenuity allowed for implementation of many interventions. The need to work as a group to access external inputs like iron roofing sheets and vaccines had been explored and appreciated as a credible option during consultation and training sessions. This is an approach a number of farmers were able to adopt and found useful.

3.5.7 Monitoring and Evaluation

This process also took a participatory approach and was carried out by farmers, extension workers and researchers individually and as a joint team. Individual participant farmers were responsible for the day to day monitoring of their flocks in terms of production characteristics (eggs laid, addition and reduction to flock size, feeding, health) and utilisation characteristics (sales, consumption, gifts). The local extension workers regularly visited their respective cluster farmers at their homes to guide and assess the progress made in terms of implementation of interventions. The extension workers would then relay relevant information to the researchers. They were also responsible for organising farmers to jointly purchase those external inputs not affordable by individual farmers as well as acting as the mediators between farmers and researchers. The researchers and extension workers jointly visited the farmers on a quarterly basis to monitor and evaluate the progress, while at the same time reacting to farmers' concerns (Photographs 3.7 and 3.8). The team also validated farmers' records and collected extra data for archiving and analysis.

Photograph 3.3. Farmers feeding chicks inside a portable pen at a village in Njoro region Kenya

.

Photograph 3.4. Portable chick pen, feeder and watering container used by a farmer at a village in Bahati region Kenya

Photograph 3.5. Group brooding of chicks from different batches of hatching at a village in Bahati region, Kenya

Photograph 3.6. A chicken house with iron roofing and mud walls as an adaptation of the housing intervention at a village in Ngarua-Laikipai region, Kenya

Photograph 3.7. A farmer feeds her indigenous chicken as research team

looks on at a village in Njoro region, Kenya.

Photograph 3.8. Laying nests with eggs laid by indigenous chickens in a farm at a village in Bahati region, Kenya

3.5.8 Data collection and analysis

A wide range and quantity of data was collected from these farmer participatory activities and has been categorised into three types of variables – treatment uptake (housing, vaccination, deworming, supplementation), flock demography (flock size and flock dynamic characteristics) and production characteristics (eggs laid, eggs set and hatchability). Most of these data are in an electronic format in a compact disc at the inside part of the front cover of this thesis.

Due to the complexities surrounding the process of collection and recording of eggs from all the laying hens in a flock, it was not possible to record total egg production for each hen on a daily basis. The recording was therefore on egg production for a sample of 4 - 6 hens per farm. For a more accurate presentation of egg production performance, three consecutive production hen cycles were recorded for each hen over the study period and used for the analysis. A typical hen cycle was the time between start of laying to the time a hen became broody. The typical hen cycle was chosen because egg production by indigenous chickens generally follows a laying and brooding cycle with most hens managing at least 3 cycles per year (Ndegwa *et al.,*1999).

The criteria of choosing the hens to be observed for egg production were based on easily recognisable characteristics a farmer could use to identify them and selected hens were then named accordingly.

The records on all the treatments and the flock demography characteristics were analysed for 173 farms but those on the production characteristics were from fewer farms. The production characteristics, eggs laid, eggs set and hatchability had records from 107, 127 and 121 farms respectively.

The analyses of these data is described in depth in chapters 5 (descriptive statistical analysis,), 6 (Inferential statistical analysis of production characteristics) and 7 (quantitative analysis of flock demography)

Demographic characteristics on additions, reduction, unplanned reductions and controlled reductions were considered as totals in the 5 periods. Treatments were similarly considered as totals in the 5 periods. Production characteristics of hatchability and egg production were based on a hen's laying and brooding cycle. Mean hatchability per hen over 3 cycles and predicted egg production per hen per cycle were used in our investigation.

The descriptive analysis in Chapter 5 focuses on the farmer participatory research data, highlighting its nature and scope, providing summaries of various data in the form of patterns for treatment characteristics, graphical presentation of trends for flock size, totals of flock demography dynamic factors (total addition, total reduction, total controlled reductions, total unplanned reductions) and average hen values for production characteristic – eggs laid, eggs set and hatchability in a typical hen-cycle.

The inferential statistical analysis in chapter 6 investigates effects of farm, cycle or hen on the production characteristics in all the 20 villages. The basic unit of analysis was either the farm or hen within a farm. The investigation was also done to determine effects of the treatments and the flock demography dynamic characteristics on the production characteristics. The statistical methodology included the use of general linear model (GLM) procedures of SAS that fitted farm, hen and cycle combinations to assess and compare levels of variation. The mean squares were ranked in ascending order and plotted against their ranks to produce cumulative distributions whose patterns were investigated for their differences and effects of variations. The methodology also involved use of regression analysis to investigate the treatment and flock demography dynamic effects on both the hatchability and egg production characteristics. Regression analysis of the eggs laid was based both on difference between the eggs laid in cycle 1 and eggs laid in cycle 3, as well as on predicted eggs laid values for cycle 2, calculated from the fitting of analysis of variance.

Demographic analysis was carried out to classify farms according to their flock size trends in five periods of time within and across villages and regions into similar or dissimilar groups. The purpose of this analysis was to summarise flock size categories among a large number of farms into a few identifiable groups with distinct characteristics. The analysis involved the use of a dissimilarity index (DI) defined as the sum of squared differences of flock size values for a pair of farms from period 1 to period 5. Due to the large number of computations involved in the calculating the dissimilarity index values between all pairs of groups of farms, analysis used SAS procedures.

3.5.9 Lessons and experiences from the participatory research

As pointed out earlier, the research process was set up to allow poor farmers to create and accumulate capital assets for their fight against poverty, by their being actively involved in the research process. Groups or cluster formation aimed at effective and efficient interaction and learning between the farmers and research team and between individual farmers themselves. In so doing, it was hoped mutual trust and teamwork would be established thereby enhancing the stock of their social capital. Targeting women was a means to empower them to acquire specific skills and derive direct benefit from the research process. Training was a capacity building process for effective participation in project implementation by the farmers. Physical assets for carrying out the project were to be accessed more easily through joint group purchase of those inputs individual farmers would not easily afford on their own. This was done through a method popular with poor women called ‘the merry go round’ in which the group provides a specific item in turn to each member from the contributions made by all.

The visits by research team to the farms and information obtained as a result made the basis for evaluation reports. An assessment of these reports by a committee of scientists constituted by organisers of the Kenya Agricultural Research Institute’s Fifth Biennial Scientific Conference, praised the project for its “originality” and “novelty” (KARI, 1999) and subsequently ranked it third among 37 projects evaluated from 17 KARI centres.

The participatory process also enabled the successful conducting of a large project despite the limited resources of time, money and expertise available for the purpose. At least 120 out of 200 farmers initially selected for the project made records of some kind over the study period and beyond. This is a significant achievement and we owe the farmers a great deal for the success achieved. There is justification, therefore, to take back to these farmers the results of this study and to carry out an impact assessment to establish the long-term effect of the project on their livelihood status.

Highlights of this research activity may be summarised as follows:

- Almost 500 farmers attended the training sessions from which 200 were initially selected to participate in the research process.

- The project adopted a collegial mode of participation.

- The project farmers were allowed choice of a variety of interventions to adapt and or adopt at own time and style.

- Farmers drove the pace of the research process and determined its fate.

- Observations and recordings of many activities were done by individual farmers.

- Mutual trust was created among the players involved.

- Farmer-cluster formation as an organised entity allowed for pooling of resources, thus enabling acquisition of some external inputs (vaccines, and implementation of some activities such as housing by individual group members.

- Great confidence and interests in their birds and rearing activities were created among farmers.

- Data and information collected from this process formed a major analytical component of this PhD thesis.

3.6 Communication and Dissemination

According to Norrish *et al*., (2001), communication and information dissemination are key components within the research process. In our case, these were and are being achieved by a combination of media products and communication activities as described by Garforth (1998) in Norrish *et al*., (2001). These include among others, preparation of new materials from information gathered and communication and dissemination to wider readership by way of conferences, e-conferences, e-mailings, newsletters, peer-reviewed journals, this PhD thesis, seminars, workshops, pamphlets, and practical manual. These activities are provided in greater detail by boxes 3.1, 3.2, 3,3, 3.4 and 3.7 - 3.10 in appendix 3 and highlighted in the following references:

- Ndegwa *et al*.,2000, 2001a, 2001b provide details of communication and dissemination at conferences.

- FAO/INFPD, 2002 2001b provide details of communication and dissemination via electronic conferences.

- Ndegwa et al., 2000 show communication and dissemination through newsletters publication.

- Ndegwa *et al*., 2001d; 2001e; 2002a provide information on research and development project proposals.

A more comprehensive communication and dissemination strategy from the farmer participatory research with indigenous chickens had been planned to be undertaken through a project proposed and submitted for funding to DFID, UK (LPP programme) but the funding had not materialised by the time of submitting this thesis (Ndegwa *et al*. 2001d). A development project proposal with indigenous chicken was a finalist in a competitive bidding forum, Development Marketplace of the World Bank (WB-DM2001, 2002).

3.7 General points of observations and conclusions from the whole research process with indigenous chickens.

Participation of stakeholders in a project makes it possible to have a wide coverage within short time periods and can reduce operational costs. The participant farmers and the local extension workers were able to implement the project using local resources, individual choice and adaptation of technologies as well as setting the pace of the research process. They also undertook activities such as recording and organising for vaccination that would otherwise have required involvement of the researchers. This helped reduce financial and time costs to complete the project.

Active involvement of stakeholders in a development activity builds trust and generates enthusiasm. The project identified and sought involvement of the stakeholders from the outset of the research process. According to Dalal-Clayton *et. al*., (2003), this is an important undertaking that ensures effective working together in order to achieve desired project outcomes. It also instils confidence especially among farmers who are able to carry out project activities within the limits of their abilities and understanding. There is also the restoration of pride among the poor farmers for their resources, which is necessary for sharing knowledge and experiences. This was evidenced by the readiness in which many of them were willing to discuss about their flock of chickens and to explain the progress they had made with implementing the interventions. As we found in a number of villages, farmers were able to share information with other neighbouring farmers outside the project who then started similar activities to improve the management of their birds.

Poor people especially women farmers in rural areas can bring about a change in their deprivation by harnessing local resources accessible to them. This lesson is exemplified by one of the project farmers who had managed, through her personal enthusiasm and determination, to harness indigenous chicken to take her family out of the depth of extreme deprivation and hopelessness. A case study is narrated by Ndegwa *et al.,*(2001b) as provided in Box 3.5, about a woman named ‘Wanjiku’.

Box 3.5: Case study showing how harnessing of a local resource (indigenous chickens) can uplift livelihoods

ROLE OF FAMILY POULTRY (SCAVANGER POULTRY) PRODUCTION IN SUSTAINABLE LIVELIHOODS AND POVERTY ERADICATION – THE CASE OF WANJIKU – PRESENTED AT THE INTERNATIONAL ASSOCIATION OF COMMUNITY DEVELOPMENT CONFERENCE IN ROTORUA, NEW ZEALAND 2 – 6 APRIL 2001

J. M. NDEGWA

Wanjiku (not her real name) is a single mother of 3 in her 40s. I met her in the course of my field visits conducting an on-farm farmer participatory research project in 1996/1997. She was a project farmer in one of the groups we were dealing with. Wanjiku and her 3 children had been sheltering in a friend's home for a number of years as they were landless. She was greatly motivated by our training and sensitisation sessions focusing on opportunities offered by improved management of indigenous chicken.

This unassuming lady was determined to shake off the chains of impoverishment. In her landlessness and terribly humiliating indigence, Wanjiku decided enough was enough. With her meagre earnings from selling her labour to neighbours, she would buy a hen now and a cock later. Slowly by slowly, Wanjiku had her own small flock. But then her eyes were firmly focused beyond her small 'wealth'. She began to manage her flock of birds to make it a 'commercially' viable enterprise.

Her strategy involved 'synchronised' hatching whereby two or more hens would be allowed to sit (incubate) on eggs at the same time. This meant that Wanjiku was able to have about 50 or more chicks at the same time. She would then rear and sell them off as a single batch. She did this several times and soon she had enough money to purchase a small piece of land of her own. Eventually Wanjiku managed to put up a modest house by the local standards where she moved in with her family.

Firmly and happily in her new home, Wanjiku continued with her chicken project but she now expanded the enterprise to include vegetable growing. Her children were very helpful in these endeavours. Soon she had bought another piece of land and expanded her 'capital assets'. Other developments in her homestead include a separate house for her sons to keep with her community's traditions, and water storage tanks – for her vegetable growing in her kitchen garden. The family now has extra sources of income from sales of fresh vegetables, seedlings and surprisingly, from sale of rain water harvested by roof catchments.

My observation of this lady has convinced me that the war to eradicate poverty can be won and establishment of sustainable livelihoods can be made a reality. This requires the right approaches – the Wanjiku method. To hasten the process, resources should be harnessed and directed through the 'right' channels. Focusing on the poor and landless, their participation and use of local resources such as family poultry (scavenging poultry) is an imperative.

This example of a woman determined to uplift her life from the depth of deprivation to a decent standard of livelihood provides evidence that poor people can transform their lives. They need to be encouraged and supported to sustain and enhance development initiatives.

Training and information sharing can allow the poor people to recognise and take advantage of opportunities to improve their livelihoods. This could also create impetus for driving and sustaining a development project among the clients. Within three months of our farmer training session, one very enthusiastic farmer had adapted hatching and brooding management strategy and had increased the flock size ten-fold from 12 to over 120 birds. We were able to use his strategy in our advice to other farmers.

The participatory approach adopted in this project has allowed for sustainability of project activities and creation and enhancement of capital assets among farmers in various groups. Members of a group in region 1 and another in region 4 for instance, were found still active and organised in carrying out other activities beyond what they did in our project (see Box 3.6).

Box 3.6: Perceived benefits from the indigenous chicken participatory research process

1. One family in region 3 village 4, had a strategy that enabled it to pay for secondary school education of their children by adopting synchronised hatching and group rearing of birds. The birds would then be sold all at once to coincide with back-to-school date. The family did not have out-of-farm income but were able to educate their three children from rearing and selling indigenous chicken. This phenomena was told to other project farmers to motivate them. In the context of the theme in the PhD thesis, this family provide evidence of the potential in the indigenous chicken system as a livelihood asset.

2. Three farms, one in region 1 and two in region 4, increased the size of their flock way above others from about 20 birds to 150-200. They had also very high total controlled reductions ranging from 170-200. They adopted the interventions early and in subsequent periods leading to the high levels of production. These farms were not be included when calculating average values for their respective groups to avoid exaggerating information about the general trends. All the same they serve to illustrate that indigenous chicken has great potential as a resource of poverty reduction strategies among rural poor people. They also individually demonstrate the effect of improved management practices and ‘magic’ of farmer participation with a collegial mode.

3. One group of farmers from region 1 and a farmer from region 4 in the indigenous chicken project continued with activities like recording many months after phasing out of the project. The same farmer group had even started another project of small-scale commercial layers and expanded membership with more farmers who were not in the indigenous chicken research project. The farmer from region 1 narrated how the indigenous chickens had become a valued resource for her household by supplying eggs and meat for her children’s breakfast and other dinners meals. The children grew healthier and concentrated well at school.

4. Other farmers not initially included in the indigenous chicken research project got information and inspiration from project farmers and started their own chicken groups. One such group, in region 1 village 3, borrowed reading materials and received induction from some project members and were able to replicate interventions such as housing, chick rearing, supplementary feeding, disease management among others.

- 5. A number of young people are making a living buying indigenous chickens from farmers which they then sell to customers in urban areas as exemplified by Kamau (not his real name) in region 5 of the indigenous chicken research project. This self-employed young man uses his bicycle to go around searching for chickens to buy in the villages hence providing a market outlet for farmers as he secures a supply of chickens for his business. He keeps the birds in portable pens in strategic locations in an urban area from where he sells them live to his customers who include any interested passer-by, hotels or regular customers.

- 6. Some relatively well-off individuals have also realised there is potential to generate income from rearing indigenous chicken. One such case is in region 5 where a gentleman switched from keeping commercial layers to rearing indigenous chicken and has been supplying fertile eggs for hatching purposes at a premium.

- 7. Indigenous chickens have a ready and high-demand market arising from cultural preference of the taste, texture of meat, and deep yellow colour of the egg yolk. They often fetch high prices and are particularly gender-responsive in the fact that women and young people can own and have total control in their use. This is evidenced by an observation made during a visit to a remote rural market called Chepararia in West Pokot in Western Kenya where Pokot women sold chickens and eggs to traders from as far as Nairobi. This provides opportunity for economic enhancement and asset resource building.

- 8. Many rural and urban trading centres have markets for indigenous live birds and eggs. Examples include Chepararia in West Pokot and ‘Burma’ in Nairobi. The latter receives bulk of its merchandise from Ukambani region. Transportation of birds usually done using special baskets woven with wooden sticks and placed on top of ‘matatus’ or buses.

- 9. Mostly indigenous chickens were sold as live birds and sometimes customers would then have them slaughtered by their sellers. This is also a practice common in Hong Kong’s ‘Mong Kong’ market. There is therefore a need for local councils to establish special facilities for marketing indigenous chicken birds with mini abattoirs and refrigeration to allow this type of business to flourish.

The group in region 4 had managed to start keeping and rearing commercial type layer chicken ranging from 20 to 50 or so birds per farmer which they had jointly purchased as day-old chicks alongside their indigenous chicken flocks though in separate enclosures. This was after the project had been phased out. The same group had expanded its membership from the original ten to twenty five and had formally registered as a community development self-help group with the government’s social services department.

In comparison to this observation and conclusion, an evaluation of 25 projects sponsored by the World Bank (Zazueta, 1995, Dalal-Clayton, *et. al.* 2003) found 13 of them abandoned after financial assistant ended. The evaluation concluded that the main causes of failure were lack of participation by the local people and lack of attention to building local organisations

On the other hand many authors have provided local examples of successful development based on participation of local the community (Aguirre, 1962 and Wolf 1957 for projects in Central and South America comparing RRA and PRA; Kieveliz, 1995 - describing Rapid District Appraisal (RDA) in Indonesia; Pretty and Kiara,1995 and Harding *et. al.,* 1996, on soil and water conservation in Kenya).

Constant interaction with development agents can be an effective means to maintain impetus for a development activity by providing much needed encouragement to the poor farmers who would otherwise feel abandoned if not entirely exploited, by data and information 'gatherers'. In the clusters with enthusiastic local extension workers, farmers' zeal and determination was kept aglow. This was the case with the Njoro group above. Participation is also regarded as the most significant factor for project effectiveness but the best results are achieved when people are involved in decision-making through all stages of the project as opposed to when they were only involved in consultations mainly for data and information extraction (Narayan,1993 and Dalal-Clayton, *et. al.* 2003).

Female local extension workers tended to be more enthusiastic and effective in organising and encouraging the farmers and most of them joined their clusters as members. Eight out of twenty village level extension people working directly with the village groups were women. They enhanced confidence among their farmers and helped sustain the development spirit so far created. From my experience, women extensionists were more inclined to grasp and understand opportunities available for enhancing the livelihoods of farmers, especially the poor women who in any case form the bulk of agricultural workforce in rural areas.

Security is an important factor for the success of any development project. Some clusters in our study area were caught up in violent skirmishes in the period around the general elections in 1997. This threatened the security of farmers and in some instances, the situation was so bad that farmers abandoned their farms in search of safety elsewhere. For two of the households in our project, it was catastrophic. One family lost the man who was the household's head and another lost a secondary school age daughter. But despite these incidences, there was a surprising determination by farmers in the affected areas to continue with the project activities. Poultry production was more attractive to farmers compared to other livestock activities in such areas, as they were less likely to be targeted for theft.

Involvement of beneficiaries and other stakeholders in projects involving anti-poverty initiatives such as the indigenous chicken project, is important for achieving desired objectives. Guijit and Hinchcliffe, (1998) point out that the active involvement of people and interest groups in research, analysis and planning mean that all participants should have knowledge of the results. They also note that this implies effective and timely feedback, the sharing of reports, and recognition of all contributions. We have endeavoured to meet most of these targets through the communication and dissemination strategies described earlier but there is still more that needs to be done. An effective feedback would include going back to all the individual farmers to provide them with simplified and detailed reports about the project findings as well as doing an impact study to assess post project scenarios. Another strategy would be holding of a stakeholder workshop to report the findings and recommendations arrived at after our elaborate analysis. This will avoid an 'anti-climax' situation of the participatory process outcome. However, the author has visited a number of these groups in four of the 5 regions of the study and discussed general development issues, encouraging their members to be involved more in self-help groups activities focusing on saving and credit schemes and income generation.

Participatory research is not meant to replace traditional approaches that characterised agricultural technological systems into subsystems of basic, strategic, applied and adaptive research. Rather, the participatory approaches help to make sense of them.

Participatory research involving livestock is not easy to carry out as research involving crops because of the limitations imposed by natural and other factors. For instance, animals cannot easily be 'planted' in one position as plants and are more prone to be subject to factors like diseases, individual animal behaviour, thefts or limited numbers available for the research. Farmers might have to dispose of the animal in the course of the research or might be taking too great a risk with their only wealth-repository item and hence might not be in a position to apply certain treatments of the research. Generally animals have greater 'sentimental' values to a farmer than plants and hence participatory research using animals poses special challenges that call for studies to develop greater understanding and mechanism to overcome them.

There is a big variation between carrying out a research project on-station under standard and controlled conditions where random variations are greatly minimised and doing a farmer participatory research. In farmer participatory research such as ours, a sizeable number of farmers would not follow a recording system 'imposed' from outside but would instead record information as they deem fit. This poses a great challenge in the latter situation for prudent management and analysis of data which we have endeavoured to achieve in chapters five, six and seven.

The basic tenets in both on-station and FPR is to generate new ideas that contribute to better understanding of situations of life and what needs to be done to bring about positive changes. Their modalities involve use of selected representative samples of entities from a population being studied due to impracticalities of covering such populations in their entireties. In both cases there is also the need to collect data from observations made of given characters whose investigation over time provide the ideas being sought.

3.8 Conclusion

This chapter has provided the methodology and process of the research from on-station to farmer-managed activities and hence encompass a whole continuum of farmer participatory research as described by Pound *et al*. (2003).

The farmer participatory research process described in section 3.5 was carried out with little knowledge of the now current development paradigms. However, retrospectively and with hindsight, this process is presented within the context of these development parameters and standards in the discussion and conclusion chapter 8 as a way of making the experiences of the research process a treasure for reference by anyone involved with similar objectives especially in livestock based activities.

CHAPTER 4

RESEARCHER-MANAGED ON-STATION STUDIES WITH INDIGENOUS CHICKENS IN KENYA

4.1 General overview

On-station studies of indigenous chickens were carried out to understand their character and potential. The objective of the on-station research activities was mainly to gain greater understanding of characteristics and nature of indigenous chickens. The aim was to generate and disseminate relevant information on improved production management practices for use by farmers and support services. The technology provided by extension and development agencies to the farmers relating to indigenous chickens was usually based on information mainly for commercial poultry production, an entirely different system. Again, previous development and extension activities had not done much to change prevalent negative attitudes and perception by various stakeholders on indigenous chickens' potential as a livelihood strategy, and hence failed to create enthusiasm in the rearing of these birds among majority of smallholder poor farmers. The on-station research was designed to bridge the knowledge gap.

A number of research studies were hence carried out to generate information on indigenous chickens reared under controlled standard management practices. This chapter highlights four research papers that provide information and methodology and conclusions of these on-station research studies. Two are published in international scientific journals while the other two have been submitted for possible publication as well. The latter are discussed at length in this chapter and a compact disk with original data attached on the inside front cover page of this thesis. Only brief summaries of the former are provided here as the published on-station papers are included as appendices at the back of this thesis. These four papers fall into three general categories namely, growth characteristics, nutritional requirement and hatching characteristics. The four papers were:

1. Growth characteristics of indigenous chickens lines and a cross with Rhode Island Red in Kenya (Ndegwa *et, al.* 2004a –accepted (2005) for publication in the Tropical Agricutural Journal and included in this chapter).

2. Growth characteristics of six reciprocal crosses of Kenyan indigenous chickens (Ndegwa et al., 2004b – unpublished/submitted to Tropical Ainmal Production and Health Journal and included in this chapter).

3. Growth performance of indigenous chickens fed diets with different protein levels. (Ndegwa *et.al*., 2001c).

4. Hatching characteristics of eggs from six reciprocal crosses of Kenyan indigenous chickens artificially incubated (Ndegwa *et al*., 2002).

4.2 Growth characteristics studies

The two studies on growth characteristics were similar, but differed in the type of chicken used and the time of the experimentation. The first involved Kenyan indigenous chicken lines namely *Nyeri, Kericho and Taita* and a cross of Rhode Island Red and *Nyeri.* The second study involved reciprocal crosses of the three Kenyan indigenous lines and investigated effect of different sire and dam lines on production characteristics of the crosses. In both studies, body weight measurement was recorded per individual bird on weekly basis from the time of hatching. The data was analysed by use of a growth model, *Gompertz*, and non-linear regressions to determine growth characteristics for specific type of chicken and their sexes.

4.3 Growth characteristics of indigenous chicken lines and a cross with Rhode Island Red in Kenya

4.3.1. Introduction

It is estimated that the indigenous poultry population comprises over 70% of total poultry population in most African countries (Ibe, 1990). In Kenya, over 70% of the total poultry population of 25 million comprise of the indigenous chicken (MOLD, 1990). The majority of these chickens are in rural areas and kept by about 90% of households (Stotz, 1983.) There are usually 10 – 20 birds per household (Ndegwa *et. al*., 1998; Stotz, 1983; MOALD&M, 1993).

Indigenous chicken produce more than 50% of total eggs and 70% of poultry meat in Kenya (MOALD&M, 1993). Since over 70% of the human population in Kenya and other African countries live in rural areas (Ibe, 1990; Stotz, 1983; Shaw and Gatheru, 1998), there exists potential for indigenous chicken to supply much of the required animal protein. This calls for an understanding of the production characteristics of the birds with a view to improving their performance.

Recent research and development strategies to improve the performance of indigenous chicken have been implemented in Kenya. The present study demonstrates one such attempt. The aim is to characterise the growth pattern of indigenous chicken originating from different regions in Kenya and a cross of one with Rhode Island Red using non-linear growth models analysis.

4.3.2 Materials and Methods

Two hundred and one straight-run, one day old chicks were used in this study conducted at the National Animal Husbandry Research Centre, Naivasha, Kenya in 1993. The chicks were hatched from eggs produced by four parental lines; *Nyeri, Kericho, Taita* (named after the district of origin in Kenya) and a cross of Rhode Island Red with *Nyeri* after artificial incubation. The chicks were wing-banded at hatching for identification. They were individually weighed at hatch and subsequently, on a weekly basis, for 20 weeks during the growing period (see appendix 4.1).

Electric brooders were used for 4 weeks with chicks from different lines on different compartments. The birds were then transferred to deep litter pens and reared separately. Sexing was done at 12 weeks of age and a partition put in each pen to separate male from female birds.

Feeding and watering were provided *ad libitum* throughout the study period. Chicks were fed on a broiler starter ration during brooding; a grower ration containing 18% crude protein and 2800 kcal metabolisable energy per kg feed, was offered to chicks for the rest of the study period.

4.3.3 Statistical Analysis

A non-linear (nlin) regression analysis procedure (SAS, 1985) was used to fit the growth model. Various models were tried to fit the data. Some of the models were general mathematical functions; others were specific growth models from the literature (Causton, 1983; Adam et. al., 1988; Brody, 1945; Ratkowsky, 1989; Brown and Rothery, 1993; Bertalanffy, 1960; Lawrence and Fowler, 1997; Wilson, 1977). The mathematical models were a quadratic and a non-linear function with parameters for estimation. The growth models were:

- Brody's self -accelerating growth function – w=a*exp(b*t); logw=loga+b*t
- Logistic – w=a/(1+bexpk*t); logw=loga-log(1+b*exp(-k*t))
- Mono-molecular – w=a(1-b*exp(-k*t)); logw=loga+log(1-bexp-k*t)
- Gompertz – w=a*exp(-b*exp(-k*t))
- Von Bertalanffy – w=a(1-b*exp(-k*t))**3
- Quadratic – w=β0 + β1*t + β2*t**2
- Non linear – w=α +β*t**θ

The Raphson-Newton method (SAS 1985; Ratkowsky, 1989) was applied among other iteration methods for parameter estimation. This method uses derivatives in its iterations to search for parameter estimates.

From among these models, the *Gompertz* equation was found to fit the data generally and hence, has been used in statistical analysis. An advantage of Gompertz growth function is that it allows both the accelerating and decelerating phases of growth to be incorporated in the same equation (Lawrence and Fowler, 1997).

The analysis was based on fitting natural logarithm of mean weights, which conforms to the suggestion by Causton (1983) that growth functions should be fitted to data in log form. The Gompertz log-form model used was:

Logw=loga–b*exp(-k*t)

Where w is the measured weight that was related to age t, in weeks. The three parameters in the model, a, b and k were obtained by a least-square fit to the data. The parameter a, is the asymptote to which the growth curve i.e. size of the bird tends. Both b and k are constants of relative growth rate (R=kbexp-k*t=kloga-klogw). The logarithm of the relative growth rate R, is a linear function of time with gradient –k and intercept log(k*b). R is also a linear function of the logarithm of size, with gradient –k and intercept kloga. The initial parameter estimates were a=2500, b=4.5 and k=0.1. It is important to provide initial parameters as near to the estimated values as possible for convergence criterion to be met (Ratkowsky, 1989, Brown and Rothery, 1993; SAS, 1985).

4.3.4 Results and Discussion

Table 4.3.1 shows regression equations relating the weight of male and female birds to time from hatching in the four lines of indigenous chicken. Figure 4.3.1 shows observed and fitted mean weight trends of the male and female birds while Figure 4.3.2 shows plots of fitted log mean weights.

Table 4.3.1: Regression equations relating log body weight in grams of indigenous chicken to time in weeks of growth from hatching.

Dependent variable Log(mean weight)	Regression function	
	Male	Female
Nyeri (L1)	Log5689-5.008*exp(-0.0772t)	Log3092-4.405*exp(-0.0877t)
Kericho (L2)	Log3944-4.758*exp(-0.0883t)	Log2610-4.358*exp(0.0936t)
Taita (L3)	Log5202-5.071*exp(-0.0800t)	Log2364-4.346*exp(-0.1020t
RIRx*Nyeri* (4)	Log6278-5.046*exp(-0.0784t)	Log2834-4.2574exp(-0.0976t)

The male birds attained higher weights than females after the 12th week of age. The asymptotic weight in the male birds ranged from 3940 to 6300 g. Female birds had a range from 2300 to 3100 g, about half the weight of males. RIRx*Nyeri* cross had the highest values of the parameter a as expected, due to the hybrid vigour of the two individual lines but also because of the influence of RIR, a heavy breed of chicken

Among the three pure indigenous lines, *Nyeri* had highest value of a in both sexes. *Kericho* males had higher a value than the *Taita* but it was vice versa in case of the female birds. The range of the parameter b was from 4.700 to 5.050 and from 4.250 to 4.360 in the male and female birds respectively. The value of k ranged from .0.0770 to 0.0880 for male and female birds respectively. The parameter b is related to initial weight of the birds while k is a constant of growth rate. The larger the k value, the shorter the period taken to it was to reach final weight a. Generally, female birds had higher k values than the male birds and hence attained their mature weight earlier.

The growth pattern of the males was indistinguishable from that of females in the first part of the period up to 8th week of age in all the 4 lines. In later stages, males grew faster and attained higher weights than the females at 20 weeks of age. As mentioned earlier, sexing of the birds was done at 12th week of age when it was physically possible to distinguish between the sexes. Figure 4.3.1(a-d), gives the growth pattern of both male and female birds and shows a clear distinction between the sexes in their weight after the 12^{th} week. There was however some peculiar values in the body weight of female birds between week 13 and 15, which could have arisen by mixing-up of male and female data. The week 15 data on females is omitted. Despite this misnomer, the growth pattern between the two sexes emerged distinctly.

Looking at Table 4.3.1 and Figures 4.3.1 and 4.3.2, it seems the differences in asymptote a among the lines, is the major explanation for the differences of the fitted curves.

Figure 4.3.1: Observed and Predicted weight plotted against week of age of male and female chicken of (a) *Nyeri, (b) Kericho, (c) Taita* and (d) RIRx*Nyeri* lines and cross.

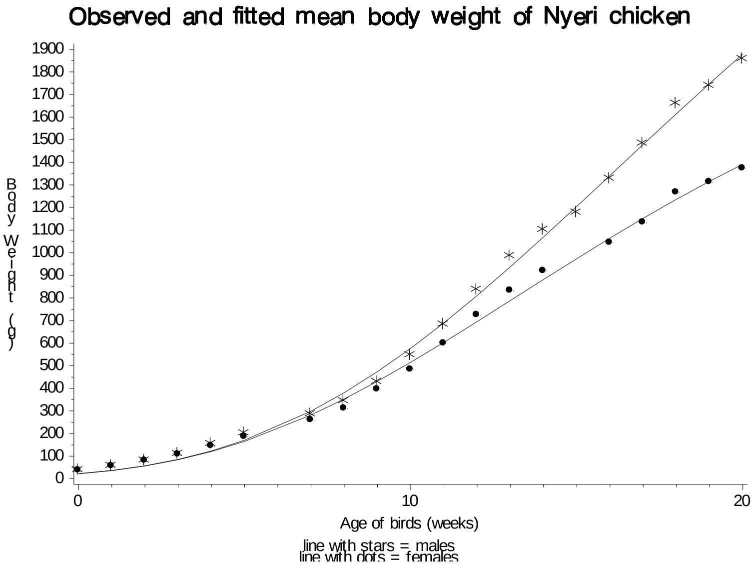


Figure 4.3.1a.

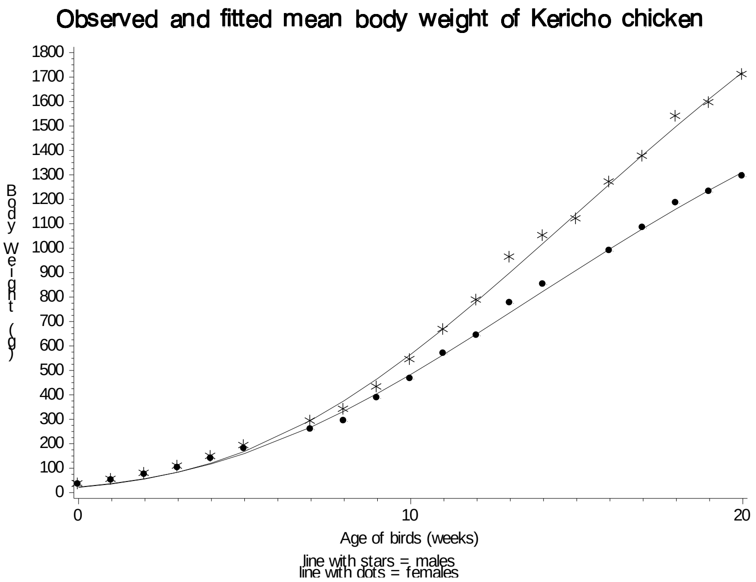


Figure 4.3.1b.

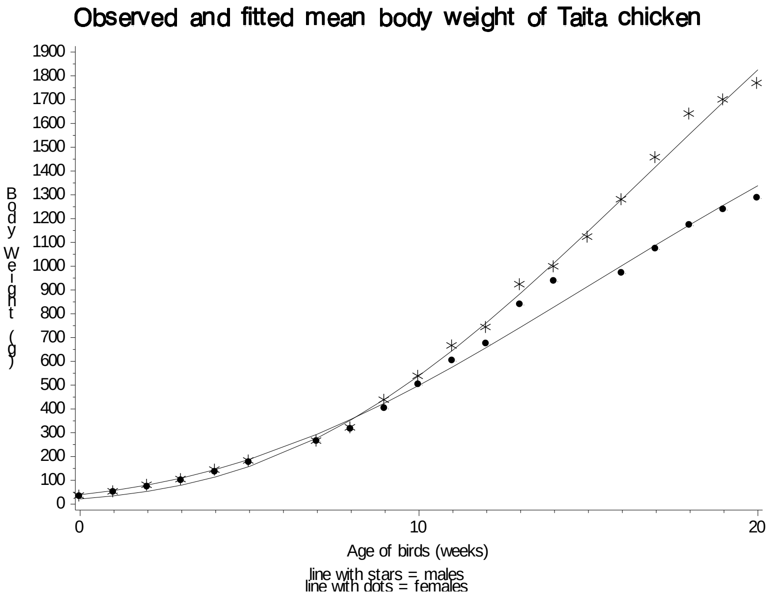


Figure 4.3.1c.

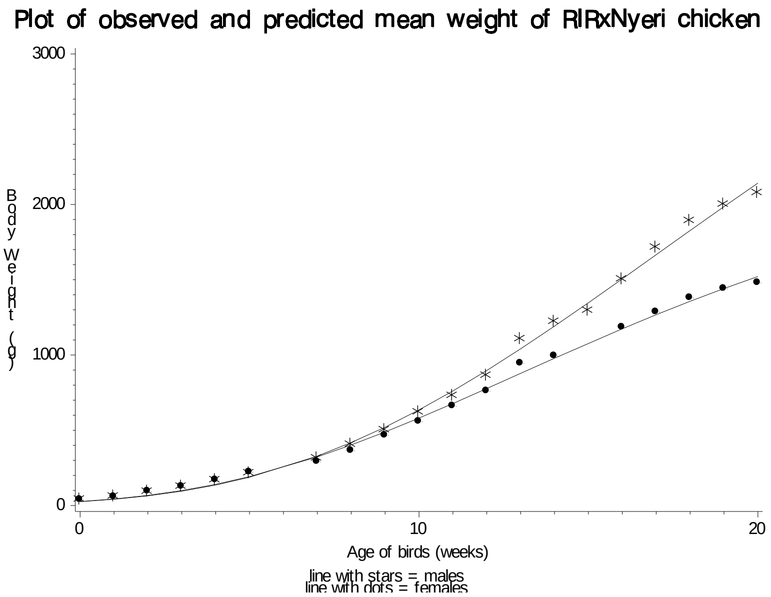


Figure 4.3.1d.

Figure 4.3.2: Plots of fitted log of mean weights against weeks of age of individual lines on same graph for (a) males and (b) females

Figure 4.3.2a.

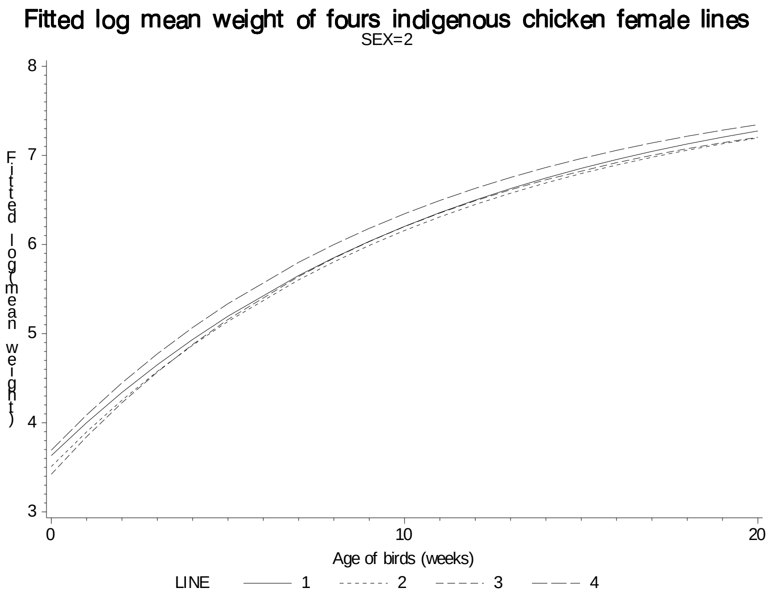


Figure 4.3.2b.

To present the differences between the fitted curves for the four parental lines more formally, we use an analysis of the residual variation about the fitted curves. This is similar to the analysis of residual variation described by Mead et. al., (2003). Details of the analysis are in Table 4.3.2. The first comparison is between fitting separate curves for the four parental lines and fitting a single curve to the combined data set. The sum of squared residuals for the single fitted curve is much larger than the sum of squared residuals for the separate curves. An F-test to assess the difference between the residual sums of squares for the two models gives F statistics of 14.90 and 14.76 for male and female birds respectively on 9 and 68 degrees of freedom with the F statistic being very highly significant. Hence, a single fitted curve is not acceptable as a summary of the four sets of data for either sex.

To examine the suggestion that the differences between the separate fitted curves are caused solely by the variation between the a values with the variation of b and k values being insignificant, we fitted a set of related curves in which the b and k values were constrained to be the same for all four data sets, while the a values were allowed to be different. The residual sums of squares for this model (related curves) are also in Table 4.3.2 and comparisons are made with the common curve and with separate curves. The residual sums of squares about the related curves are quite close to that for separate curves, but very different from that for the common curve.

The F-statistic for comparing the related curves with separate curves is 1.62 for both male and female birds on 6 and 68 degrees of freedom and is not at all significant. Hence, for both male and female birds we can accept the fitted model with constant b and k and varying a.

Tables 4.3.3 and 4.3.4 show detailed analysis of growth patterns in terms of asymptotic, final or mature body weight a, initial body weight, constant of rate of approach to mature weight k, maximum growth rate and half growth time of male and female birds.

Table 4.3.2: Analysis of residuals sums of squares with degrees of freedom, mean squares and F-ratios for comparison of common curve model with separate and related curve models for the four parental lines.

Model	RSS	DF	MS	F
Males				
1. Separate curves different a, b, k	0.1968	68	0.0029	
2. Difference (3)-(1)	0.3889	9	0.0432	0.0432/0.0029=14.90 ($F_{9, 68}$ = 2.04)
3. Common curve same a,b, k	0.5857	77		
4. Related curves different a, same b, k	0.2249	74	0.0030	
5. Difference (4)-(1)	0.0281	6	0.0047	0.0047/0.0029=1.62 ($F_{6, 68}$ = 2.25)
6. Difference (3)-(4)	0.3608	3	0.1203	0.1203/0.0030=40.1 ($F_{3, 74}$ = 2.76)
Females				
1. Separate curves different a, b, k	0.2241	68	0.0033	
2. Difference (3)-(1)	0.4387	9	0.0487	0.0487/0.0033=14.76 ($F_{9, 68}$ = 2.04)
3. Common curve same a, b, k.	0.6628	77		
4. Related curves different a, same b, k	0.2570	74	0.0035	
5. Difference (4)-(1)	0.0329	6	0.0055	0.0055/0.0033=1.62 ($F_{6, 68}$ = 2.25)
6. Difference (3)-(4)	0.4058	3	0.1353	0.1353/0.0035=38.66 ($F_{3, 74}$ = 2.76)

Table 4.3.3: The asymptotic (final or mature) weight a in g, log of, and, initial weight in g, constant (k) of rate of approach to a, maximum growth rate in g/week and half growth time in weeks of male indigenous chicken

Line/cross	Final weight a	Log(initial weight) = loga-b	Initial weight g	k, constant of rate of approach to a	Maximum Growth rate =k*a0.368 g/week	½growthtime $t_{1/2}$ =(logb-log0.6932)/k Weeks
Nyeri	5191	3.61	37.1		153	
Kericho	4924	3.54	34.5		145	
				0.0809		24.33
Taita	4849	3.53	34		143	
RIRxNyeri	5756	3.7	40.4		169	

Table 4.3.4: The asymptotic (final or mature) weight a in g, log of, and, initial weight in g, constant (k) of rate of approach to a, maximum growth rate in g/week and half growth time in weeks of female indigenous chicken

Line/cross	Final weight a	Log(initial weight) = loga-b	Initial weight g	k, constant of rate of approach to a	Maximum Growth rate =k*a0.368 g/week	½growthtime $t_{1/2}$ =(logb-log0.6932)/k weeks
Nyeri	2692	3.57	35.4		99	
Kerichoi	2521	3.5	33.1		93	
				0.0953		19.33
Taita	2551	3.51	33.6		94	
RIRxNyeri	3018	3.68	39.6		111	

Initial weight ranged from 34 to 40 g and from 33 to 40 g in male and female birds respectively. The variation is small but appears to be correlated with final weight. Maximum growth rate occurs when weight=0.368a (Brown and Rothery, 1993). The growth rate from the Gompertz growth function is k*w(t)ln(a/w(t)). Substituting w(t) with 0.368a gives maximum growth rate of k*a0.368. The maximum growth rate of all the four lines of indigenous chicken was in the range of 140 to 170 and 90 to 110 g/week/bird in male and female birds respectively.

The k and half growth time values were the same in all the four lines but different between the sexes. In males, k was 0.0809 and in females, it was 0.0953. The half growth time was about 24.33 and 19.33 weeks in male and female birds respectively. The higher k value in females (sex2) resulted in them having shorter half growth time but lower final weight than the male birds (sex1). As noted earlier, the female birds clearly matured earlier than their male siblings.

The fitted curves and residuals analyses indicate a significant difference in growth pattern among the four lines for both male and female sexes. The *RIRxNyeri* cross (line 4) was superior to the other three lines throughout the growing period in both sexes. The *Nyeri* line (1) was slightly superior to both *Kericho* (2) and *Taita* (3) in both sexes. Growth patterns of the latter two were hardly distinguishable although the male birds of Taita line attained higher weights than the *Kericho* line*.* The reverse was observed for the females.

The asymptote a is the maximum value to which the weight of the birds tended. It was different for the different lines and strongly influenced the fitted curves. All the birds were still increasing their body weight at week 20 and the graphs do not therefore give a precise indication of asymptotic behaviour. The values given in the predicted equations are, therefore rather imprecise estimates based on weight data available. It would seem that for this kind of analysis, data should be collected for several more weeks to give a clear picture of its asymptotic character.

The observed and predicted mean body weights at 18 weeks are shown in Table 4.3.5. In male chicken, they ranged from 1480 to 1830 g and from 1510 to 1900 g for predicted and observed weights respectively. In females, the range was from 1150 to 1360 and from 1160 to 1380g for predicted and observed weights respectively. This indicates a larger variation among males than females.

Table 4.3.5: Observed and predicted Mean body weight (g) of the indigenous chicken at 18 weeks of age.

Line/Cross	Male			Female		
	Predicted mean weight	Observed mean weight	Standard error	Predicted mean weight	Observed mean weight	Standard error
Nyeri	1617	1616	29.6	1232	1265	20.3
Kericho	1481	1514	20.8	1156	1183	11.8
Taita	1560	1638	32.0	1176	1170	20.2
RIRxNyeri	1832	1897	41.1	1355	1378	19.0

4.3.5 Conclusions

The use of the growth model simplified the statistical analysis of the large volume of data collected over the 20 weeks period. According to Wilson (1977), the immediate benefit of fitting an equation to growth data is the reduction in the volume of data required to provide the same information. The Gompertz equation with only three parameters, accurately represents the growth of broilers to 210 days when supplied with values 5.59, 4.19 and 0.19 for a, b and k respectively. Mitchell et al. (1931) fitted 4-order polynomial and reduced 15 data points to five parameters. Conventionally, in growth data, point-by-point comparison will be made between treatments by analysis of variance. Wilson notes that this approach ignores the fact that each body weight measure is a sample of a continuum and thus may extract much less than the total amount of information in the data. Where data are collected frequently, models of bird growth may be constructed and used in making decisions. Buffington *et al*. (1973) used Gompertz equation on data for turkeys to aid those designing cages and other equipment.

Female birds had higher values of the growth rate constant k and shorter half growth time but lower final weight a than the male birds.

Among the three indigenous chicken lines, the *Nyeri* had consistently superior performance over the other two in both the male and female sexes. The difference in growth patterns between *Kericho* and *Taita* birds was not consistent with some overlaps along the predicted curves. However, the *Kericho* males had a slightly higher final weight of male birds while Taita's female birds gave a higher final weight over the *Kericho* ones.

4.4 Growth Characteristics of six reciprocal crosses of Kenyan indigenous chicken

4.4.1. Introduction

Indigenous chicken, reared extensively by rural households, are characterised by low productivity in terms of meat and eggs (Stotz, 1983). This is attributed mainly to poor feeding, management regime, and low genetic potential (Ndegwa, et. al., 1998; Ndegwa and Kimani, 1996; Musharaf, 1990; Musharaf et al., 1990; Provost et al., 1990). However, lack of data on genetic parameters has hampered their development and characterisation as breeds.

Despite the low productivity with all the attendant constraints, there exists a potential for indigenous chicken production system to supply much of required animal protein to the rural people. It is estimated that 90% of rural households keep indigenous chicken often in flocks of 10 - 20 birds (Mbugua, 1990; MOLD, 1990 Ndegwa et. al., 1999;) Indigenous meat and eggs are more preferred and often fetch higher prices than the exotic commercial poultry products. As reported by Ndegwa et. al., (1998), the delicious taste, texture of carcass, little fat content and flavour make indigenous poultry meat a highly appreciated and marketable product. Eggs from indigenous birds are similarly preferred due to their taste and yolk colour.

Rearing of indigenous birds is mainly by women all over sub-Saharan Africa, as it is lowly rated in terms of its importance in the farming system. It provides an area for rural women to generate some income. Indigenous chicken production should therefore be improved as a strategy to empower the rural women who mainly bear the effects of the extreme poverty prevailing all over the sub-Saharan Africa region.

The flock is mostly unimproved although efforts had been made by the National Poultry Development Project (NPDP) of the Ministry of Agriculture and Livestock Development (MoALD,1993), to improve the local chicken through cockerel exchange programmes in twenty-six districts in Kenya. Egg-type hybrids and pure breed Rhode Island Red chickens were used. The genetic and economic impact of this exercise has not been quantified. Besides, this attempt at crossbreeding was unplanned and did not aim at establishing the genetic merit of the local chicken using clearly defined genetic indicators, such as heritability and correlation.

Planned improvement of local chicken in Nigeria was found to be appreciably improved by crossbreeding rather than selective breeding, (Oluyemi, 1979). Similar observations were made by Asiedu & Weaver, (1993). Crossbreeding has been a major tool for the development of present day commercial breeds of chickens (Sheridan, 1981) and could likewise be used to improve the local chicken.

The aim of this study was to investigate and compare the growth performance of reciprocal crosses of indigenous chicken originating from the *Taita, Nyeri and Kericho* districts in Kenya as an attempt at generating information about the birds for use in research and development strategies to improve productivity.

4.4.2. Materials and Method

Three hundred and eighty nine unsexed one day old reciprocal crossbred indigenous chicks were used in the study at the poultry research unit of the Kenya Agricultural Research Institute, National Animal Husbandry Research Centre, Naivasha in 1993 and 1994. The crosses were from three lines of indigenous chicken originating from the *Nyeri, Kericho and Taita* districts in Kenya and all possible crosses were made. These districts are far removed from each other with distinct agro-climatic conditions. *Taita* is located in the coastal region of the country at low altitude and relatively dry. *Nyeri* is in the central highlands and has a wet climate because of the seasonal movement of the Inter Tropical Convergence Zone (ITCZ) and the influence of local geographical factors. It has good and well-drained soils. *Kericho* lies in the western region of the country, is also wet, and has good soils. This region is wet throughout the year, mainly because of the moisture influx from Lake Victoria.

The resulting six crosses were, *Nyeri*Kericho* (NK), *Kericho*Nyeri* (KN), *Nyeri*Taita* (NT), *Taita*Nyeri* (TN), *Kericho*Taita* (KT), and *Taita*Kericho* (TK). The first in the combination is the male.

The crossbred chicks were from eggs laid and hatched at the research unit in a 'Comfort' model hatchery with wing bands placed on each chick for identification. They were raised from day-old to 30 weeks of age in a deep litter (wood shavings) production system. Brooding was on the floor using 250 watts bulbs. The chicks were raised on a standard rearing ration containing 18% crude protein and 2800 Kcal per kg feed (Table4.4.1)**.** Feed and water were provided *ad libitum*. Similar to the study with the indigenous chicken lines discussed earlier in section 4.3.2, the sexing of reciprocal crosses was also done at 12 weeks of age and a partition put in each pen to separate male from female birds.

Table 4.4.1.: Composition. of the chick diet

Ingredient	% composition
White maize	35.8
Wheat meal	38.0
Sunflower cake	3.0
Soya cake	18.5
dl - Methionine	0.25
Mineral/vitamin premix	0.25
Salt	0.30
Anticoccidiol	0.10
Calculated analysis:	
ME, (kcal/kg)	2800
Crude protein, (%)	18

Weighing of the birds was done at hatch and subsequently on a weekly basis for each individual chick identified, by the help of the wing band (see appendix 4.2).

4.4.3. Statistical analysis

Statistical analysis of the data was similar to the one described by J. M. Ndegwa, (this thesis) for the indigenous chicken lines using the Gompertz growth model. Differences between the fitted curves for the six reciprocal crosses were evaluated by analysis of residual variations similar to the one described by Mead et. al., (2003) and J. M. Ndegwa (this thesis).

4.4.4 Results and Discussion

Table 4.4.2 shows the regression equations relating the weight of male and female birds to time from hatching in the six reciprocal crosses of indigenous chicken.

Table 4.4.2: Regression equations relating log body weight in grams of indigenous chicken reciprocal crosses to time in weeks of growth from hatching.

Dependent variable Log(mean weight)	Regression function	
	Male	Female
*Nyeri*Kericho*	Log2796-4.257*exp(-0.1125t)	Log2031-3.954*exp(-0.1183t)
*Kericho*Nyeri*	Log2795-4.191*exp(-0.1315t)	Log2022-3.853*exp(-0.1313t)
*Nyeri*Taita*	Log2702-4.307*exp(-0.1161t)	Log2153-4.137*exp(-0.1177t)
*Taita*Nyeri*	Log3002-4.325*exp(-0.1172t)	Log2013-3.928*exp(-0.1253t)
*Kericho*Taita*	Log2610-4.338*exp(-0.1288t)	Log1738-3.967*exp(-0.1355t)
Taita*Kericho	Log2860-4.457*exp(-0.1164t)	Log2040-4.073*exp(-0.1157t)

In all the six crosses, a similar pattern emerged where body weights of both the male and female birds were indistinguishable in the early stages of growth up to around the 10^{th} week of age (Figure 4.4.1). Thereafter, male birds outgrew their female siblings quite fast in terms of body weight gain. This would be brought about by a differential change in hormonal activity between the two sexes around this point in their growth stage as the birds get to sexual maturity. Figure 4.4.1 shows mean weight trends of male and female birds.

The range of parameter b was from 4.191 to 4.457 and from 3.853 to 4.073 in the male and female birds respectively. As in the case of parameter a values, these too were higher in the male than in the female birds. For the k values, they ranged from 0.1125 to 0.1315 and from 0.1157 to 0.1355 for male and female birds respectively - a reversed trend. As in section 4.3, the larger the k value, the shorter the period taken to reach final weight a. The male birds continued growing long after their female siblings got to their peak. Female birds matured earlier than the male birds and this has an implication in their management practices due to differential nutrient and behavioural requirements at such a point in the growth curve.

In all the six reciprocal crosses (Figures 4.4.1a-f), both male and female birds exhibited a similar growth pattern difficulty to discern during the early weeks in the growth period before the 10^{th} week of age. The pattern was much the same as that noted in the previous study given in section 4.3. The observed mean body weight at 6 weeks of age was 342 ± 14 and 304 ± 12 g for male and female birds respectively. Beyond the 10^{th} week of age, there were clear differences in body weights discernible from the plots and the observed values. The observed mean body weight at 18 weeks of age was 1691 ± 46 g and 1261 ± 26 g for male and female birds respectively. Sexing of the birds using physical features was therefore only possible beyond week ten

Figure 4.4.1: Observed and predicted weight plotted against week of age of male (∗) and female (•) (a) *Nyeri*Kericho, (b) Kericho*Nyeri, (c) Nyeri*Taita, (d) Taita*Nyeri, (e) Kericho*Taita and (f) Taita*Kericho* reciprocal crosses.

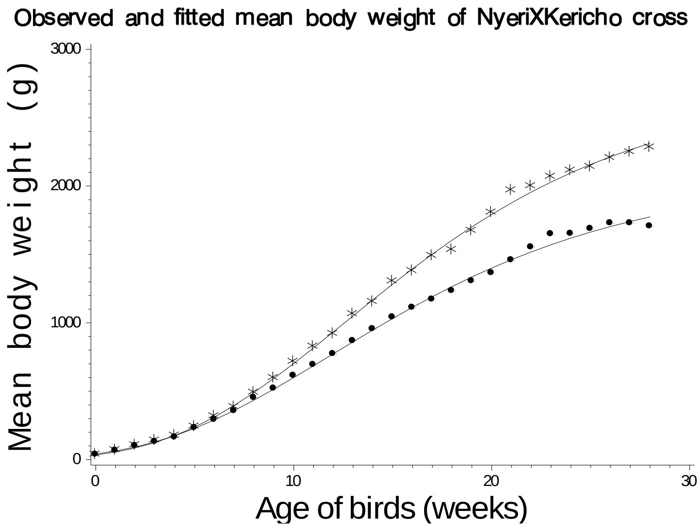


Figure 4.4.1a

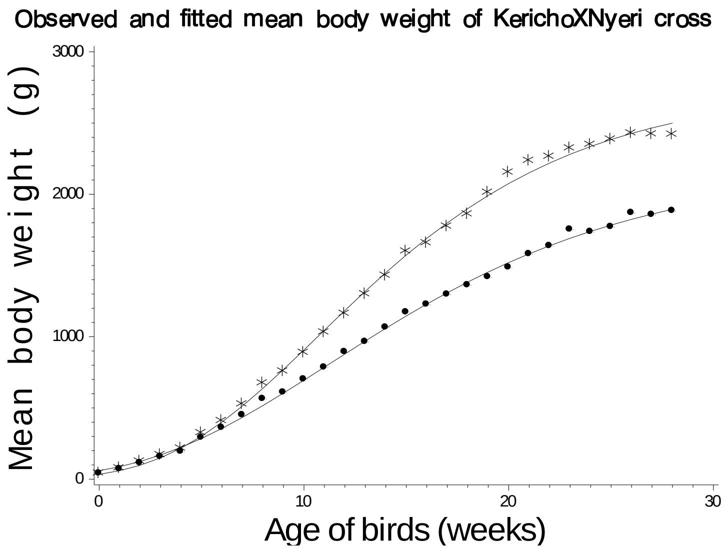


Figure 4.4.1b

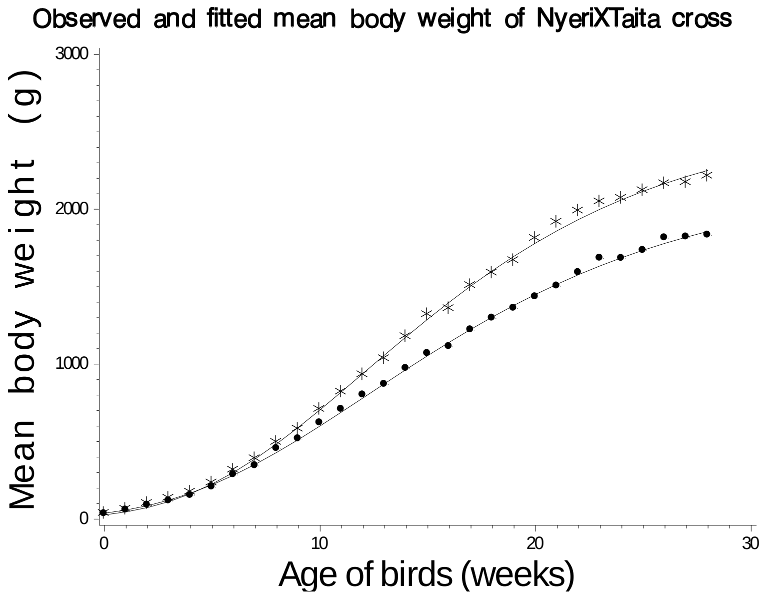


Figure 4.4.1c

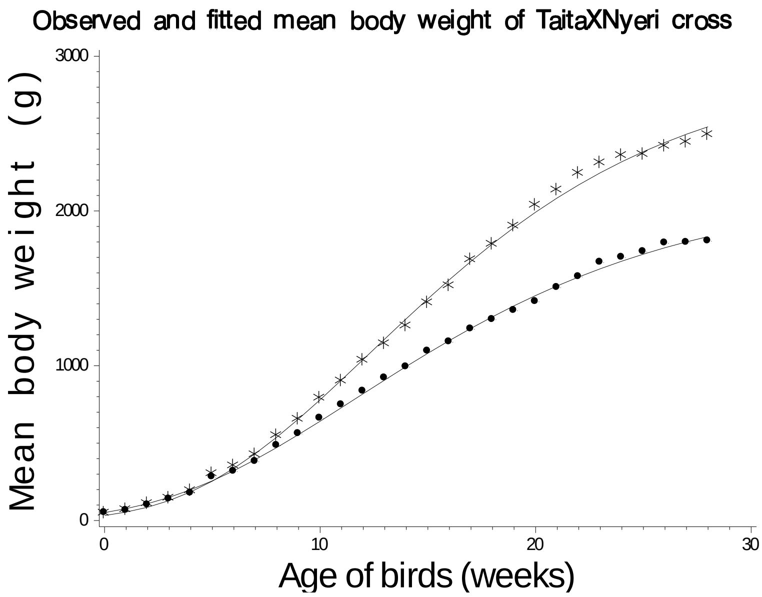


Figure 4.4.1d

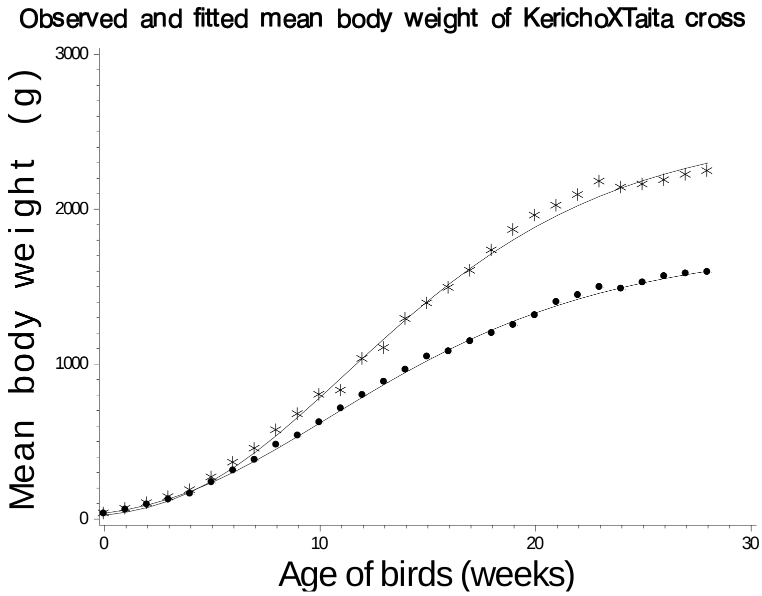


Figure 4.4.1e

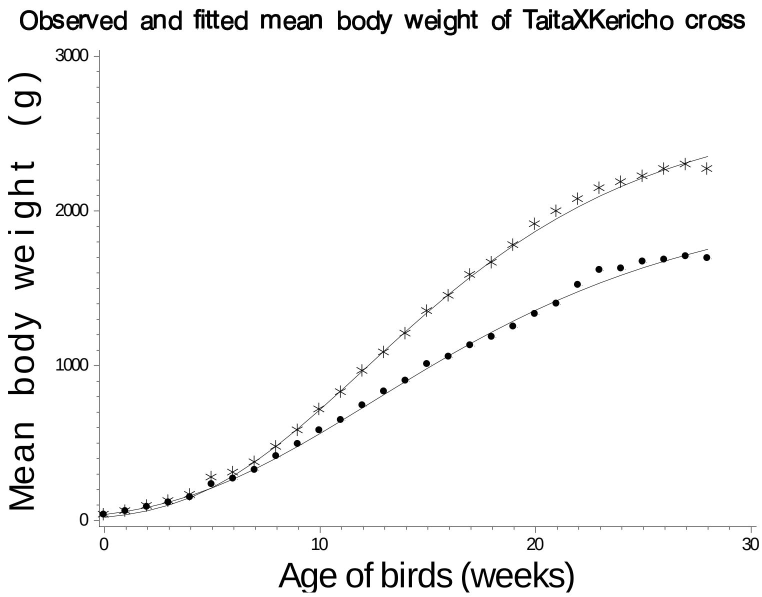


Figure 4.4.1f

Figure 4.4.2: Plots of fitted log mean weights against weeks of age of individual crosses for the (a) male (b) female birds

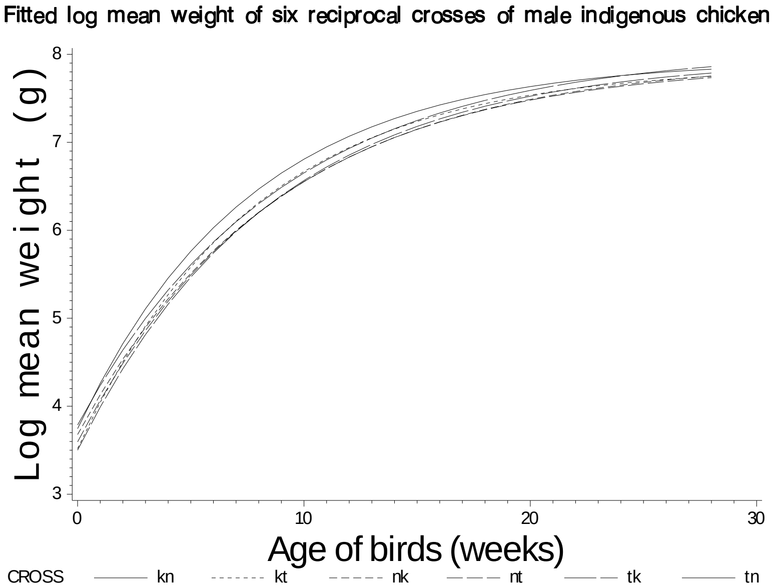


Figure 4.4.2a.

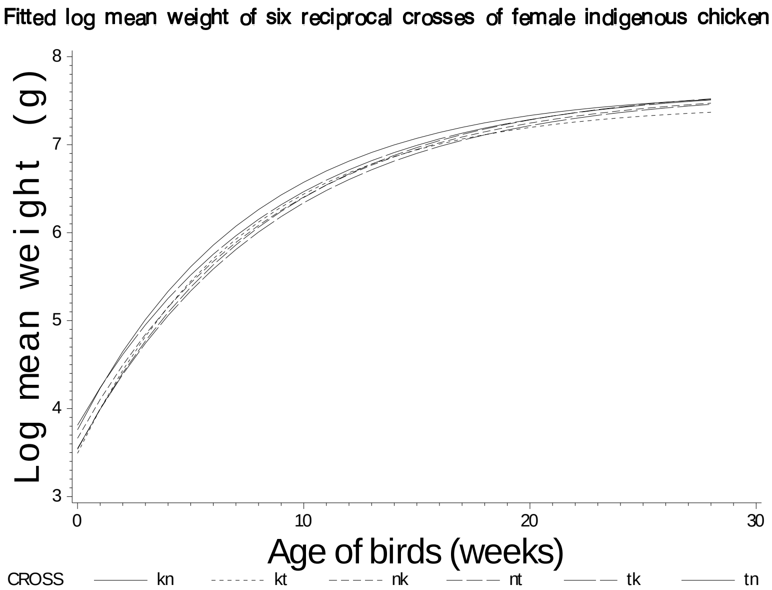


Figure 4.4.2b.

There seems to be an interesting 'mix' of genes in the various combinations resulting in heaviest male birds being of a different though similar combination to that of heaviest female birds. The male birds are heaviest when the *Taita* line is the sire, but for the heaviest female birds, it is when *Taita* line is the dam. In the previous study with pure lines, among the male birds, *Nyeri* were the heaviest followed by *Taita* while in case of the female birds, *Nyeri* and *Kericho* were the heaviest in that order (J. M. Ndegwa –this thesis).

From the information given in Table 4.4.2 and looking at Figures 4.4.1 and 4.4.2, it seems the differences in the regression parameters a, b and k, contribute more to the differences in the fitted curves among the six crosses. These differences are presented more formally by use of an analysis of residual variation described by Mead et al., (2003) and J. M. Ndegwa (this thesis) whose details are shown in Table 4.4.3.

A comparison is made between fitting separate curves for the six crosses and fitting a single curve to the combined data set. The sum of squared residuals for the single fitted curve is much larger than the sum of squared residuals for the separate curves. Difference between the residual sums of squares for the two models are assessed by an F-test giving F statistics of 42.0 and 40.38 for male and female birds respectively on 15 and 156 degrees of freedom. The F statistics is clearly very highly significant. Hence, the data of the six crosses cannot be summarised in a single fitted curve for either sex.

Table 4.4.3. Analysis of residuals sums of squares with degrees of freedom, mean squares and F-ratios for comparison of common curve model with separate curve models for six reciprocal crosses of indigenous chicken

Model	Residual Sum of Squares	Degrees of Freedom	Mean Squares	F-ratio
Males:				
1. Separate curves	0.2521	156	0.0016	
2. Difference (3)-(1)	1.0079	15	0.0672	0.0672/0.0016=42 $(F_{15, 156})$ =1.22
3. Common curve	1.260	171		
Female:				
1. Separate curves	0.2026	156	0.0013	
2. Difference (3)-(1)	0.787	15	0.0525	0.0525/0.0013 =40.38 $(F_{15, 156})$ =1.22
3. Common curve	0.9896	171		

Table 4.4.4 shows significance level of comparison with similar analysis as the above for all possible combinations. They were all significant ($p<0.05$) except for comparison between *Nyeri*Kericho* and *Nyeri*Taita* male birds. The *Nyeri* male line seems to exert a similar and dominant influence on the other two lines for the male offspring.

Table4.4.4: Significance[1] of comparison between separate and combined equations of reciprocally crossed indigenous chicken at 5% level.

Comparison	Significant	
	Male	Female
All	yes	yes
*Nyeri*Kericho vs Kericho*Nyeri*	yes	yes
*Nyeri*Taita vs Taita*Nyeri*	yes	yes
*Kericho*Taita vs Taita*Kericho*	yes	yes
*Nyeri*Kericho vs Nyeri*Taita*	ns	yes
*Kericho*Nyeri vs Taita*Nyeri*	yes	yes
*Kericho*Nyeri vs Kericho*Taita*	yes	yes
*Nyeri*Kericho vs Taita*Kericho*	yes	yes
*Taita*Nyeri vs Taita*Kericho*	yes	yes
*Nyeri*Taita vs Kericho*Taita*	yes	yes

[1]: ns = no significance difference; yes = significant difference

Tables 4.4.5 and 4.4.6 show detailed analysis of growth patterns in terms of asymptotic, final or mature body weight a, initial body weight, constant of rate of approach to mature weight a, maximum growth rate and half growth time of male and female birds. Initial weight ranged from 33 to 42 g and from 33 to 43 g in male and female birds respectively.

These figures are similar to those from the earlier study by J.M. Ndegwa (this thesis) involving individual lines although the former are just slightly higher than the latter. As was the case in the earlier study, the variation is small but appear to be correlated with final weight. Maximum growth rate, k*A0.368 (Brown and Rothery, 1993) of all the six crosses of indigenous chicken was in the range of 115 to 135 and 87 to 98 g. per week in male and female birds respectively.

These values are close to, though slightly lower than, those of the individual lines of indigenous chicken shown in the previous study in section 4.3 which was in the range of 140 to 155 and 90 to 100 g per bird per week, in male and female birds respectively.

Table 4.4.5: The asymptotic (final or mature) weight a, in g., log of, and, initial weight in g, constant (k) of rate of approach to a, maximum growth rate in g/week and half growth time in weeks, of indigenous chicken male reciprocal crosses.

Cross	Final weight a	Log(Initial weight) = loga-b	Initial weight	k, constant of rate of approach to a	Maximum Growth rate =k*a0.368 g/week	$^{1/2}$Growthtime, $t_{1/2}$ =(logb-log0.6932)/k weeks
*Nyeri*Kericho*	2796	3.68	39.6	0.1125	116	16.13
*Kericho*Nyeri*	2795	3.74	42.3	0.1315	135	13.68
*Nyeri*Taita*	2702	3.59	36.4	0.1161	115	15.73
*Taita*Nyeri*	3002	3.68	39.7	0.1172	129	15.62
*Kericho*Taita*	2610	3.53	34.1	0.1288	124	14.24
*Taita*Kericho*	2860	3.50	33.2	0.1164	123	15.99

Table 4.4.6: The asymptotic (final or mature) weight a, in g., log of, and, initial weight in g., constant (k) of rate of approach to a, maximum growth rate in g/week and half growth time in weeks, of indigenous chicken female reciprocal crosses.

Cross	Final weight a	Log(Initial weight) = loga-b	Initial weight g	k, constant of rate of approach to a	Maximum Growth rate = k*a0.368 g/week	$^{1/2}$Growthtime, $t_{1/2}$=(logb-log0.6932)/k weeks
*Nyeri*Kericho*	2031	3.66	39.0	0.1183	88	14.72
*Kericho*Nyeri*	2022	3.76	42.9	0.1313	98	13.06
*Nyeri*Taita*	2153	3.54	34.4	0.1177	93	15.18
*Taita*Nyeri*	2013	3.68	39.6	0.1253	93	13.84
*Kericho*Taita*	1738	3.49	32.9	0.1355	87	12.87
*Taita*Kericho*	2040	3.55	34.7	0.1157	87	15.31

For the male birds, the asymptotic weight (a) values of the six crosses ranged from 3002 to 2610 g. Asymptotic weights of the female birds on the other hand, were lower at the range of 1738 to 2153 g., a similar range as that of the male birds. The *Taita*Nyeri* crosses had the highest a values among the male birds while in the case of females, the *Nyeri*Taita* crosses had the highest a values. The difference between asymptotic weight for males and for females ranges from 549 (*Nyeri*Taita*) to 989 (*Taita*Nyeri*).

The k values fluctuated within and between the sexes and ranged from 0.1125 to 0.1315 and from 0.1157 to 0.1355 in male and female birds respectively. These values influenced the values of half growth time, which ranged from 13.6 to 16.1 weeks and from 12.8 to 15.3 weeks in male and female birds respectively in all the six crosses. As was the case in the earlier study with the individual lines, the female crosses took a shorter time to mature although at a lower final weight than the male birds.

From the fitted curves and residuals analysis, an indication is given of a significant difference in growth pattern among the six crosses for both male and female birds. For the male birds, *Taita*Nyeri* crosses had the highest maximum weight while in female birds, it was *Nyeri*Taita* crosses. The *Kericho*Taita* crosses had the lowest maximum weight in both the male and female birds. The line of indigenous chicken used as dam and as sire in a particular combination of the offspring in both male and female birds mattered.

Generally, the *Nyeri* line seems to perform potentially better when used as dam in male and female offspring when all the parameters defining their growth are taken into account. The *Taita* line seems to potentially perform well when used as sire in both male and female offspring. *Kericho* line also seems to potentially perform better in both male and female offspring when used as sire. These observations would definitely have implications in genetic improvement strategies of indigenous chicken and should be taken into account when designing such strategies.

The asymptotic nature of the fitted curves for the six crosses is better expressed than was the case in the earlier study with individual lines (JM Ndegwa – this thesis) where the data used was only for up to 20 weeks of age, a time when the birds were still growing and hence affecting prediction. In the present study, data used was extended to 30 weeks of age and hence improved prediction, as seen from the fitted curves.

The observed and predicted mean body weights at 18 weeks of age are shown in Table 4.4.7. In male chickens, they ranged from 1580 to 1890 and from 1530 to 1860 g for predicted and observed weights respectively. In case of the female birds, the range was from 1220 to 1410 and from 1180 to 1360 g for predicted and observed weights respectively. These figures are higher compared to those reported in the earlier study for individual lines but in both cases, there was a larger variation among male birds than in the female birds.

There seem to be an effect of hybrid vigour because of crossing between different indigenous chicken lines. The *Kericho*Nyeri* cross had the highest body weight values at this point and also highest maximum growth rate for both male and female birds. Its half growth time in both sexes was also among the shortest at 13 weeks.

Table 4.4.7: Observed and predicted mean body weight (g) of the indigenous chicken crosses at 18 weeks of age.

Crossing	Male			Female		
	Predicted mean weight	Observed mean weight	Std[1] error = Sd/sqrtN	Predicted mean weight	Observed mean weight	Std error
*Nyeri*Kericho*	1594	1531	35.3	1269	1232	20.9
*Kericho*Nyeri*	1886	1858	31.4	1405	1361	25.7
*Nyeri*Taita*	1586	1586	29.8	1310	1296	27.7
*Taita*Nyeri*	1765	1783	29.9	1324	1297	19.2
*Kericho*Taita*	1701	1729	39.1	1229	1196	22.3
*Taita*Kericho*	1652	1660	61.7	1226	1182	54.8

[1]**:**Std=Standard error; Sd=standard deviation; sqrt N=squareroot of N, sample size.

The *Taita*Kericho* cross had the least body weight value at 18 weeks with lowest maximum growth rate as well as longest half growth time of the female birds. For the male birds, the least body weight value was shown by the *Nyeri*Kericho* cross. Nevertheless, this trend would change with time

There seems to be an interesting 'mix' of genes in the various combinations resulting in heaviest male birds being of a different though similar combination to that of heaviest female birds. The male birds are heaviest when the *Taita* line is the sire, but for the heaviest female birds, it is when *Taita* line is the dam. In the previous study with pure lines, among the male birds, Nyeri were the heaviest followed by *Taita* while in case of the female birds, *Nyeri* and *Kericho* were the heaviest in that order (J. M. Ndegwa –this thesis).

4.4.5. Conclusions

The results of this study help to shed more light into the growth characteristics of indigenous chicken and should be used for further research aimed at improvement of production performance for the benefits rural farmers who are the main rearers of these birds. If birds are adequately fed, one can easily plan, for instance, when to market them to raise cash for specific household needs such as paying for school fees. Research should focus on improvement of growth parameters such as reducing the half-growth time and increasing asymptotic weights without increasing cost of production.

Cross breeding of the indigenous chickens among themselves was an important step towards more and meaningful utilisation of local indigenous resources so abundant in rural areas. There was an improvement in growth performance of the crosses compared to that of individual lines. This finding should be taken up by research and development agencies to set up more appropriate breeding strategies that will conserve and raise production potential of this important but often neglected local resource of the rural poor. There is some potential for improving performance of indigenous chicken through judiciously applied cross breeding strategies among indigenous flocks.

Based on the fitted curves and the asymptotic or maximum (potential) weight, there were significant effects between reciprocal crosses and among the six crosses of indigenous chicken. From the results of this study, it seems to matter which line of indigenous chicken is used as dam or sire to obtain the best performance of either male or female offspring. These observations should inform future research and development breeding strategies for improvement of indigenous chicken.

While the regression procedures used in this study are similar to those used in the earlier study involving individual lines of indigenous chicken, in the present study, the fitting was smoother with obvious asymptotes. This could have arisen out of the differences in length of study period between the two, which was 20 and 30 weeks in the first and second study respectively. Future research work using growth models and statistical techniques highlighted in this study should take cognisance of this observation to minimise residual sums of squares and obtain a good fit with clear asymptotes.

As was the case with the analysis of growth parameters of individual lines of indigenous chicken (J. M. Ndegwa – this thesis), the use of the growth model in this study was also very useful and it simplified statistical analysis of enormous amount of data collected regularly over a long period (see appendix 4.2). Much of the data would not have been used in the analysis without such statistical tools and this would have given a less accurate picture of the growth pattern.

4.5 Lessons from the on-station growth studies relevant to farm-level applications

The use of growth models could be an important research and development technique on indigenous chicken both on-station and on-farm to determine their patterns of growth and development characteristics. Various factors affecting growth could be incorporated to explore their sensitivity in a growth model.

The growth characteristics of the different lines and sexes of indigenous chicken provide useful information for development of strategic approaches in their management and improvement even at farm level. For example, the growth patterns at different times indicates a need for particular nutrients (high energy or protein. They at different times also provide a guide to predict size at specific periods, which might be used in marketing strategies. Generally, the information provides better understanding of how the birds grow and respond to interventions. This could lead to more efficient and cost-effective strategy of rearing indigenous chickens to enhance livelihoods.

4.6 Nutrition studies: Growth performance of indigenous chickens fed diets with different protein levels.

The third paper was nutrition based to establish protein level requirements at various growth phases of a mixed sex flock of indigenous chickens with data statistically analysed using covariance method. This has been published in the Tropical Animal Health and Production Journal (Ndegwa et al., 2001c). In this study, 300 indigenous (local) chicks of mixed sex, hatched from eggs originating from Kericho, Nyeri and Taita, were randomly allotted to 16 pens at four weeks of age, and reared under a deep litter production system. Four treatment diets were formulated to contain increasing amounts of crude protein. The aim was to achieve crude protein levels of 18, 20 22 and 24%.. The proximate nutrient contents of the diets were determined at the nutrition laboratory of the National Animal Husbandry Research Centre, Naivasha, using standard methods of analysis (AOAC, 1990).

The diets were randomly allocated to the pens, with four pens per diet. The sex of the birds was determined at 12 weeks of age, using the colour of the feathers and other characteristic male attributes. Each bird had been wing-banded at hatch. The birds were weighed individually on a weekly basis up to the age of 19 weeks. Feed and water were provided *ad libitum.* The mean body weight was determined for each pen and hence for each diet. The proportion of males in each pen was also determined.

Statistical analysis was then carried out on the data collected at 6, 12 and 19 weeks of age using the computational procedures of General Linear Models (GLM) of Statistical Analysis System (SAS, 1985) and covariance analysis according to Mead *et al.,* (2003), to determine the main dietary treatment effect and the covariate effect of the proportion of male birds. This enabled simultaneous regression analysis and determination of the effects of the different proportion of males in each pen at each period, which allowed the data to be adjusted so as to indicate the true dietary effect. The birds had been allocated to each pen at random without knowledge of whether they were male or female. Using data of the body weights in such an uncontrolled mixed flock, without allowing for the differences between males and females, would have resulted in inaccurate information. The test of significance to determine the main dietary treatment effect and the covariate effect of proportion of males in each pen by an assessment of the residuals involved the standard procedure of model fitting, whereby the factor whose effect is being evaluated, is fitted last in the model (Mead *et al*., 2003).

For a complete write-up of this study, see the article enclosed at the back of this thesis.

4.7 Hatching study: Hatching characteristics of eggs from six reciprocal crosses of Kenyan indigenous chickens artificially incubated

This study focused on hatching characteristics of two consecutive batches of eggs from the six reciprocal crosses of indigenous chickens in Kenya - *Nyeri*Kericho* (NK), *Kericho*Nyeri* (KN), *Nyeri*Taita* (NT), *Taita*Nyeri* (TN), *Kericho*Taita* (KT), and *Taita*Kericho* (TK). The work has been published in the Tropical Agricultural Journal (Ndegwa *et al*., 2002).

The birds were raised under a cage system during the laying period. Feeds and water were provided *ad libitum*. Eggs were collected and stored for not more than two weeks under room conditions (18 – 19 °C) in both batches. A total of 1816 eggs were set. The first batch of 861 eggs was incubated in the month of April 1994 and the second batch of 955 eggs, a month later in May of the same year. Both months fall within the long rainy season in Kenya with similar ambient temperature regimes. The incubator used was a setter and hatcher type model IPS 1 PAS REFORM. The setting temperature and humidity were respectively 99.8°F and 85.0°F. The temperature was adjusted to 99.7°F after one week and to 99.6°F after ten days. At day 18 of incubation, the temperature was adjusted to 99.4°F. Relative humidity was raised to 92°F (75%) at day 20 of incubation. The eggs were fumigated using potassium permanganate before incubation. Candling was done after 7 days of incubation to check for infertile eggs that were then removed from the incubator. Another candling was done on day 18 to remove eggs with dead embryos. Eggs were then transferred to separate hatchers on the same day. At hatching very weak and deformed chicks were not considered hatched and were hence culled.

Fertility, hatchability, reproductive capacity and embryo mortality were determined from data collected on number of eggs set, infertile and fertile eggs, dead and live embryos and chicks hatched. Fertility was determined by the proportion of fertile eggs of eggs set. Hatchability was derived from chicks hatched out of fertile eggs. Reproductive capacity was calculated as proportion of the number of chicks hatched out of the total eggs set while the embryo mortality was calculated as proportion of live embryos out of the number of fertile eggs. Chi-square statistical analysis was conducted on the data to test differences of the above proportions among the six crosses.

Hatchability ranged from 47 to 66 and 74 to 84 percent in the first and second batch respectively while reproductive capacity was in the range of 41 to 56 and 65 to77 percent. There were very clear indications of significant differences in embryo mortality among the crosses in both the first and the second batch. Values ranged from 12 to 40 and from 3 to 15 percent respectively in the first and second batch. The reciprocal crosses of indigenous chicken in this study have a distinct characteristic as defined by the hatching parameters under consideration. The NK and KN were superior to the other combinations but had only small differences between their reciprocals. On the other hand, KT and TK combinations had the least values of the parameters but had also only minor differences between their reciprocals. The NT and TN reciprocals were in-between the others but inconsistently varying between themselves and with other crosses. The NT cross, tended to be closer to (N+K), and TN closer to (K+T).

The differences between the two batches indicate importance of management practices in artificial incubation of eggs as they do influence observed results.
The consistency of information from the data in the two batches, however, gives an indication of the distinctiveness of characteristics of the indigenous chicken crosses under this study. The study has brought out some important points that help in the understanding of the nature of these birds necessary for future elaborate investigations.

A complete write-up is enclosed in the pouch at the back of this thesis.

4.8 Conclusions on on-station research experience

The findings and experiences obtained from working with indigenous chickens informed the subsequent farm level participatory studies. Also importance of the on-station research in the whole continuum of participatory research process was amplified from the lessons and experiences that emerged from the participatory process. Working on poor farmers' own local resource in an 'elite' environment elicited an inclination among researchers towards focusing on practical solutions to the need of these farmers. The spirit of working with, rather than for, the farmers in their own individual circumstances was inculcated in the hearts of the researchers.

The subsequent on-farm participatory research as explained elsewhere in the thesis, greatly benefited from the understanding of some of the characteristic of indigenous chicken production parameters. The researchers developed courage and great enthusiasm to carry out more research work on indigenous chickens, especially focusing their role in livelihoods systems among poor farmers.

The research was also instrumental in drawing the attention of key stakeholders to this wonderful local resource by communication made through a variety of fora including workshops, agricultural shows and reports. As a result, a number of initiatives have been undertaken in the development of the indigenous poultry systems among poor rural farmers and more so, in the participatory research processes that this thesis describe.

CHAPTER 5

FARMER PARTICIPATORY RESEARCH DESCRIPTIVE ANALYSIS

5.1 Introduction – data description and categorisation

The farmer participatory research on-farm methodology is described in detail in chapter 3. We carried out the studies between 1996 and 1999 to evaluate effects of improved management practices on performance of indigenous chickens at farm level and most importantly, the consequences for farmer participation in the implementation of the research activities. We were highly enthusiastic to work directly with farmers in their own surroundings, situations and circumstances in order to not only impart our ideas and visions, but also to learn from their rich experiences.

The study involved selection of location (5 regions and 4 villages per region), selection of farms based on farmer's willingness to participate (10 farms selected per village), training and sensitisation meetings (selected farmers and their neighbours plus frontline extension personnel), introduction of intervention options (see Box 5.1), implementation by farmers, and monitoring and evaluation. The farmers used their own local inputs in implementing the project interventions and recorded various project activities and outputs including some aspects of management and production. The project was monitored over a span of five, 3-months long periods. Monitoring was by a visit every three months to each farm to evaluate progress and confirm the farmer's records. This was also the time for more consultation and sharing of experiences.

Box 5.1: Indigenous chicken project improved intervention options and how they were adapted by farmers

1. Housing:
- majority of farmers had adopted housing interventions designed to provide shelter from heat, wind cold, rain, thieves, and predators; provide adequate ventilation , lighting and space for birds, feeders, drinkers, nests, resting rafts and for people getting in and out with ease, easy to clean and disinfect to prevent diseases, internal and external parasite infestation. Features included:
- Roofing(farmers used materials such as iron sheet, plastic sheeting, reeds ('*makuti*') and grass)
- Walls (had to be smooth – mainly mud, some timber, others rafters)
- Floor (dry and smooth and had to be kept clean – mostly earthen, some raised timber, a few were cemented)
- Chicken run (provided scavenging area to glean feeds and exercise – farmers used chicken wire, chain link, offcut timber or droppers)
- Chick pen (high priority for chicks rearing up to 8 weeks, and which contributed to relatively very low mortality levels of 5 -20% compared to over 80% normally reported for ordinary systems(Ndegwa *et. al.,* 1999*)* – most were portable made from timber, tin, wire mesh, intertwined rafters, and reeds baskets)

2. Feeding:
- recommendation on feeding was for a free-choice system comprising both scavenging and supplementation
- almost all farmers supplemented their chicken flocks using mostly local materials (cereal grains – maize, sorghum, millet, wheat, oats, barley; boiled potatoes tubers and peelings, sweet potatoes (*Ipomeo batata*), cassava (*Tapioca*), arrow roots, beetroots, carrots; pumpkins, boiled grain and leafy *amaranthus* ('*terere*'), green vegetables, leafy weeds, grasses; fullfat oiseeds – sunflower, rapeseed, 'thawani' (rapeseed family), croton megalocapus ('*mukinduri'*), groundnuts; cooked legume seeds and leafy parts – peas, beans; *leuceana*, *cariandra,* and *sesbania;* in-season fruits - avocados, plums, mangoes, pineapple, bananas; mineral sources - ground egg shells, ash, common salt*)*
- a few farmers bought external materials to feed their birds (compounded feeds, fishmeal, maize bran, cotton seed meal, soya meal, sunflower meal, bone meal, limestone, common salt, mineral and vitamin premix)
- scavenging was practised by all farmers mainly within 'runs' or enclosures during cropping and around the homestead and farm when there was no crop
- clean and relatively cool water was also provided by all farmers in a variety of containers

3. Health management:
- to prevent and treat diseases some farmers used either or both conventional and traditional strategies:-
- almost all farmers used traditional medication and some did not use any conventional methods.
- conventional medication included:
a) vaccination against Newcastle disease;
b) drugs for respiratory, gut and other problems;
c) control and treatment of endo-parasites – *helminths* using *dewormers*
d) control and treatment of ecto-parasites - mites, fleas and lice using powders
- traditional medication was done using a variety of materials e.g. *Aloe spp.('mugwanugu', 'thukurui'*), hot pepper, garlic, *Mexican marigold* ('*mubangi*'), stinging nettle *('thabai'*), *neem*, pumpkin leaves, pyrethrum, black soot('carbon'), hot ashes;
- other strategies included maintaining clean chicken houses and use of disinfectants such as '*kerol*' or *magadi s*oda and spraying walls with *acaricides.*

4. Hatching and Brooding:
- this was a strategy to produce replacement and incremental flocks rather than buying replacement day-old chicks from a commercial hatchery as is the case with commercial poultry systems.
- the strategy also focused on minimising flock mortality associated with unimproved systems.
Hatching (synchronised and consecutive) involved use of a cock:hen ration of 1:10 to maximise fertility, proper nests (dry, clean, good litter material, quiet, with less light, isolated).
- Synchronised hatching – several hens let to get broody and provided incubation eggs at the same time.
- Consecutive hatching - a broody hen provided with incubation eggs immediately chicks are hatched repeatedly for up to 5 times.
- These strategies ensured farmers got many chicks at once hence increasing flock size several fold within a short period of time.
- Only a few farmers, though were able to apply synchronised and consecutive hatching
Brooding aimed at preventing chick mortalities by providing good management:
- separating chicks from mature birds – special chick housing (portable baskets, pens, isolated chick area).
- feeding good quality feed – high energy and protein, well ground
- clean cool drinking water
- protection against cold, predators, diseases,

5. Breeding:
-aimed at improving genetic potential of indigenous chickens
- maintaining of cock:hen ratio of 1:10,
- selecting high performers(eggs and growth) and good features (large body size, sturdy)
- avoiding inbreeding (removal of cocks after six months and exchanging with others farmers)

Intervention options were based on a training manual by Ndegwa *et. al.*, (1998c)

There was however, a six-month gap between visits 2 and 3 when there was no visit to the farms due to the security concerns at the time especially in regions 1 and 2, as explained earlier in chapter 3. These factors might have therefore played a key role in the behavioural patterns of flock demography. For the purpose of this study, 'periods 1 - 5' refer to the records at the end of the period.

The current chapter deals with initial analyses of the data recorded by the farmers. The aim was to investigate effects of the introduction of a number of interventions, referred in this context as treatments to each of the 200 farms selected across 20 villages in five different regions (see Appendix 5.1 for a complete listing of villages and regions) on the characteristic behaviour of these farms and their indigenous chicken flocks. The interventions were through introduced through training and sensitisations services and consultations. Ten farms were initially selected in each village but some dropped out due to factors outside the scope of the study such as security concern. The data analysed here has been categorised into three types of variables – treatment uptake, flock demography and production characteristics (Table 5.1.1). The records on all the treatments and the flock demography characteristics were analysed for 173 farms but records on the production characteristics were from fewer farms. The production characteristics, eggs laid, eggs set and hatchability, had records from 107, 127 and 121 farms respectively.

The number of farms in each of these categories has been disaggregated by region and village and is shown in Table 5.1.2.

Table 5.1.1: **Demography, treatment and production characteristics for investigation of similarities and differences between farm groups.**

Family of Characteristic	Description of Characteristic	No. Farms with records
Treatments[2]	- Total housing	173
	- Total vaccination	
	- Total deworming	
	- Total supplementation	
Flock Demography[1]	- Flock size at each period	173
	- Total flock additions	
	- Total flock reductions	
	- Total unplanned reductions	
	- Total controlled reductions	
Production	- Predicted egg production per hen cycle	107
	- Egg production difference in cycles 1 and 3	107
	- Eggs set	127
	- Hatchability	121

[1, 2]: totals refer to sum value of a character observed or calculated over 5 periods.

Half of the villages had their original total of 10 selected farms with records on flock demography and treatment characteristics. For the production characteristics, all 20 villages had less than 10 farms with the records. The average number of farms with records in each village was 8.7, 5.3, 6.3 and 6.0 for both treatments and demography, hatchability, eggs laid, set eggs and hatchability respectively.

Table 5.1.2 Number of farms in 20 villages with records on demography, treatment and production characteristics

Region/Village	Number of selected farms	Number of farms with records			
		Treatment/Flock Demography	Production		
			Eggs laid	Set eggs	Hatchability
1 / 1	10	10	8	8	8
1 / 2	10	10	7	7	7
1 / 3	10	10	4	5	5
1 / 4	10	7	5	5	5
2 / 1	10	10	6	6	6
2 / 2	10	8	6	6	6
2 / 3	10	8	6	6	6
2 / 4	10	7	5	5	5
3 / 1	10	9	4	5	5
3 / 2	10	10	6	6	6
3 / 3	10	9	7	8	7
3 / 4	10	6	6	8	6
4 / 1	10	10	5	6	6
4 / 2	10	7	6	6	6
4 / 3	10	9	4	6	6
4 / 4	10	3	3	5	3
5 / 1	10	10	5	9	9
5 / 2	10	10	5	8	8
5 / 3	10	10	6	6	6
5 / 4	10	10	3	6	5

The shortfall in the number of farms with records on treatment or flock demography characteristics is mostly indicative of drop out by some from the project. For the production characteristics, the shortfall is not necessarily due to farmers opting out. There were both farmer and hen factors at play. One reason for this disparity is that farmers were in control of the daily monitoring aspects and some did not keep one or the other of the records because of a variety of reasons.

Some farmers kept records on one characteristic and not another for the same hen depending on availability of someone to assist in the recording if they could not do it themselves. Such a situation calls for development of a more targeted, flexible and suitable method of record keeping at farm level. A few farmers lost enthusiasm and interest in the project at some point and hence did not bother recording. Others farmers forgot or they just did not see the importance of keeping records. In some cases, the selected hens might have not yielded results for recording. This scenario points to the complexity of participatory on-farm experimentation and the need for input of statistical expertise in designing stage.

To sustain enthusiasm and revive interest among the farmers, we used some persuasion and education with a good measure of success. Most kept up-to-date records even when we took a longer time to visit them and even long after the project had been phased out. This also happened in areas where serious insecurity problems had previously occurred forcing, many people to temporarily flee their homes.

Generally, the response on records keeping was encouraging. The flock demography dynamics and the treatments characteristics had the most records and it seems many farmers found these easier to handle. However, the number of farms with production characteristics records were from fewer despite recording from only a selected number of hens among the farmers' flocks. The selection of 4-6 hens from which to make production records was necessitated by the complexity farmers would experience identifying which hen had, say, laid an egg when if more hens (ten or more) were selected.

All the variables were based on farmer records. The intervention treatment included the four explanatory variables housing, vaccination, de-worming and feed supplementation, introduced through a process of training and sensitisation of farmers. Exploratory variables to investigate effects were the flock demography and the production characteristics. Application of the treatments depended on individual farms capacity, ability and time allocation. Farmers used their own local resources and new knowledge from the training to apply the treatments. Hence, the treatments were not uniform in all the farms as highlighted in chapter 3.

5.2 Treatment Characteristics

Table 5.2.1 illustrates the treatment uptake raw data at period 1 for farms in each village and region, using an example farm from each village. Complete records from all the farms in the five regions and for the rest of the five periods are shown in appendix 5.2 but are generally in the form shown here.

Table 5.2.1: Treatment uptake from farms selected from 20 villages in five regions in period 1.

Region	Village	Farm	Treatment Uptake[1]			
			Housing	Vaccination	Deworming	Supplementation
1	1 (LK)	LK1	1	0	0	1
1	2 (LS)	LS1	0	0	0	1
1	3 (LC)	LC1	1	0	0	1
1	4 (LO)	LO3	1	0	0	1
2	1 (OS)	OS1	1	0	0	0
2	2 (OP)	OP1	0	0	1	1
2	3 (OM)	OM1	0	0	0	1
2	4 (OK)	OK2	1	0	0	1
3	1 (BK)	BK1	0	0	1	1
3	2 (BM)	BM1	1	0	1	1
3	3 (BS)	BS1	0	0	0	1
3	4 (BW)	BW1	1	1	1	1
4	1 (NP)	NP1	1	0	0	1
4	2 (NG)	NG1	1	1	1	1
4	3 (NN)	NN1	0	1	1	1
4	4 (NL)	NL1	0	0	0	1
5	1 (NSK)	NSK1	0	0	0	1
5	2 (NM)	NM1	1	0	0	1
5	3 (NKR)	NKR1	1	0	0	1
5	4 (NMR)	NMR1	1	0	1	1

[1]Treatment Uptake: 0 = treatment not applied; 1 = treatment applied

The treatment uptake records illustrated here show whether and when a particular farmer implemented the specific treatment in the form of housing, vaccination, de-worming or feed supplementation. Once the housing treatment was applied, it inevitably remained applied in subsequent periods. In case of the other three treatments, application could have been done in one period and be skipped in the next period(s). When a treatment was applied in a certain period, this was indicated with a value of one, otherwise a zero was entered. For example, the first row shows that farm LK1 in village 1 and region 1, had applied housing and supplementation (each given a value of 1) in period 1, but did not apply vaccination and deworming (each given a value of 0) in the same period.

Looking at this illustration, the treatment uptake characteristics, housing and supplementation had most entries with one indicated. The records for the other four periods were similar to this illustration.

Levels of treatment uptake per farm are calculated as totals for each form of intervention. These are illustrated in Table 5.2.2 for the selected sample of farms in the 5 regions.

Table 5.2.2: Levels of treatment uptake distribution for 20 farms selected from 20 villages in five regions as totals for 5 periods

Region	Village	Farm	Treatment[1]			
			totHse	totVac	totDwm	totSpl
1	1	LK1	5	0	1	4
1	2	LS1	2	0	2	4
1	3	LC1	5	0	1	5
1	4	LO3	5	1	1	5
2	1	OS1	5	1	1	4
2	2	OP1	4	3	5	5
2	3	OM1	4	1	3	5
2	4	OK2	5	1	3	5
3	1	BK1	4	2	3	5
3	2	BM1	5	2	5	5
3	3	BS1	3	0	4	5
3	4	BW1	5	4	4	5
4	1	NP1	5	3	3	4
4	2	NG1	5	2	3	5
4	3	NN1	4	2	3	5
4	4	NL1	3	1	3	4
5	1	NSK1	0	3	1	5
5	2	NM1	5	1	2	5
5	3	NKR1	5	1	2	5
5	4	NMR1	5	1	2	5

[1]Treatment:
totHse = total periods housing intervention was applied
totVac = total periods vaccination intervention was applied
totDwm = total periods deworming intervention was applied
totSpl = total periods supplementation intervention was applied

The levels ranged from 0 – 5, indicating the number of times a given treatment was applied out of the possible 5 periods (0 - not applied at all in 5 periods; 5 -

applied in all the 5 periods). For example, Total Housing uptake for 5 weeks (totHse) was obtained from:

Housing1 + Housing2 + Housing3 + Housing4 + Housing5
i.e. sum of housing values in periods 1 – 5.

In our illustration, farm LK1 in village 1 of region 1 had a totHse with a value of 5 meaning that housing was done at each of the five periods. The same farm had a total Vaccination uptake (totVac) of value zero, a total Deworming uptake value of 1 and a total supplementation value of 4. Treatment uptake levels for all farms in the five regions are provided in appendix 5.3

Two forms of diagrams are used to describe the pattern of uptake of interventions. The first is the frequency distribution of levels of each treatment shown by Figure 5.2.1(a – d) corresponding to the treatments housing, vaccination, deworming and supplementation respectively, as a pattern for each region. These levels indicate the number of times or periods a treatment was applied and range from 0 (no application at any period) to 5 (application of an intervention in each period).

The housing frequencies of farmers at levels of 0 and 5 in each region were larger compared to the frequencies at other levels (Figure 5.2.1a). This is because of the fact that many of those who applied housing intervention as defined for the experiment, did so in period 1 and being a physical, more durable and non consumable structure, it would be reflected in other periods. Only a few farmers had housing at levels 1 to 4 showing a few taking up housing after the initial period. One farmer in each of the regions 1 – 4 and 3 farmers in region 5 applied housing only once, which must mean the use of housing for the first time at period five. The proportion of farmers not using housing at all was large and as discernible as that of the farmers using housing all the time in each region. Regions 1 and 5 had the largest proportions in this category.

Having housing in all the five periods, implies that one had also housing treatment in period 1. From Figure 5.2.1a, 30% of all the farmers in the five regions had housing in period 1. Generally, only a quarter of farmers in the entire five regions did not have housing as a treatment in any period. This is a good reflection of the enthusiasm farmers had in taking up our interventions right from the beginning.

Housing intervention as a scientific technology was a familiar entity to the farmers although many of them had not felt the need to invest in it before. They easily understood from our training sessions its importance in reducing losses from vagaries of weather, theft, predation and infection by diseases. The application of housing was also easily affordable using locally available materials. Hence, the high frequencies at level 5 observed in all the five regions indicate early and sustained use by a large proportion of farmers. The reasons why some farmers did not use housing at all may be a reflection of their high level of poverty and hence they could not afford to invest in this activity. A majority of those who were able applied housing early in the project period.

Figure 5.2.1a. Frequency distribution of housing treatment

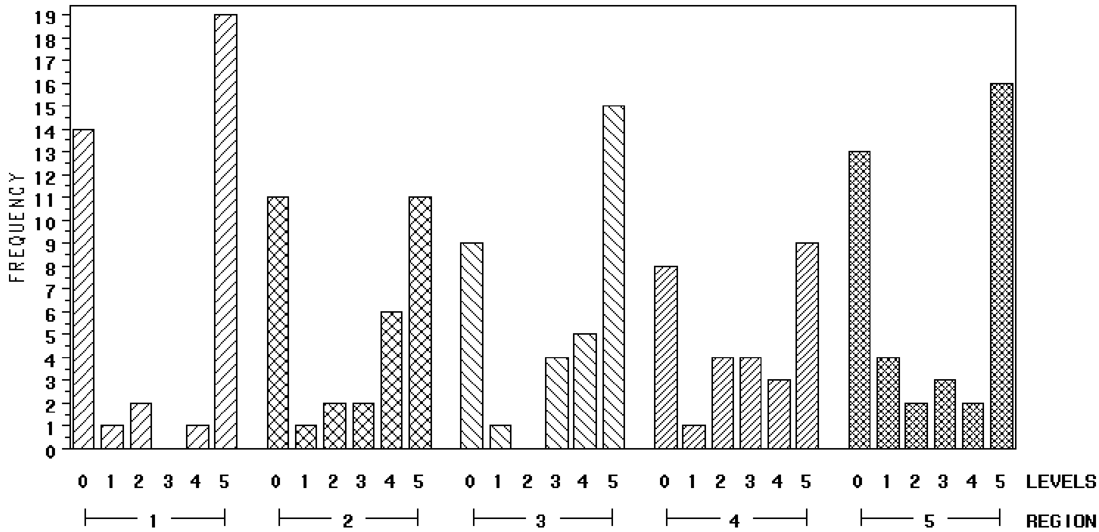
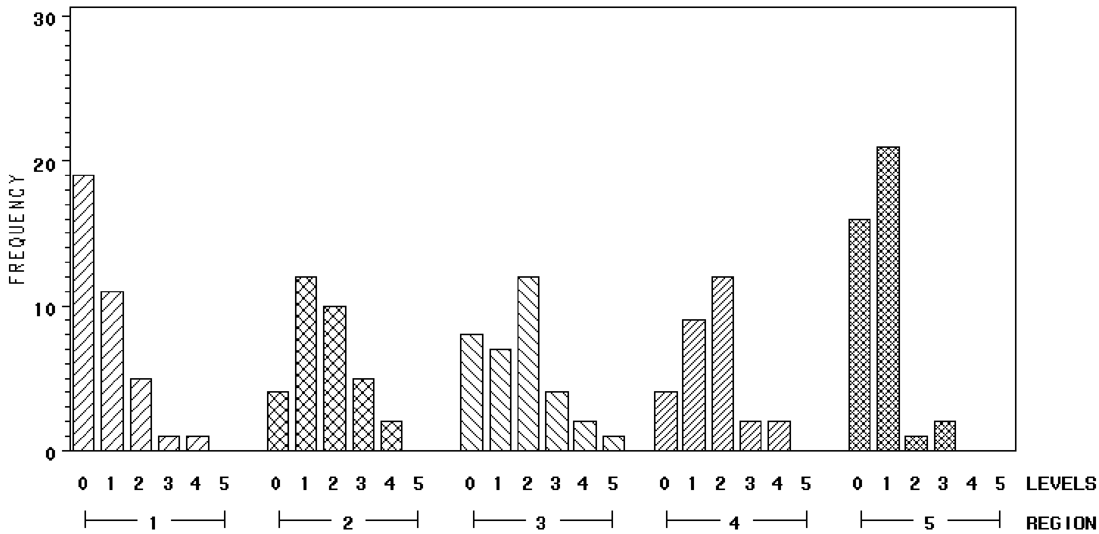


Figure 5.2.1b. Frequency distribution of vaccination treatment



The vaccination frequency distribution pattern is shown in Figure 5.2.1b. The most frequent levels are 0, 1 and 2 in all regions except for region 5. There was hardly any vaccination at level 5. The zero level had a high frequency in regions 1 and 5. In general, most of the farms that had vaccinated had only done it once or twice. Regions 1 and 5 had the largest proportions of farmers (38 and 50% respectively) who did not vaccinate at any period. However, only about one quarter of farmers in all the five regions did not vaccinate at any period. This again is another good indication of the enthusiasm for participation in the project's activities by the farmers. Most vaccination was done on a group basis whereby farmers in a group jointly bought vaccine and shared doses. It is unlikely that individual farmers could have afforded to act independently due to the high cost and dosage packing of the vaccine.

The deworming pattern of levels of application (Figure 5.2.1c) shows a distribution with a peak in the middle with more farmers at levels 2 and 3 than at other levels in all the regions. There were only 3 farms (1 in region 2 and 2 in region 3) at level 5 overall. Hence, regular use of deworming was not frequently practised but the majority of the farms had dewormed at some period. Only a minority (10%) of the farmers in the entire five regions had not had deworwimg at any period at all. Deworming was done using anti-helmintics drugs easily available and cheap from local drug shops. Lack of application in every period was mainly because farmers were not able to discern or understand its importance in management of their flocks. However, this usage was a good indication of farmers willingness to try out new formal ideas they learned from our training sessions.

Figure 5.2.1c. Frequency distribution of deworming treatment

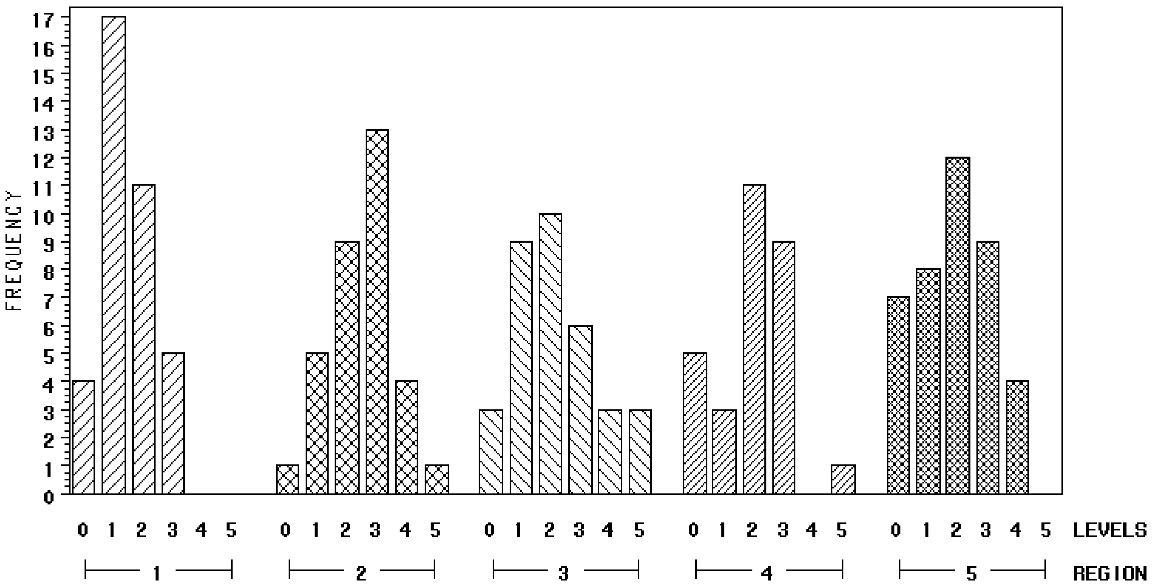
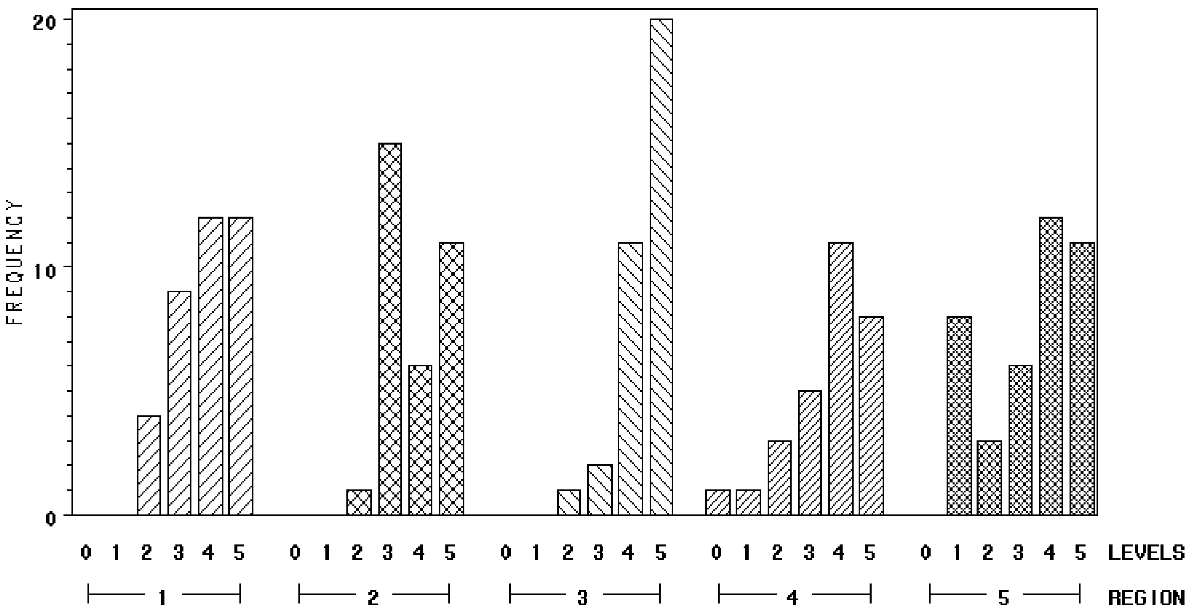


Figure 5.2.1d. Frequency distribution of feed supplementation treatment



The feed supplementation frequency distribution on levels of application was skewed to the right with most of the farmers at level 3 and above in every region as shown by Figure 5.2.1d. There was generally an upward trend in the number of farmers from period 1 to 5. Almost all farmers had supplementation at least in one period. Close to a quarter of the farmers in each region applied supplementation in all five periods. Region 3 had the highest number of farmers at level 5 with more than half of them applying supplementation in every period. Application at levels 1 and 2 was by only a small number of farmers (only one farmer at level 2 while the other regions had between 4 and 5 farmers).

The second diagram describing the pattern of intervention uptake is shown by Figure 5.2.2 (a – d) and provides a chronological summary of the numbers of farmers taking up the interventions on housing, vaccination, de-worming and feed supplementation in periods 1 to 5 and in each of the regions 1 to 5.

The housing pattern for the number of farmers, who applied in each period, shows an upward trend in all the 5 regions (Figure 5.2.2a). Region 1 had more farmers with housing in periods 1 and 2 than the other regions with only regions 3 and 5 surpassing it in latter periods. Region 3 was similar to region 5 while region 2 was similar to region 4 in the number of farmers with housing. About 58% of farmers in the entire five regions had housing in 5 periods. The first diagram (Figure 5.2.1a) showed that 30% of farmers had housing in period 1 hence the upward trend. Generally, the housing treatment was applied widely and frequently in all regions.

The time distribution pattern of the number of farmers using vaccination shows a general increase with period in all the regions (Figure 5.2.2b). Regions 2, 3 and 4 had generally highest number of farmers doing the vaccinations. Generally, most application was in done in later periods 3, 4 and 5.

Figure5.2.2a. Numbers of farmers taking up housing by the end of periods 1–5

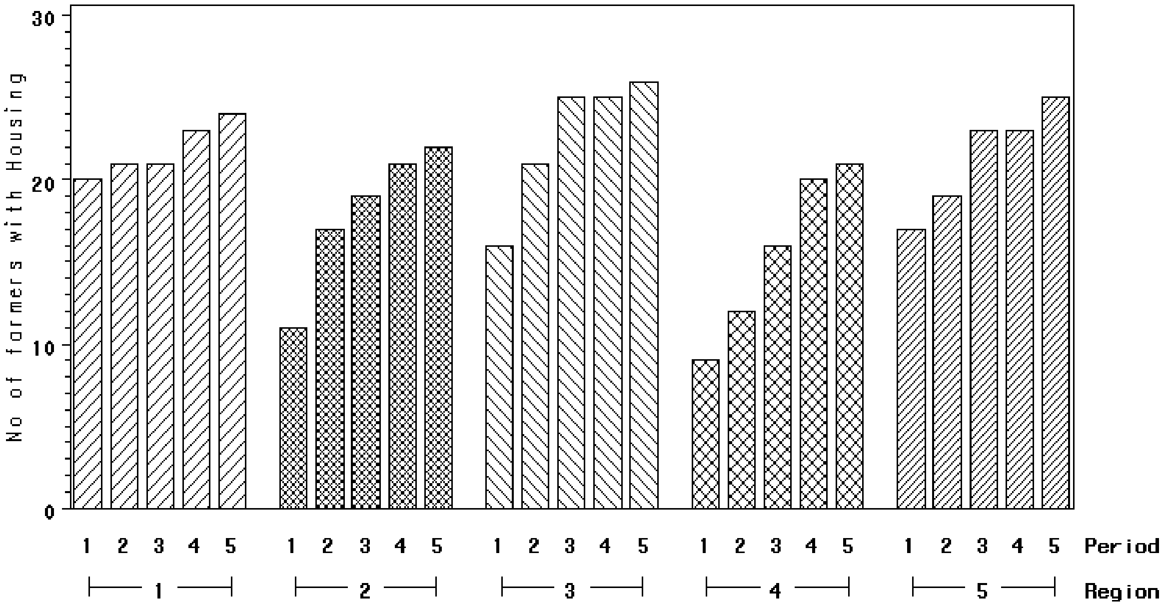
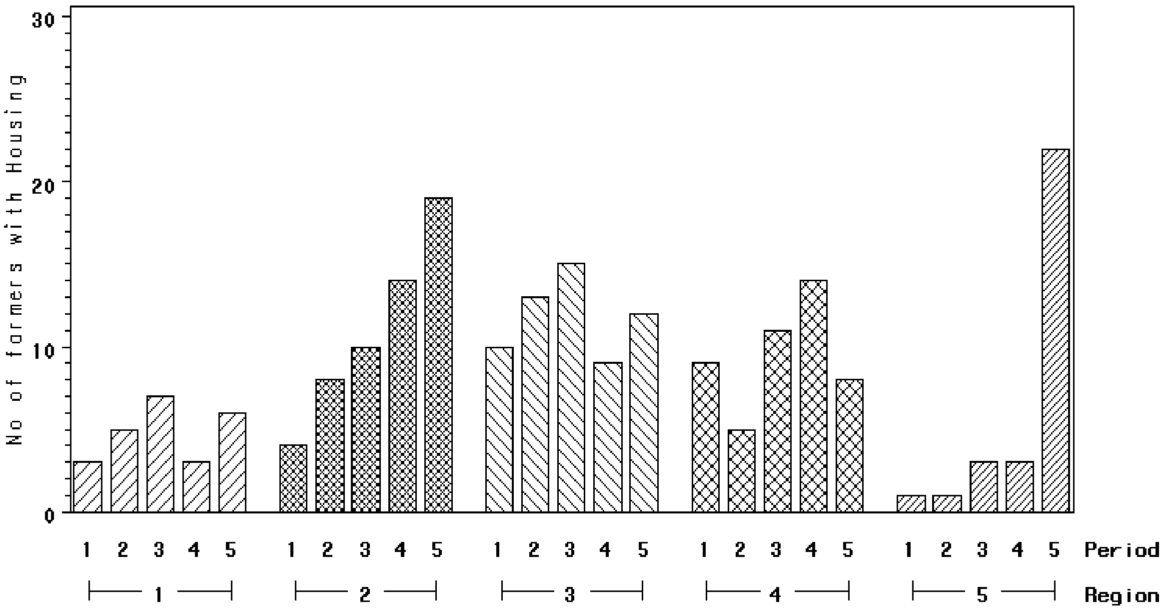


Figure 5.2.2b. Numbers of farmers taking up vaccination in periods 1–5



Period 5 in regions 2, and 5 recorded the largest number of applications with about 50% of farmers doing vaccination in period five. Close to 30% of the farmers did vaccination in period five in all five regions. Region 3 had almost the same number of applications in every period. However, the pattern of the vaccination uptake in region 5 was completely different from those in the other four regions with only a few farms having done vaccination in periods 1-4 while period 5 had a large number of farms vaccinating. This was probably due to a late realisation of its importance by the farmers but there was also an element of organised group vaccination at this period.

The pattern of the numbers of farmers taking up deworming treatment is shown in Figure 5.2.2c. This shows that more farmers applied deworming in later periods giving an upward trend of the number of farmers deworming over the periods. About 25 percent of farmers had vaccination in period 1, and about 40% in period 5. Periods 3 – 5 generally seem to be the time most applications were done. Regions 1 and 4 had similar patterns and both had the least application rates generally.

The pattern for the number of farmers taking up feed supplementation at each period and in each region is provided by Figure 5.2.2d. There was a small upward trend in the number of farmers who supplemented their chicken flocks from period 1 to 5 in each region with period 1 registering at least 10 farmers. Region 4 had the least number of farmers in each period compared to the other regions. Close to 50% of farmers generally, had supplementation at each period.

Figure 5.2.2c. Numbers of farmers taking up deworming in periods 1–5

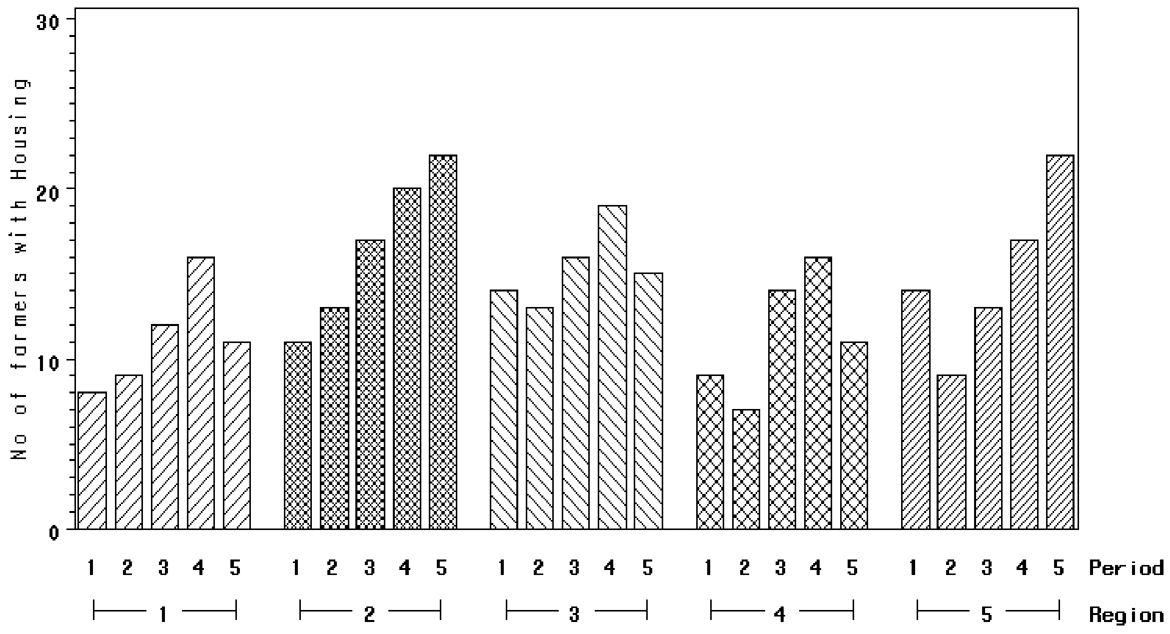
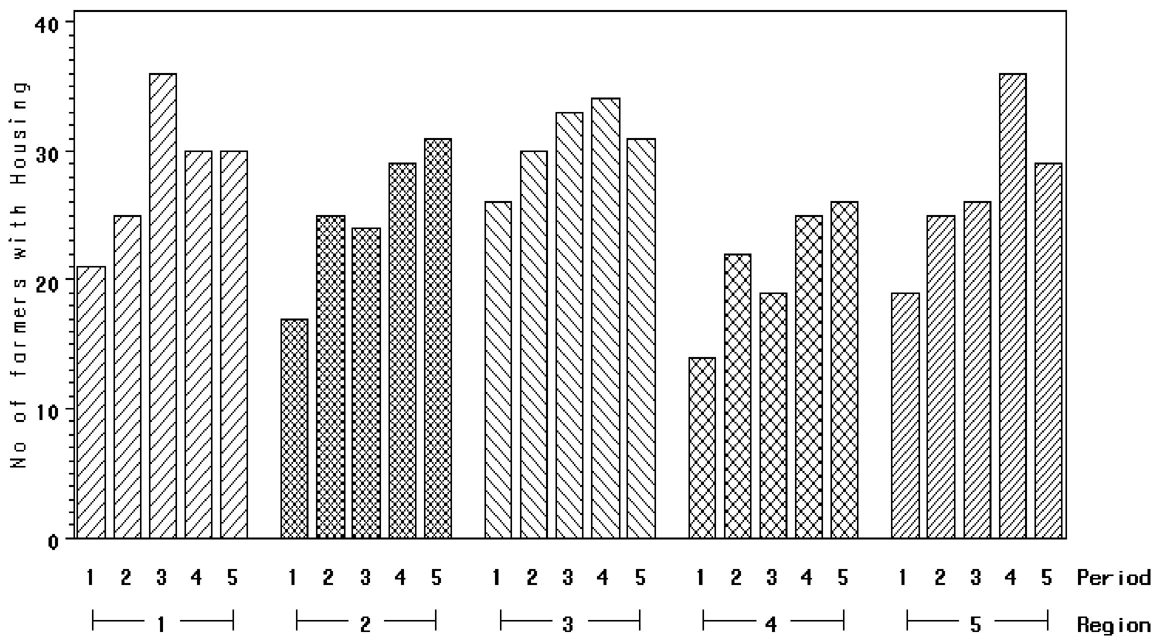


Figure 5.2.2d. Numbers of farmers taking up feed supplementation in periods 1–5



The two sets of diagrams provide an understanding of the treatment application in terms of number of times it was done, period of application and number of farmers involved. They also provide information on important regional differences if any, on application of the treatments.

The feed supplementation and the housing interventions seemed to have been applied early in the study and in the rest of the later periods by majority of the farmers, although they have rather different patterns because housing has non-decreasing levels. There is little variation between periods in the take up of the two interventions. Similarly, there were little regional differences in these interventions though region 4 was low on both. These two treatments were applied by use of locally available resources and hence many farmers found it possible to take them up from the early periods across the regions.

Summaries of the total numbers of treatment applications and the average levels of treatment application in 5 regions, over the entire 5 periods are provided in Table 5.2.3 and Table 5.2.4 respectively. These summaries support the arguments presented about the treatment levels and number of farmers.

Table 5.2.3: Total numbers of treatment applications in regions 1 – 5.

Region	Treatment			
	Housing	Vaccination	Deworming	Feed Supplementation
1	109	24	56	142
2	90	55	83	126
3	113	59	77	154
4	78	47	57	106
5	107	30	75	135
Total	497	215	348	663
Proportion	50%	21%	35%	66%

Table 5.2.4: Average total level of treatment application in 5 periods in regions 1 – 5.

Region	Number of farms	Treatments[1] mean total values			
		Thse	Tvac	Tdwm	Tspl
1	37	2.8	0.7	1.4	3.9
2	33	2.7	1.7	2.5	3.8
3	33	3.1	1.6	2.1	4.4
4	26	2.6	1.6	2.0	3.7
5	40	2.6	0.7	1.9	3.4
standard deviation range		2.0 – 2.4	0.8 – 1.3	0.9 – 1.3	0.7 – 1.5

Treatments[1]:Thse = Total level of housing; Tvac= Total level of vaccination; Tdwm = Total level of deworming; Tspl = Total level of feed supplementation. Maximum level is 5.

In general terms, feed supplementation had not only a high level of use by all farmers in each period, but also a high number of farmers taking it up early in the study. This observation is an indication of positive farmer response to our prior training and sensitisation sessions, where emphasis was put on the importance of feed supplementation to meet birds' nutritional requirements using locally available feed resources. This was a feasible innovation for anyone who recognised inherent livelihood opportunities in the research process. Strict emphasis was particularly placed on the need to feed young chicks with high protein rich feedstuffs. So the understanding by farmers about some basic nutritional science and the fact that most of the required nutrients could be found among local materials, might have greatly influenced the observed response by farmers in the application of feed supplementation treatment.

The vaccination and deworming treatments tended to have more variation between periods and regions. The majority of farmers in regions 3 and 5 applied the two treatments in period 5. The pattern in region 5 is very different from the other 4 regions for the vaccination, which differed mainly on the number of farmers. Vaccination in particular needed greater technical and monetary intervention than other treatments and was applied by farmers in different villages and regions at different periods of time. Application of deworming had a resonance with that for vaccination in that both were generally done up to a total of 3 times, and in the later periods. This was due to the fact that this was 'new science’ for most of the farmers and application of both treatments required investment in external inputs, which most farmers had difficulty affording early in the project. Most farmers seemed to have taken time also to understand and probably appreciate the importance of applying vaccination and deworming. With time, and because of persuasion from the research team, some farmers were able to take them up in later periods of the process. The deworming was particularly baffling to a majority of the farmers who had no prior knowledge of likelihood for infestation of their chicken flocks by internal worms and the implications for the flock’s performance.

One of the objectives of the study was to have the farmers participate fully and actively in the research process as a novel approach to technology transfer. Such farmers would benefit directly from the research by appreciating its significance. They would also understand better what a technology entails and be able to apply the same within their personal circumstances and situations. There was also the hope that other non-participating farmers would be influenced by and learn from the farmers who were involved in the research. Looking at the patterns of distribution of levels of treatments uptake and the numbers of farmers applying a technology over the periods, a great deal has been done towards the achievement of the stated objectives. Farmer’s enthusiasm in the research process was created and was a major driving force that helped to sustain the impetus.

Farmer participatory research can therefore be seen, from the perspective of the current study, to be a tool for technology testing and transfer at the very point it is needed and designed to support. This is a quick and effective means of generating and disseminating information. The weakness of the tool however, is that it is dependent on development of enthusiasm among its clientele and is difficult to control and minimise random variation for ease of statistical analysis and investigations. A hundred and seventy three farms out of the 200 originally selected had records on treatments and this to me is exciting as it is an indication of strong farmer participation in the research process through implementation activity. There were a similar number of farms across the regions (except in region 4, which had only half the original number of farms selected) which suggests little regional variation in support for these processes.

The use of available local resources enhanced early uptake of housing and supplementation by farmers. This points to the potential need for the provision of credit inputs to enable farmers to secure other resources required to implement project activities, particularly early on. Creation of enthusiasm and interest among target groups require strengthening their capacity to be able to undertake and implement project activities.

5.3 Demography Information

Table 5.3.1 shows demographic characteristics in period 1 using a selected sample of farms, one each from the 20 villages in the 5 regions. The rest of the data is found in appendices 5.4 - 5.8. The table shows raw data as recorded by farmers for 5 periods on flock size and its dynamic factors - additions to the flock, losses, sales, consumption and gifts from the flock. The data was analysed to provide summary information about behaviour of farms using a set of tools – plots of flock trends over the periods, flock dynamics of additions and reductions, demography analysis to classify farms and use of the flock dynamics in regressions to get optimal operation models.

Due to the small values of most of these factors, losses, sales, gifts and consumption were grouped broadly as reductions and this was in turn categorised either as controlled (sales, consumption and gifts) or unplanned (losses).

The demography characteristic flock size is used in chapter 7 to classify farms using demography analysis, into a smaller number of farm types from the large figure of 173 whose differences with other exploratory variables was investigated. The number of farms with records on flock sizes is less than the initial 200 farms since some had dropped out of the project mainly due to security concerns in two regions (1 and 4) and the farmers’ circumstances.

Table 5.3.1: Demography characteristics[1] of a selected sample of farms in 20 villages in period 1

Region	Village	Farm	Flocksize	Demography dynamics				
				Addition	Loss	Sale	Gift	Consumption
1	1	LK1	9	5	0	1	0	0
1	2	LS3	28	12	0	4	1	2
1	3	LC4	15	9	6	0	0	0
1	4	LO9	44	12	0	2	5	1
2	1	OS1	18	20	0	3	0	0
2	2	OP3	21	12	0	20	1	2
2	3	OM4	14	25	0	2	1	5
2	4	OK8	44	12	0	2	5	1
3	1	BK1	18	5	0	1	0	0
3	2	BM1	123	63	5	43	1	2
3	3	BS4	14	25	0	2	1	5
3	4	BW9	44	12	0	2	5	1
4	1	NP1	18	20	0	3	0	0
4	2	NG2	23	20	2	2	0	6
4	3	NN5	15	9	6	0	0	0
4	4	NL6	10	20	1	2	0	1
5	1	NSK2	20	10	0	0	0	2
5	2	NM1	24	10	2	0	1	1
5	3	NKR6	12	13	2	0	0	2
5	4	NMR5	14	15	10	5	3	1

[1]:Demography characteristics – flock size and dynamics (addition, loss, sale, gift and consumption as recorded in each farm

The demography analysis is reported more elaborately in chapter 7 of this thesis. Flock size dynamics over the 5 periods are represented by the farm flock sizes at the beginning and flock size characteristics of change through the period (total addition, total reduction, total unplanned reduction and total controlled reduction).

The trends of the flock size averaged for farms in a village over 5 periods are represented in Figure 5.3.1 and cover all the five regions. Flock size values from 15 farms - 2 from region 2, 3 each from regions 1, 3 and 4, and 4 from region 5, were considered extremes (either too large or too small) and therefore left out from the flock trends. The flock size trends provide preview of the flock levels maintained by farmers over time. There was a general rise of flock sizes in the farms from low levels of between 10 – 20 birds per farm to mainly medium levels of 20 – 30.

The flock size trends in all regions had a fall between visits 2 and 3. This corresponds with the long duration of time (6 months) between the two visits and state of high insecurity due to political violence associated with the electioneering mentioned earlier.

Figure 5.3.1a shows the flock size trends of farms in four villages in region 1. All the farm trends generally went up initially from average lows of 14 in villages 1, 2, and 3, although there was a dip between visits 2 and 3. Farms in village 4 (Ol Moran) had the sharpest fall in flock size. The trend in village 2 started high above 35 but gradually decreased to below medium low at around 20, lower than levels of the farms from the other villages. Farms in the other villages had similar flock size trends with an upward trend that started from lows of 13 – 16 and ended up with highs of 25 – 33. The flock size of farms in village 3 however started lowest and ended up lowest. The Ol Moran area was most affected by the state of insecurity, forcing at least three farmers out of their farms after period 2. However, the determination and enthusiasm of the farmers was such that they continued with project activities and their flock size trends bear this out. Generally, the flock size in region 2 increase from below 20 to near 30.

The average flock size trends in villages in region 2 are shown in Figure 5.3.1b. The general flock size trend increased steadily over the periods for farms in villages 1, 3 and 4 from just below 20 to medium levels around 25. The trend for farms in village 2 had a slight negative gradient all through the periods ending up lowest at 15 despite having started at a similar medium level (>20) with those in village 1. The flock size of the farms in village 1 remained above those of other farms except in period 5. Similar to the farm flock size trends in region 1, there was also a general drop between periods 2 and 3, in region 2, though only slightly so in the latter period. However, unlike in region 1, region 2 had a drop in flock trend between visits 4 and 5. Generally, the flock size in region 2 increase steadily from below 20 to above 20

.

Figure 5.3.1a. Average farm flock size in 4 villages in region 1 (Laikipia)

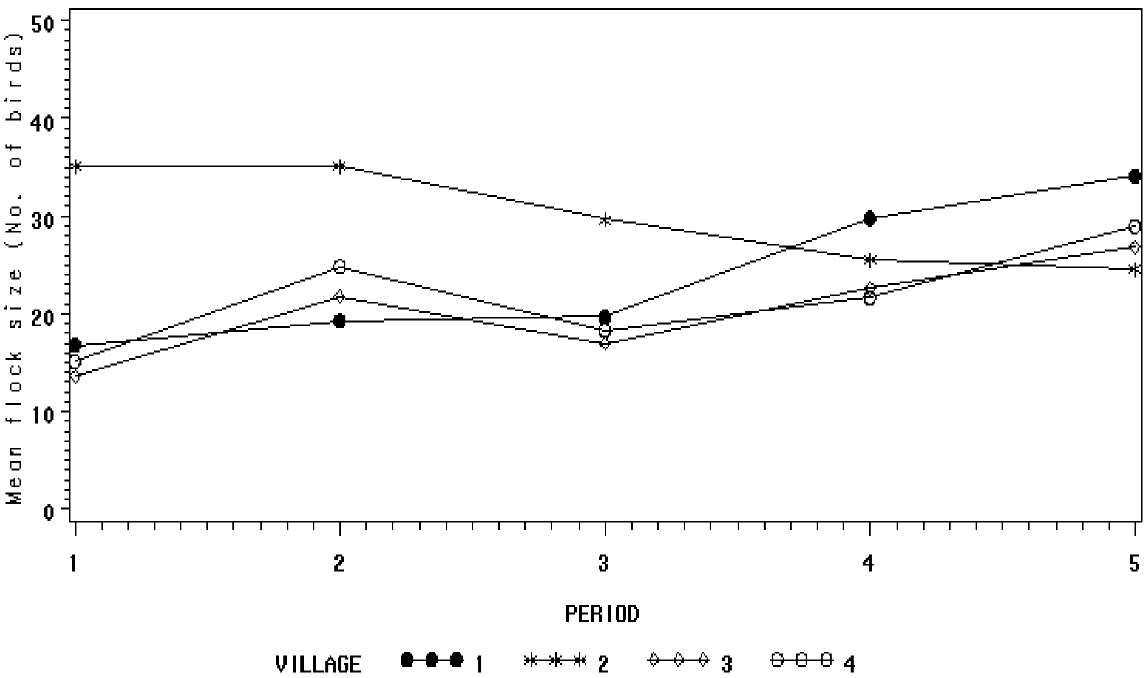
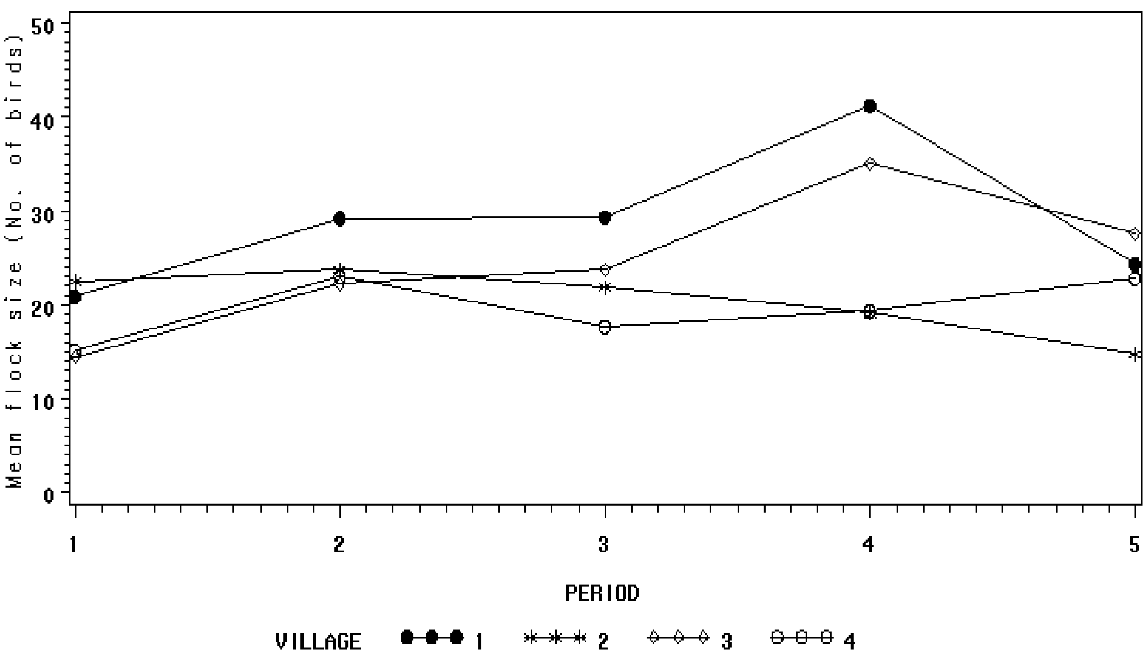


Figure 5.3.1b. Average farm flock size in 4 villages in region 2 (Ol Kalou)



Flock size trends of farms in four villages in region 3 are shown in Figure 5.3.1c. The trends in all the farms generally was an increase from around 20 to medium levels of 25. There was, as elsewhere, a decline between periods 2 and 3 but in this case, only farms in village 4 were affected. The trend for farms in village 4 was lowest and below 20 although it was slightly above farms in village 3 in period 1 and 2. Farms in villages 1 and 2 had higher levels above the medium 25.

Figure 5.3.1d shows the flock size trends for farms in four villages in region 4 which had an upward trend from a low level of below 20 to a medium level of below about 30. There was the characteristic dip of the flock size trend between periods 2 and 3 except in village 3. The dip was more pronounced for farms in villages 2 and 4 (Likia) with both ending up with lower flock size levels (17) than their initial level (24). The trend for farms in the other 2 villages was a rise from 18 to 38. Farms in village 4 bore the brunt of political violence and heightened insecurity problems at that time.

Flock size trends for farms in four villages in region 5 are shown in Figure 5.3.1e with a general rise from about a low level of 17 to about a medium level of 27. The farms in this region seem to have had less variability in flock size trends and levels than in the other four regions. There was also a dip between periods 2 and 3 except for farms in village 1. These, however, were less pronounced than for farms in other regions.

Figure 5.3.1c. Average farm flock size in 4 villages in region 3 (Bahati)

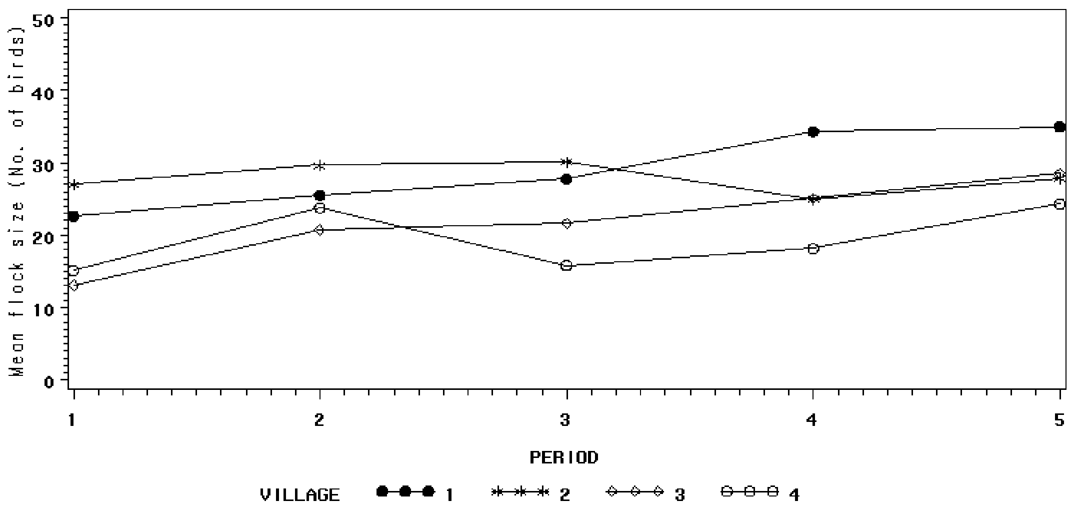


Figure 5.3.1d. Average farm flock size in 4 villages in region 4 (Njoro)

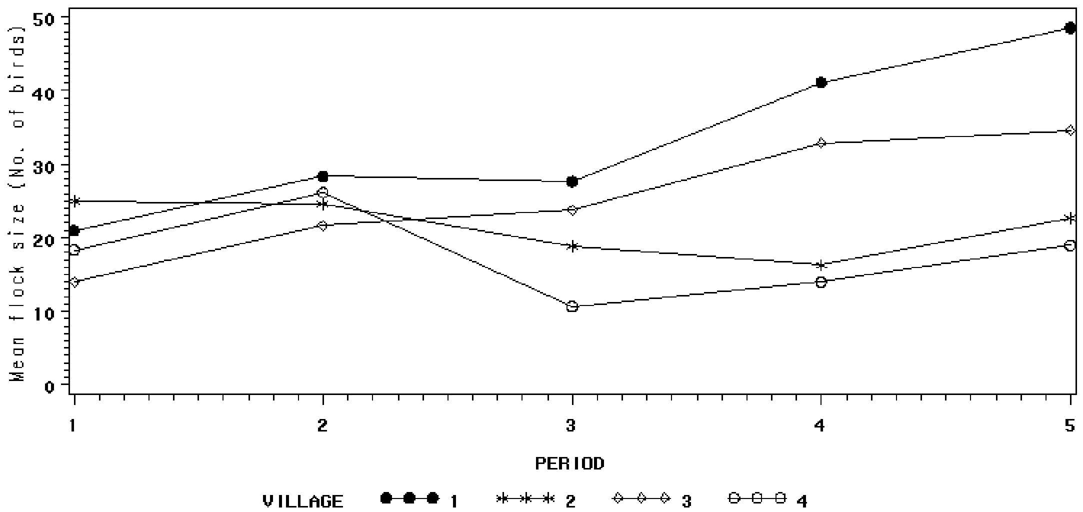
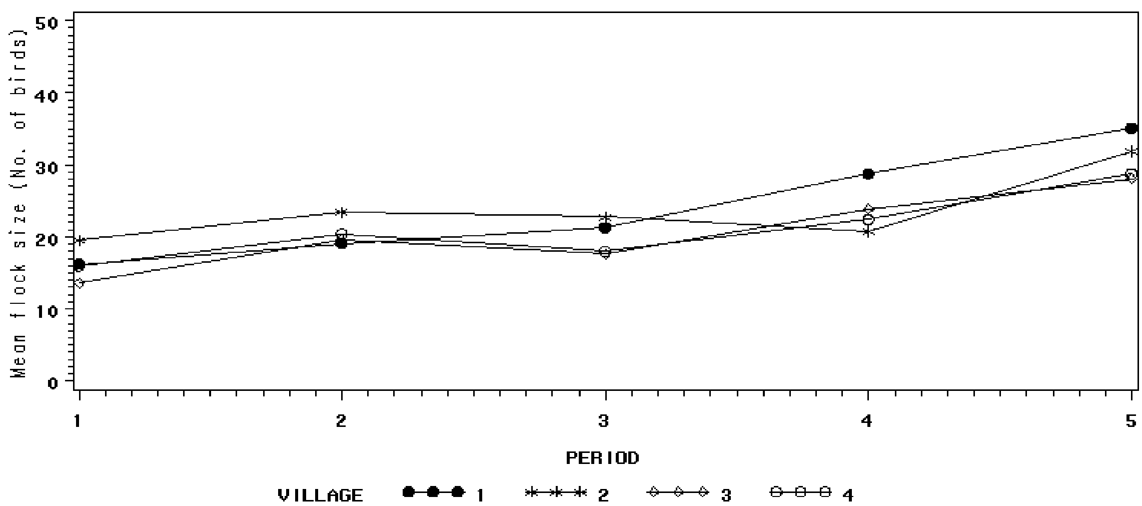
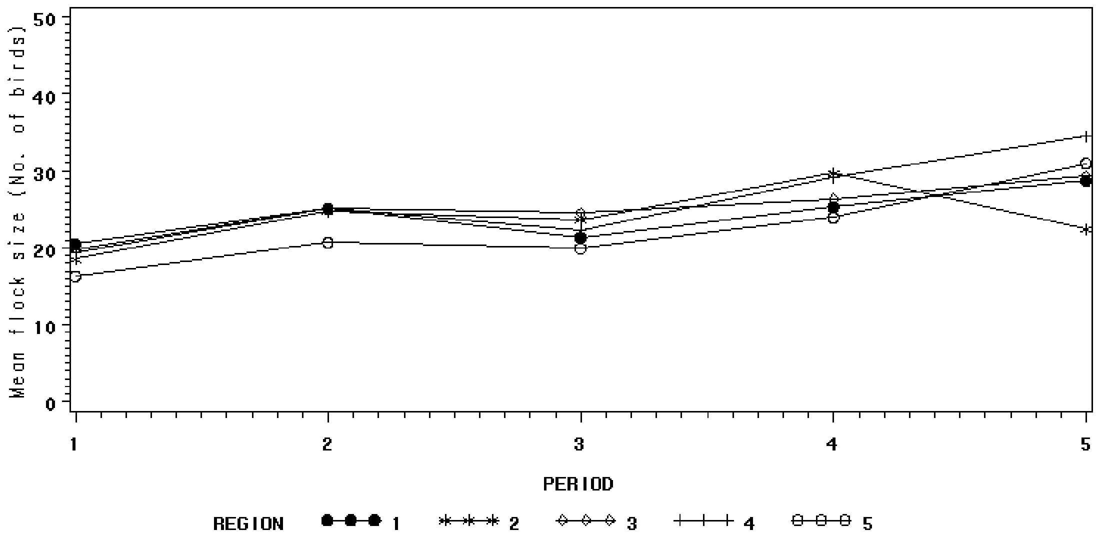


Figure 5.3.1e. Average farm flock size in 4 villages in region 5 (Naivasha)



The farm flock sizes in all the 5 regions had generally an upward trend starting with a low level of just below 20 birds in each farm, steadily rising to a medium level of just below 30 as shown in Figure 5.3.2. An interesting observation from the flock size trends is that, in all the farms, there was a characteristic dip between visits 2 and 3.

Figure 5.3.2. Average farm flock size in 5 regions



The flock demography dynamic factors summaries are provided in Table 5.3.2. This shows the total additions, the total reductions, the controlled (sum of sales, consumption and gifts) and the unplanned reductions (losses from mortality or thefts), all illustrated with a select number of farms, one from each village in every region. Full information for each farm from each village and region will be found in the Appendices 5.9 – 5.13**.** In addition to these summary demography characteristics, other factors such as maximum additions, were calculated and used to investigate their effects on flock-size based farm groups (see chapter 7) as well as on the production characteristics (hatchability and egg production) described in chapter 6, using regression models.

Summary values for the dynamic factors in all the five regions are shown in Table 5.3.3. The total additions in all the five regions ranged from 53 (region 5) to 68 (region 2) birds per farm during the 5 periods. Average total reductions were only slightly less (1-5 birds) than total additions in the five regions. Hence, the average flock size per farm increased marginally from about 20 to 25 birds.

The controlled reductions levels ranged from 30 (region 5) to 46 (region 2). There was only slight regional differences with regard to the unplanned reductions, which had a range of 17 – 19 birds per farm. Generally, there seemed to be regional differences on the levels of these flock demography characteristics with region 2 having greater additions and controlled reductions.

Table 5.3.2: Flock demography dynamic characteristics values as totals for 5 periods for a selected sample of farms in regions 1 – 5.

Region	Village	Farm	Flock demography characteristics[1]			
			TotADD	TotRD	TotURD	TotCRD
1	1	LK1	34	40	18	22
1	2	LS3	51	77	26	51
1	3	LC4	55	31	9	22
1	4	LO9	38	58	22	36
2	1	OS1	63	53	18	35
2	2	OP3	63	75	24	51
2	3	OM4	54	48	8	40
2	4	OK8	79	94	24	70
3	1	BK1	34	41	18	23
3	2	BM1	195	199	26	173
3	3	BS4	46	39	9	30
3	4	BW9	38	58	22	36
4	1	NP1	63	50	18	32
4	2	NG2	52	67	14	53
4	3	NN5	58	51	9	42
4	4	NL6	83	75	30	45
5	1	NSK2	44	32	7	25
5	2	NM1	27	33	18	15
5	3	NKR6	75	55	22	33
5	4	NMR5	63	67	21	46

[1]Flock demography characteristics: TotADD = total addition; TotRD = total Reduction; TotURD = total unplanned reduction; TotCRD = total controlled reduction.

The controlled reductions were real benefits and provide evidence of the resource being made use of as one livelihood strategy. These were within a range of about 60 – 70 percent of the total additions. The controlled reductions consisted of birds that were used as food by the household, sold to generate some income or given out as gifts, a contribution to building up of their livelihood assets of financial and social capital.

Table 5.3.3: Average totals of flock demography dynamic characteristics for 5 periods in regions 1 – 5.

Region	Number of farms	Flock demography characteristics[1] mean total values			
		TotADD	TotRD	**TotURD**	TotCRD/ **(%Totadd)**
1	37	55	52	19	34 (60%)
2	33	68	64	18	46 (67%)
3	33	56	55	19	35 (64%)
4	26	64	60	18	42 (66%)
5	40	53	48	17	30 (58%)
standard deviation range		14.8 – 21.7	13.5 – 21.4	8.3 – 10.3	8.9 – 19.8

[1]Flock demography characteristics totals for 5 periods:TotADD = Total flock addition; TotRD= Total reduction; TotURD = Total unplanned reduction; TotCRD = Total controlled reduction.

The relatively low level of unplanned reductions is a good indicator of a positive effect of the treatments and the research process generally, in the improvement in productivity.

The flock size trends of farms in all villages and regions are related to the levels of various flock demography dynamic characteristics. Hence, flock size levels alone are not indicative of better performance from a particular farm as lower flock size levels could have been due to high controlled reduction levels. However, flock size and other demography characteristics serve as important determinant factors in defining behaviour of the farms.

This section has dwelt broadly and in general on defining the flock demography characteristics but more detailed statistical analysis is given in chapter 7 where farms have been categorised into groups or clusters with distinct flock size trends and levels.

5.4 Production characteristic - Eggs laid, eggs set and hatchability

In addition to monitoring and recording changes in flock demography and treatment uptake, production performance of flocks was also a major component that was also closely monitored and recorded by farmers themselves on a daily basis. The production characteristics for which records are available for our analysis include eggs laid, eggs set, and hatchability per hen-cycle in all the three characteristics.

As already mentioned in section 3.5.8, the criteria for choosing the hens to be observed for egg production were based on easily recognisable characteristics a farmer could use to identify them and selected hens were then named accordingly. The most popular characteristics for identification were mainly:

1. Plumage colour (red - '*ndune*', '*gatune*', white - '*njeru'*, black - '*njiru*', '*muiru*', greyish – '*kibuu*', white and black spots – '*makanga*', '*nganga*', '*gakanga*')
2. Crested head ('*muthuku*', '*gathuku*', '*githuku*')
3. Naked neck ('*muchunu', 'njunu'*)
4. Body size (large – '*mutungu*', small – *'munini'*)
5. Combinations of 1-4.
6. Variety of other less commonly used identifications that were fancied by some farmers such as, 'mono-eyed' - '*chongo'*, 'lucky' –'*munyaka*', and so on.

Selection of the sample hens were done by individual farmers in their respective homesteads and in our presence, by observation of the hens in their flocks and suggesting which ones to be considered as candidates. We would also point out certain hens that we thought had distinctly distinguishable features and if acceptable to the farmer, such hens would also be included among the sample selected for the production monitoring purposes. The assumption is that since these physical features are also assumed random, there will be minimal bias in estimating total egg production.

Table 5.4.1 provides the number of hens from which records on eggs laid, eggs set and percent hatchability were obtained. As would be expected following the shortage of the farm records, the number of hens with records is also less than the number originally selected. The number of hens with records also declined steadily from cycle 1 to cycle 3.

There were only slight differences in the number of farmers with records on the three characteristics in regions 1 – 4. However, region 5 had larger differences between periods for all the three characteristics than the other four regions. This might not necessarily have been due to farmer drop out in region 5 as such. Some of the selected hens may as well have died or stopped laying eggs or ran away from set eggs. Hence, the difference between numbers of farms with set eggs and those with hatchability records. Such a scenario needs to be a consideration in future planning of on-farm, farmer participatory research.

Table 5.4.1: Number of hens in each cycle in regions 1 – 5 for three production characteristics

Production characteristic	Region	Cycle 1	Cycle 2	Cycle 3
1. Eggs laid				
	1	58	51	49
	2	51	51	51
	3	59	55	54
	4	47	33	32
	5	54	45	44
2. Eggs Set				
	1	58	52	49
	2	51	51	51
	3	60	55	54
	4	51	34	33
	5	73	51	44
3. Hatchability				
	1	55	51	48
	2	51	50	47
	3	57	54	52
	4	44	34	31
	5	70	48	41

Away to improve data quality (although likely to be too complicated to implement at farm level) would have been to have the set eggs come from the same batch of eggs laid for a particular hen but in this project, the eggs laid were used for all manner of purposes. The set eggs were therefore from different sources.

A presentation of a sample of the data taken from the farmers' records and the form in which it was analysed is shown in Table 5.4.2**.** These records include, eggs laid per typical hen cycle (derived from daily records of the selected hens), number of eggs set (these are eggs provided to a hen to sit on during brooding) and number of chicks hatched in a particular hen cycle.

Table 5.4.2: Number of eggs laid, eggs set and eggs hatched over 3 hen cycles for a single monitored hen from a sample of 20 farms (for one farm in a village)

				Cycle 1			Cycle 2			Cycle 3		
Region	Village	Farm	Hen	Eggs	Set eggs	Hatch	Eggs	Set eggs	Hatch	Eggs	Set eggs	Hatch
1	1	LK1	1111	15	11	7	20	11	7	25	9	7
1	2	LS2	1222	12	13	6	45	13	6	24	13	9
1	3	LC1	1312	17	9	4	8	10	7	15	7	5
1	4	LO3	1431	24	13	9	12	13	9	42	12	9
2	1	OS1	2111	27	10	7	42	9	7	23	10	7
2	2	OP3	2233	25	10	8	26	10	8	45	11	8
2	3	OM1	2311	12	9	7	26	9	0	24	12	9
2	4	OK3	2432	19	10	10	25	10	10	10	12	9
3	1	BK1	3111	31	12	4	28	12	4	15	12	7
3	2	BM1	3213	24	13	7	2	10	8	20	13	8
3	3	BS3	3332	21	12	6	22	12	8	12	10	8
3	4	BW1	3411	4	11	7	29	12	10	26	11	8
4	1	NP1	4113	16	11	8	12	11	5	16	10	10
4	2	NG2	4222	16	12	8	28	11	8	29	10	8
4	3	NN5	4435	14	12	8	14	10	5	16	9	8
4	4	NL3	4431	14	12	8	13	12	7	23	12	6
5	1	NSK1	5112	24	9	5	13	10	6	23	10	7
5	2	NM2	5224	25	12	9	32	13	9	32	10	9
5	3	NKR1	5311	17	10	9	15	10	3	16	10	3
5	4	NMR7	5472	29	9	0	25	9	9	21	9	6

The records provided are for three typical hen cycles for a single monitored hen illustrated from a selection of farms, one each from the 20 villages involved in the study. Complete records of these factors are included in appendix 5.14. The individual hen records were used either as such or averaged for each farm, and provided basis for data used summary analysis to investigate the variations and effects on production due to a number of causes.

An illustration of these summary data is provided in Table 5.4.3 as hen-average number of eggs laid, eggs set and hatchability in cycle 1, from a selection of farms, one each from the 20 villages. Hatchability was calculated as the ratio of eggs hatched over eggs set, multiplied by 100 to give percent hatchability.

The hen-average values of these three characteristics recorded in three typical hen-cycles are the basis for both descriptive analysis and more complex statistical analysis to investigate variations and effects of factors influencing them.

Table 5.4.3: Hen average number of eggs laid, eggs set and percent hatchability in cycle 1 from a sample of 20 farms from 20 villages in regions 1 - 5

Region	Village	Farm	Eggs laid/hen	Eggs set /hen	Hatchability %
1	1	LK1	16	10	81
1	2	LS1	15	12	58
1	3	LC1	16	10	63
1	4	LO3	18	11	80
2	1	OS1	25	12	67
2	2	OP1	14	13	77
2	3	OM1	11	10	68
2	4	OK3	18	10	100
3	1	BK1	25	12	57
3	2	*BM1*	23	11	67
3	3	BS1	14	9	77
3	4	BW1	9	12	62
4	1	NP1	16	12	55
4	2	NG1	14	10	70
4	3	NN1	16	9	78
4	4	NL3	18	11	55
5	1	NSK1	24	10	72
5	2	NM1	13	13	61
5	3	NKR1	17	10	90
5	4	NMR1	19	9	73

Further statistical analysis with whole data allows for a more complete interpretation in the observation and is provided in detail in chapter 6. The influence from the treatment and flock demography explanatory variables were investigated using methods of regression, analysis of variance and cumulative distribution of the mean squares.

Frequency distributions of the hen-cycle observations with all the three characteristics, eggs laid, eggs set and hatchability were generated to provide a snapshot summary about their patterns and are shown by Figures 5.4.1, 5.4.2, and 5.4.3 respectively. Both the eggs laid and the hatchability values were grouped into 12 and 10 classes respectively to ease the making of the frequency distribution chart and to provide for their proper interpretation. The 12 eggs laid classes had a width of 4 starting from 1 to 48 eggs while the 10 hatchability classes had a width of 10 starting from 1 to 100 percent.

5.4.1 Eggs laid

The distribution of the number of eggs laid in all the three cycles is shown in Figure 5.4.1a and has an interesting bimodal pattern contrary to our expectation for a unimodal ‘normal’ distribution. The first peak is for egg class 4 representing 13 – 16 eggs per hen-cycle. The second one peaks at egg classes 6 and 7 for 21 - 24 and 25 – 29 eggs per hen-cycle respectively. The likely reason for this peculiarity would be due to the fact that, being a biological measurement, the characteristic would be affected by genetic and environmental factors. The two peaks seem to indicate the existence of two different populations among the hens. The hens selected in different farms were not uniform in many ways which depicts the reality of the difficulties and dilemmas one faces conducting a farmer participatory research like this. Age differences among the hens seem to be one of the most likely reasons for the observed bimodal pattern when we consider the individual cycle distributions shown by Figure 5.4.1(b, c and d). The range of the number of eggs laid in each hen –cycle in the combined cycles distribution is 1 - 4 and 45 – 48 egg classes, with 10 and 9 farms respectively.

The distribution of eggs laid in cycle one (Figure 5.4.1b) is nearly the expected ‘normal’ pattern and has a peak at egg class 4 (13 – 16 eggs per hen-cycle). This peak also coincides with first peak in the combined cycles distribution which suggest it is part of the latter. The distribution has 1 egg class (11) less compared with the combined cycles.

The distribution in cycle 2 is shown in Figure 5.4.1c with a bimodal pattern similar to the one of combined cycles. The cycle 3 distribution of the eggs laid in each hen-cycle is shown in Figure 5.4.1d with a bimodal pattern similar to distributions of combined cycles and cycle 2. However, the cycle 3 distribution has 2 egg classes less (1 and 10) and two other classes, 2 and 9, has each only one observation

The eggs laid generally had an upward trend over the periods from a level of about 15 to 30 eggs per hen-cycle from cycle 1 through to 3.

Figure 5.4.1a. Frequency distribution of eggs laid in three cycles

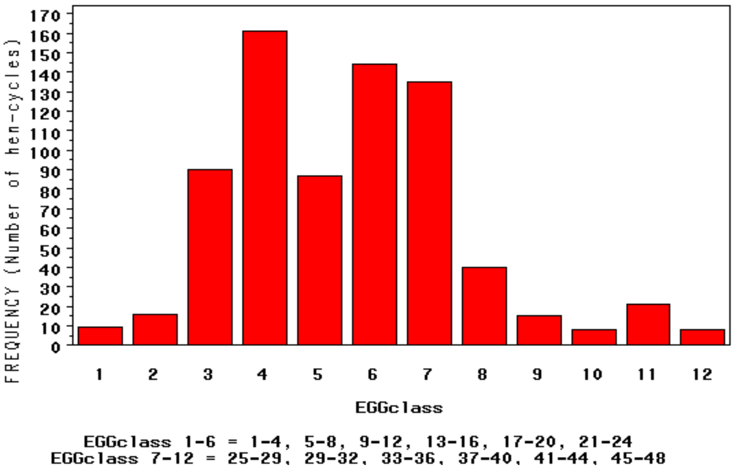


Figure 5.4.1b. Frequency distribution of eggs laid per hen in cycle 1

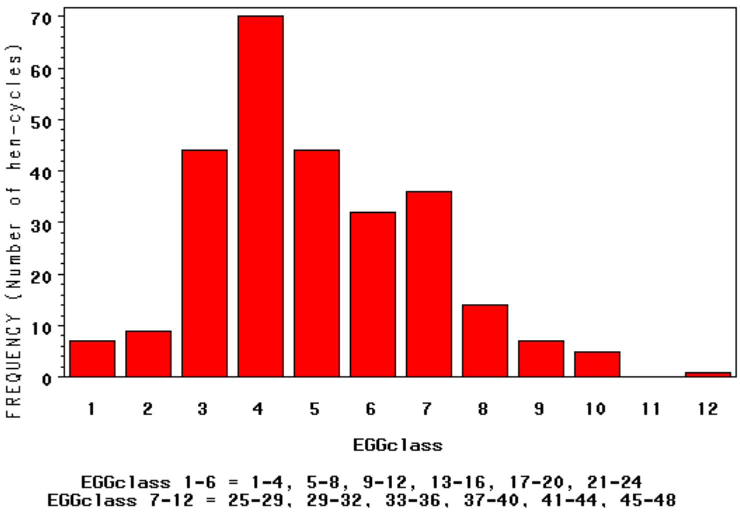


Figure 5.4.1c. Frequency distribution of eggs laid per hen in cycle 2

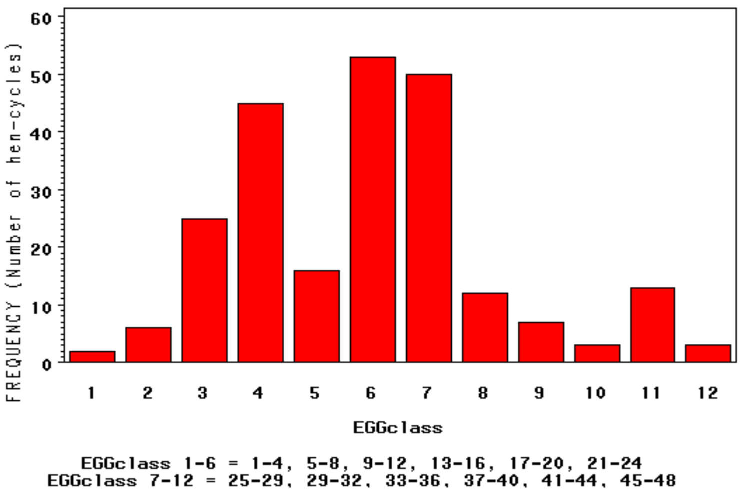


Figure 5.4.1d. Frequency distribution of eggs laid per hen in cycle 3

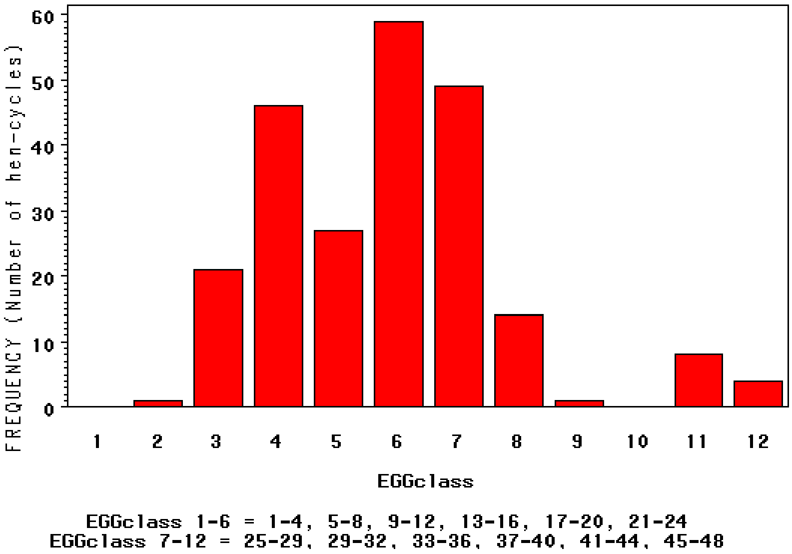
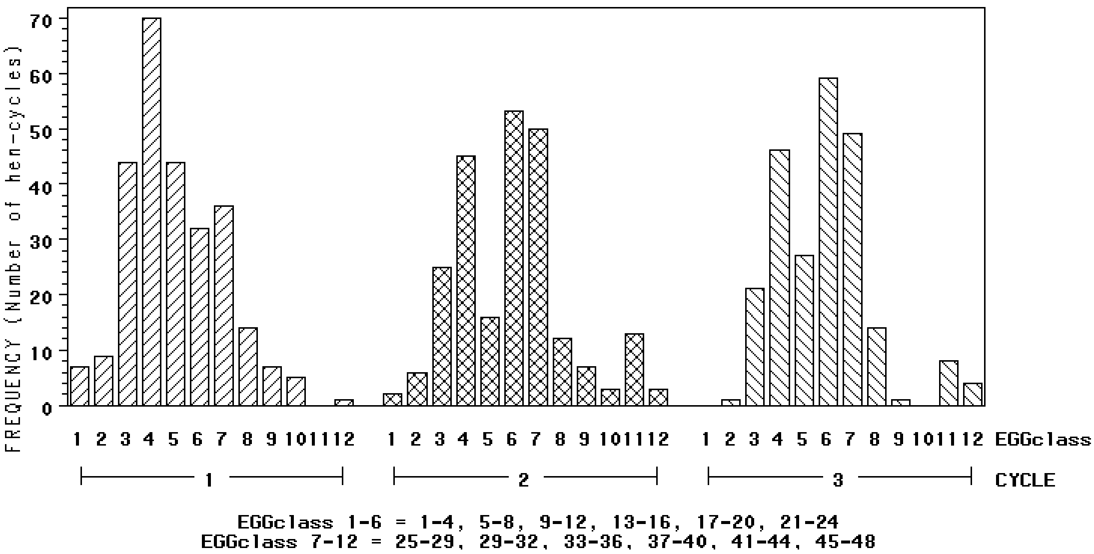


Figure 5.4.1e. Frequency distribution of eggs laid per hen in cycles 1—3



5.4.2 Eggs set

The distributions for both eggs set, and hatched, do not have much variation between cycles as in the eggs laid patterns. This is because they are governed by farmer choice and not natural variation. The eggs set distribution for combined cycles had 11 classes with a range of 5 to 15 eggs set in each hen-cycle as shown in Figure 5.4.2a. The majority of the observed hen-cycles had between 9 and 12 eggs set. The modal number of eggs set was 10.

Looking at the individual cycles distributions shown by Figure 5.4.2(b, c and d) for cycle 1, 2 and 3 respectively, the patterns are similar but have different number of hen-cycles which decreases from cycle 1 – 3. Cycles 1 and 2 had same number of classes as the combined distribution, while cycle 3 had 10. There is a dip at class 11, indicating that many farmers on average do not like setting 11 eggs. Farmers would normally prefer even numbers and hence they solely control the characteristic.

Figure 5.4.2a. Frequency distribution of set eggs in three cycles

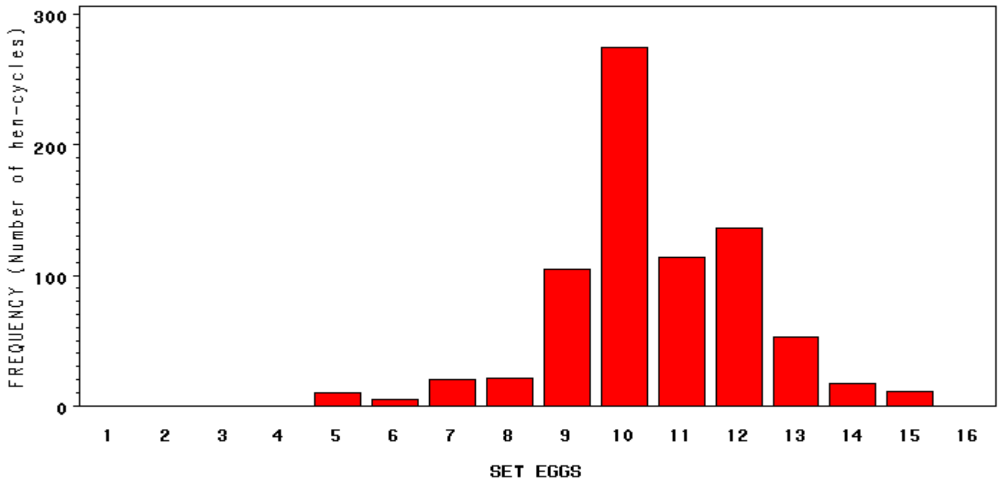


Figure 5.4.2b. Frequency distribution of set eggs per hen in cycle 1

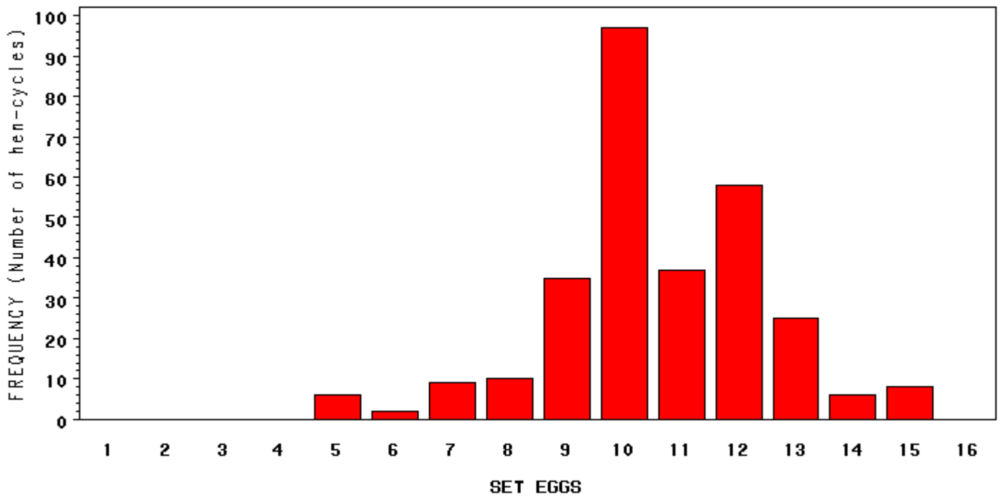


Figure 5.4.2c. Frequency distribution of set eggs per hen in cycle 2

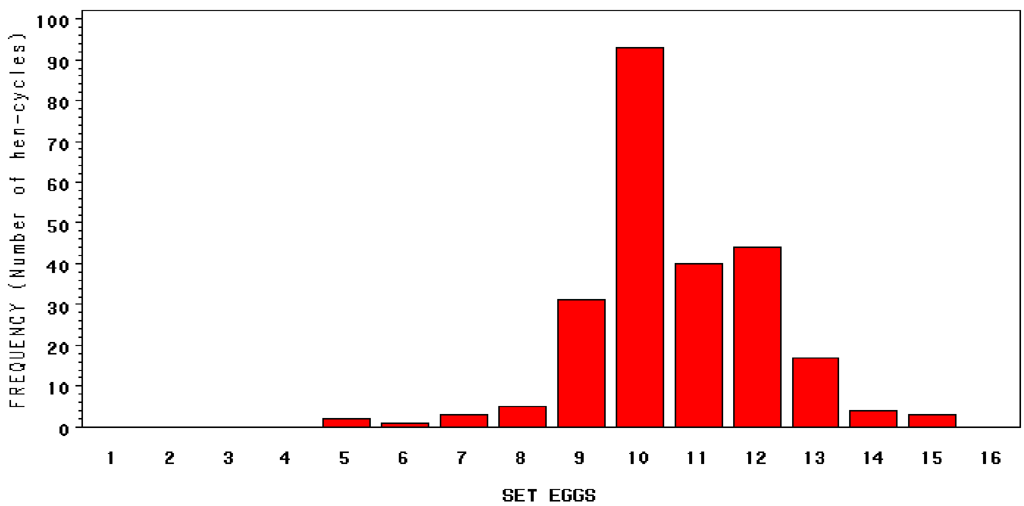


Figure 5.4.2d. Frequency distribution of set eggs per hen in cycle 3

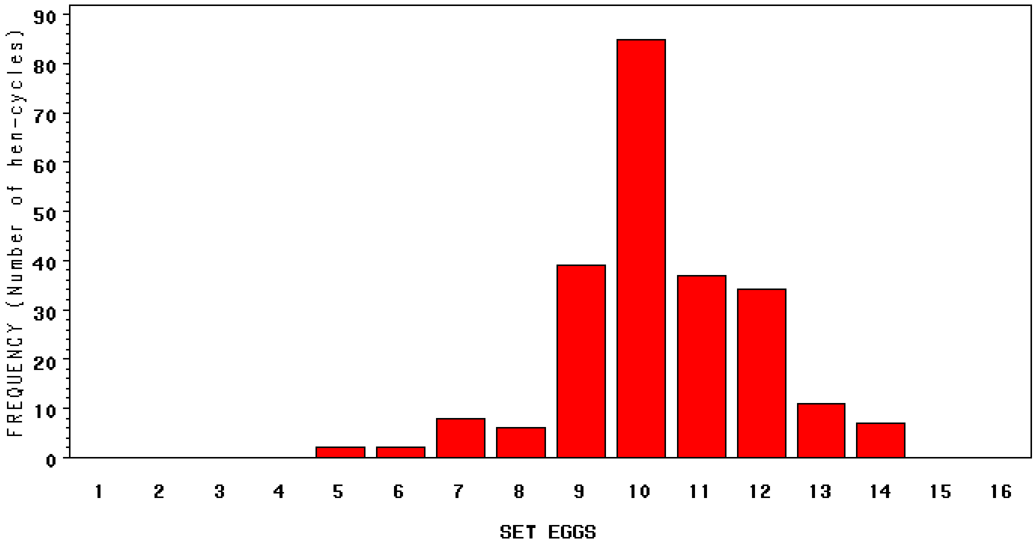


Figure 5.4.2e. Frequency distribution of set eggs per hen in cycles 1–3

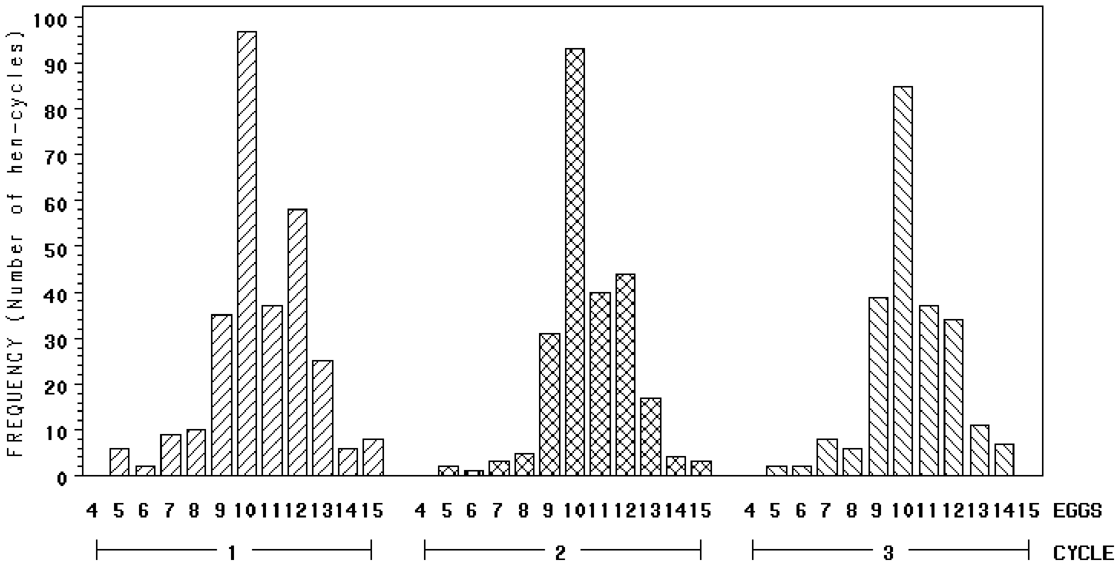


Figure 5.4.2e is a diagrammatic joint presentation of the eggs set patterns in each cycle. There is a noticeable though small decline of frequency from cycle 1 to 3. The three cycles had a similar trend of increasing frequencies and their decline after the peak. There were more settings with small number of eggs (4-8) in cycle 1 than in cycle 2 and 3. The dip at class 11 was only in cycle 1 and 2 probably indicating less preference for number 11.

Generally, number of eggs set is governed by farmer's decision, which might also be based on the number of eggs available, and previous hen performance in the number of chicks hatched**.**

5.4.3 Hatchability

The distributions of hatchability percentages (Figure 5.4.3a, b, c and e) do not also seem to have as much variation between cycles as is the case with the eggs laid patterns. The distributions had nine hatchability classes with a range from 11 – 20 to 91 – 100 percent. The interval was chosen to avoid the situation whereby the eggs set component of hatchability will lead to the production of irregular patterns that suggest something while meaning nothing, which would be the case if the distribution were done without grouping the hatchability values in this way. Otherwise, the distribution produces some classes that do not represent the actual data. Again, if you wanted to find out the frequency of say, 25% hatchability lying between say, a class of 21 and 27, there will be difficulty of assigning the 25 to either of these two classes. But the grouping ensures all values will be placed in their rightful class without any ambiguity. There was, however, a discernable decline in the number of hen-cycles from cycle 1 to 3. This is a natural progression as some hens might have had less than three recordings of hatchability values due to such factors as removal from the system or bird behaviour.

Figure 5.4.3a. Frequency distribution of hatchability in three cycles

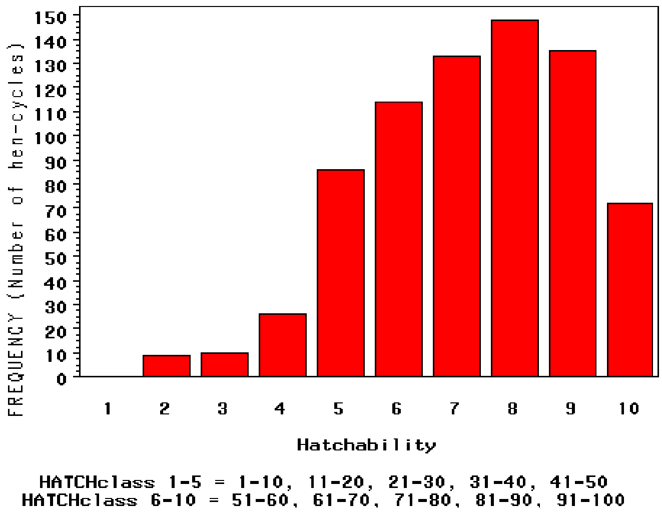


Figure 5.4.3b. Frequency distribution of hatchability per hen in cycle 1

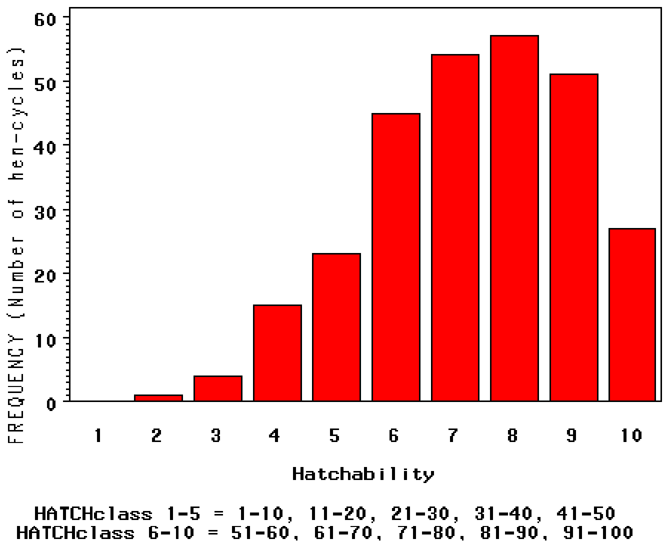
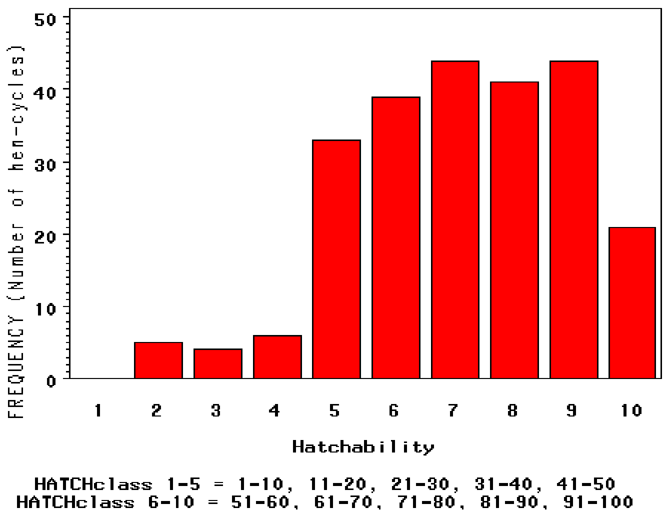


Figure 5.4.3c. Frequency distribution of hatchability per hen in cycle 2



The modal class 8 in the combined cycles was for 71 – 80 percent hatchability and had a frequency of 148 hen-cycles. A frequency of a few hen-cycles (less than 50) was observed in classes 2-4 with less than 41 percent hatchability. Majority of the hen-cycles (520 out of 720) had hatchability percents ranging from 50 to 90.

In cycle 1 (Fig 5.4.3b) the frequency distributions of the classes of hatchability percent had similar patterns as those for combined cycles. The modal class 8 had a frequency of 56 hen-cycles. The majority of the hen-cycles in this class were found in the classes 6 – 9 with percent hatchability range of 51 – 90. Each of these classes had frequencies with hen-cycles of at least 50.

The cycle 2 (Fig 5.4.3c) patterns on the other hand, had two modal classes, 7 and 9 with hatchability percents of 61-70 and 81–90 respectively. Both had same frequency of 43 hen-cycles. Classes 5-9 of this cycle had frequencies of more than 30 hen-cycles each. Otherwise, the distributions were similar to those of combined cycles.

The cycle 3 (Fig 5.4.3e) distributions were however distinct from those of the other two cycles and combined cycles with a modal class 8 having a frequency (49 hen-cycles) much larger than the rest of the classes in the same cycle. The other classes had frequencies of 40 or less. However, majority of hen-cycles were within the classes 5 -10 with percent hatchability range of 41 – 100.

Looking at all the three separate cycles together shows a gradual decline of frequencies from cycles 1 to 3 as expected and as was pointed out before. The frequencies seem normally distributed in all the three cycles and majority of the hen-cycles had hatchability percents of 60 or more.

Figure 5.4.3d. Frequency distribution of hatchability per hen in cycle 3

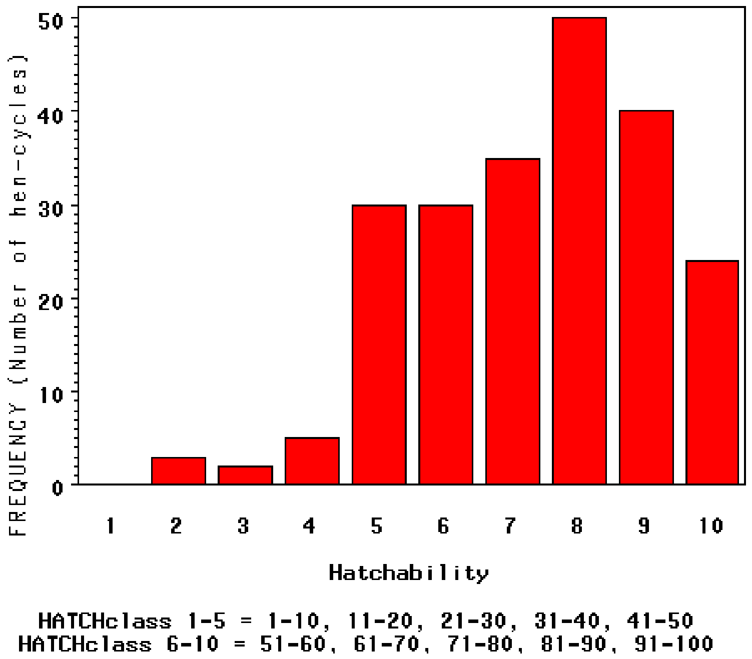
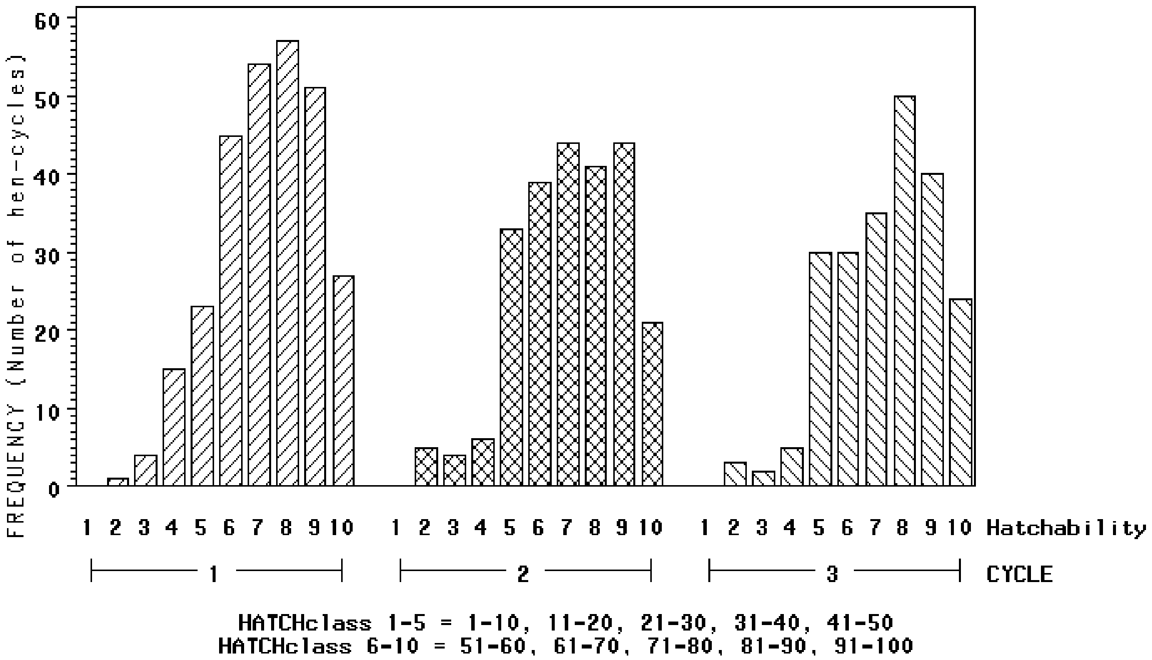


Figure 5.4.3e. Frequency distribution of hatchability per hen in cycles 1–3



5.5 Conclusions

The presentation of FPR data from the farmers' records shows the extent to which this process achieved objectives of participation. This was a result of our consulting, sensitising and training of the farmers and their active involvement in the project activities. The regular visits by the research team and continuous presence of a local extension person in each village were also critical elements for this success. The project therefore forged partnership between the parties involved.

This chapter has so far dwelt on the description of the farmer participatory research data, highlighting its nature and scope, providing summaries of various data in form of patterns in case of treatment characteristics, graphical presentation of trends for flock size, totals of flock demography dynamic factors and average hen values for production characteristic – eggs laid, eggs set and hatchability in a typical hen-cycle. The process of getting all these sets of information from the original farm records was a tedious time consuming and in some ways frustrating experience. Some farms were considered extremes and hence left out in specific analysis, while others would have no entry in some periods. So, the data had to undergo a 'cleaning' process at various stages of the analysis to produce a form that was usable for further more detailed statistical analysis described in the follow-up chapters 6 and 7.

The problems encountered in 'cleaning' the data in order to develop a coherent and precise descriptive analysis, points to the difficulties and dilemmas of undertaking farmer participatory research. We carried out this participatory research with little hindsight from previous experience as the concept was relatively new and the work might well have been among the pioneering initiatives of its kind. In this regard, important lessons have been learnt, especially the importance of continuous regular and frequent monitoring of farmers' actions by the research team, to provide guidance and boost farmers' morale and interest.

Most farmers are very poor and, the majority of them are often women who have to undertake the research process under extreme situations of indigence and being overburdened with all sorts of responsibilities besides domestic chores. A large proportion of farmers did not use housing at all reflecting their poor status. Other treatments were applied varyingly in different periods and in different regions except of course for the feed supplementation, which was applied by majority of the farmers at all the five periods of the study. The majority of the farmers did not have much difficulty sourcing the feed from within their localities. The fact that such poor farmers were able to participate in the research activities and produce the data being analysed here is very encouraging and emphasises the potential opportunities in the farmer participatory research as a concept. Ours was more of a research than a wholly development focused activity where we were very much constrained by abilities of individual farmers to use their own resources to implement the project. The enthusiasm we generated and the capacity we developed among the farmers in this process would have been more meaningful and potentially important as a livelihood and sustainable development undertaking had we also been able to focus on development aspects such as provision of soft loans to facilitate speedy implementation of the activities.

CHAPTER 6

STATISTICAL METHODOLOGY AND ANALYSIS OF PRODUCTION CHARACTERISTICS – EGGS LAID, AND HATCHABILITY

6.1 Introduction

Chapter 5 has dwelt at length on the use of descriptive statistics or qualitative analysis of the farmer participatory research study, focusing on the treatments, flock demography and production characteristics. The current chapter focuses on the use of inferential statistics or quantitative analysis of the production characteristics – eggs laid and hatchability. Chapter 7 will focus on quantitative analysis of the flock demography component. The data used in the analysis in this chapter was from 107 and 121 farms for the eggs laid and hatchability respectively, recorded in three consecutive typical hen-cycles.

The statistical analysis investigates effects of farm, cycle or hen on the production characteristics in all the 20 villages. The basic unit of analysis was either the farm or hen within a farm. The investigation was also done to determine effects of the treatments and the flock demography dynamic characteristics on the production characteristics. The outcome of the analysis provides an understanding of the behaviour of the farms in response to internal and external influences in terms of eggs laid and hatchability. The statistical methodology included the use of general linear model (GLM) procedures of the SAS that fitted farm, hen and cycle combinations to assess and compare levels of variation. The mean squares were ranked in ascending order and plotted against their ranks to produce cumulative distributions whose patterns were investigated for their differences and effects of variations. The mean squares patterns were expected to follow a chi-square distribution with a skew to the left and having a large proportion of mean squares values in the middle. The methodology also involved use of regression analysis to investigate the treatment and flock demography dynamic effects on both the hatchability and egg production characteristics. Regression analysis of the eggs laid was based both on difference between the cycle 1 and cycle 3 eggs laid and on predicted eggs for cycle 2 values calculated from the fitting of analysis of variance models.

6.2 Hatchability

The production characteristic hatchability was obtained as percentage of the eggs hatched over the eggs set for each hen that had records for each cycle as was illustrated in Table 5.4.1 on page 172.

The values for hatchability for each hen in each cycle and the cycle averages were used for statistical analysis. Table 6.2.1 gives mean hatchability and mean number of eggs set per hen in each of the 20 villages averaged over three hen-cycles.

Table 6.2.1: Mean hatchability and mean eggs set averaged over 3 cycles in 20 villages.

Region	Village	Mean Hatchability (%)	Mean eggs set/hen
1	1	76	10.7
1	2	67	10.7
1	3	70	10.8
1	4	74	10.9
2	1	70	10.5
2	2	70	11.1
2	3	64	10.8
2	4	72	9.9
3	1	62	11.3
3	2	74	10.9
3	3	75	10.0
3	4	67	10.4
4	1	66	10.7
4	2	69	9.8
4	3	66	10.2
4	4	62	10.0
5	1	75	10.3
5	2	71	10.3
5	3	65	10.1
5	4	68	10.4

The mean hatchability values in the 20 villages ranged from 62 – 76 percent, which is narrower, compared with the range of about 20 – 100 percent in the hatchability frequency distribution shown in Fig 5.4.3a in chapter 5. This difference is reasonable and expected because a sample of mean values has small variation within it while a sample of individual values would have more variation and hence a larger range as observed with the frequency distribution of the hatchability values.

6.3 Analysis of variation in hatchability

A comparison of mean hatchability between farms was carried out using an analysis of variance (ANOVA) or mean square analysis to determine whether there was any real variation. This was done fitting combinations of the three factors farm, cycle and hen with hen being always nested within farm, to investigate variation between the hen within farm, between farm and between cycles.

The mean squares (MS) values produced for hen, farm, cycle and error were then used to investigate relative sizes of different components of variations. The MS were obtained by fitting three models using a combination of the three entities to hatchability values for each village separately and hence 20 sets of analyses were made in each case for the, (1) within and between farms mean squares and (2) farm, cycle, hen, and error mean squares. Having analyses for the twenty separate villages enables us to examine the consistency of any farm effects and the distribution of mean squares. The farm variations are particularly important for examination as this determines whether regression analysis should be done or not. Regression analysis is not feasible if there is no consistency. The models were:

1) Hatch = farm to get type I between farm MS and between farm MS
2) Hatch = farm + cycle + hen to obtain type I farm and type III hen MS
3) hatch= farm + hen + cycle to obtain type I farm and type III cycle MS

The type III hen and cycle MS were obtained when each of them was fitted as the last term and allows for the variations of the terms before it in the fitting.

The investigation of the mean squares started with comparison of two terms; between farm and within farm. The MS were obtained from the fitting of model 1 and are shown in Tables 6.3.1 for each of the villages in all the five regions.

Table 6.3.1: Between and within farm mean squares, hatchability range and F-ratios among farms

Region	Village	Between farm Mean Squares (df)[1]	Within farm Mean Squares (df)	F – ratio[2]	Hatchability range
1	1	460 (7)	155 (49)	2.97*	57 – 87
1	2	225 (6)	352 (33)	0.64	57 – 79
1	3	214 (4)	175 (22)	1.22	67 – 90
1	4	542 (4)	140 (25)	3.88*	50 – 80
2	1	1153 (5)	232 (21)	4.97**	47 – 89
2	2	1074 (5)	341 (47)	3.15*	54 – 84
2	3	1245 (5)	420 (29)	2.96*	36 – 93
2	4	592 (4)	328 (28)	1.80	64 – 87
3	1	508 (4)	384 (28)	1.32	37 – 69
3	2	247 (5)	225 (38)	1.10	69 – 83
3	3	347 (7)	233 (36)	1.49	64 – 89
3	4	634 (7)	204 (34)	3.11*	47 – 82
4	1	196 (5)	239 (23)	0.82	57 – 80
4	2	1020 (5)	288 (15)	3.45*	43 – 93
4	3	276 (5)	459 (20)	0.6	51 – 78
4	4	14 (2)	210 (30)	0.06	61 – 63
5	1	304 (8)	341 (31)	0.89	66 – 92
5	2	544 (7)	209 (44)	2.60*	59 – 90
5	3	321 (5)	339 (26)	0.95	50 – 73
5	4	401 (4)	366 (30)	1.10	61 – 79

NB: Fitting model 1, hatch=farm for between and within farm MS
[1](df): degrees of freedom; [2]F-ratio: values with asterisk are significant

A village-by-village examination of the mean squares and their significance levels shows that there were only six out of twenty villages with an F-ratio of less than one, while eight villages out of the fourteen with an F–ratio of more than one had significant F values. There is therefore, enough evidence provided by these between and within farm MS, to suggest that there is more variation between the farms than there is within the farms. This could be associated with different management practices and genetic differences of hens in different farms. Hens within same farms were under similar management practices and probably with small genetic differences due to a high inbreeding likelihood, which might have reduced variations associated with the hens' genetic makeup.

The above village-by-village comparison of the MS is followed by development of cumulative frequency distributions. This is done by first ranking the MS in an ascending order as provided in Table 6.3.2.

Normally, if both the between and the within sets of MS had the same number of degrees of freedom in every village, then the ordered MS would be expected to conform to a chi-square (X^2) distribution.

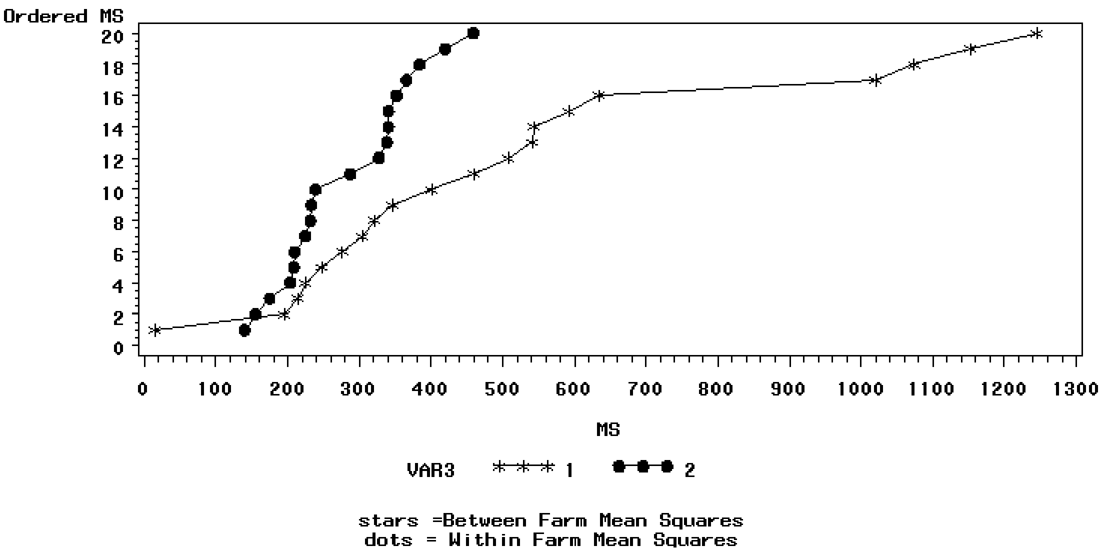
If the degrees of freedom were large, the distribution would be tailed to the right with a small number of large MS values at the end. However, if the degrees of freedom were small, the distribution would be tailed to the left with a small number of small MS values at the beginning. In our case, there would be several chi-square distributions as the degrees of freedom are different for each village. Again, with large degrees of freedom, the distribution is more symmetrical and close to a straight line.

Another way of comparing the variations is by using the method of cumulative frequency distributions of the two sets of MS (between and within farms). This is done by plotting the ranked order of the MS of all the 20 villages with their respective MS values as shown in Figure 6.3.1.

Table 6.3.2: Ranking of between and within farm mean squares of the 20 villages in an ascending order

RANKING	BETWEEN FARM MEAN SQUARES	WITHIN FARM MEAN SQUARES
1	14	140
2	196	155
3	214	175
4	225	204
5	247	209
6	276	210
7	304	225
8	321	232
9	347	233
10	401	239
11	460	288
12	508	328
13	542	339
14	544	341
15	592	341
16	634	352
17	1020	366
18	1074	384
19	1153	420
20	1245	459

Figure 6.3.1. Cumulative distribution of Between and Within Farm Mean Squares



From this diagram, one can see a clearer picture of the differences of the MS values of the two sets. The within farm distribution is more symmetrical because it has a large number of the degrees of freedom while the between-farm MS distribution is less so due to the small number of degrees of freedom. Hence, between farm MS distribution has two tails, the left one for extreme large values and the right one is for extreme small values.

Comparing these two cumulative distributions, the between farm MS are clearly larger than the within farm MS which indicates that there is less variation among hens in a farm and more variation from farm to farm in the hatchability values. The differences were not as apparent looking at the MS values in each village alone, which shows the importance of using the cumulative distribution method.

The within farm variation has several components – error, hen and cycle. The analysis of variation then proceeded by comparing the farm, hen, cycle and error MS in the 20 villages.

The farm, cycle, hen and error mean squares investigation was done by fitting models 2 and 3 respectively to obtain type I farm MS, type III hen MS and type III cycle MS. The error term MS was obtained from each of the three models. The four types of MS in 20 villages are shown in Table 6.3.3. The investigation of these mean squares was the same as the one used in the 'between and within' mean squares to compare variations among the villages on the effect of farm, cycle and hen on hatchability. Looking at the F-ratios for the farm term, 14 villages had F-ratios with a value greater than one, eight of which were significant. With the hen MS, twelve villages had an F-ratio of more than one and four of these are significant. In the case of the cycle MS, half of the villages had an F-ratio of more than one but only one of them is significant.

Table 6.3.3: Hatchability mean square values for farm, cycle, hen and error with respective F- ratios

Region	Village	Farm[1]			Cycle			Hen			Residual	
		MS	Df	F-ratio	MS	df	F-ratio	MS	df	F-ratio	MS	df
1	1	460	7	2.95*	230	2	1.47	143	13	0.91	156	34
1	2	225	6	0.82	292	2	1.07	522	8	1.91	273	23
1	3	214	5	1.11	41	2	0.21	156	6	0.81	193	14
1	4	542	4	4.93*	14	2	0.13	242	7	2.2	110	16
2	1	1153	5	4.43**	355	2	1.36	114	4	0.44	260	15
2	2	1074	5	4.69**	557	2	2.41	616	12	2.67*	231	33
2	3	1245	5	2.6*	313	2	0.65	302	7	0.63	478	20
2	4	600	4	1.83	409	2	1.25	308	6	0.94	327	20
3	1	508	4	2.63*	963	2	4.99*	716	8	3.71*	193	18
3	2	247	5	1.57	220	2	1.40	430	9	2.74*	157	27
3	3	347	7	1.64	39	2	0.18	376	7	1.78	211	27
3	4	634	7	3.66*	264	2	1.53	321	7	1.85	173	25
4	1	196	5	1.01	316	2	1.64	372	5	1.93	193	16
4	3	276	5	0.66	258	2	0.62	556	9	1.33	418	9
4	4	13	2	0.08	134	2	0.79	332	8	1.95	170	20
5	1	304	8	1.28	274	2	1.16	508	13	2.14*	237	16
5	2	544	7	3.09*	13	2	0.07	282	17	0.10	176	25
5	3	321	5	0.72	59	2	0.13	37	5	0.08	448	19
5	4	401	4	1.10	163	2	0.45	444	7	1.22	364	21

[1]Farm: Rg= region; Vg=village MS= mean square error; df=degrees of freedom; F-ratio= values with a * are significant

A summary of the MS characteristics given in Table 6.3.4 shows the range and the median of each of the mean squares. Evidence provided by the MS range and median values shows that the variation between cycles is not consistently larger than the error.

The cumulative distribution of the four mean squares given by Fig 6.3.2 shows the closeness between the cycle and the error MS as the two MS distributions are intertwined, confirming that the cycle variations are not larger than the error. There are only 2 degrees of freedom for the cycle and therefore more variability.

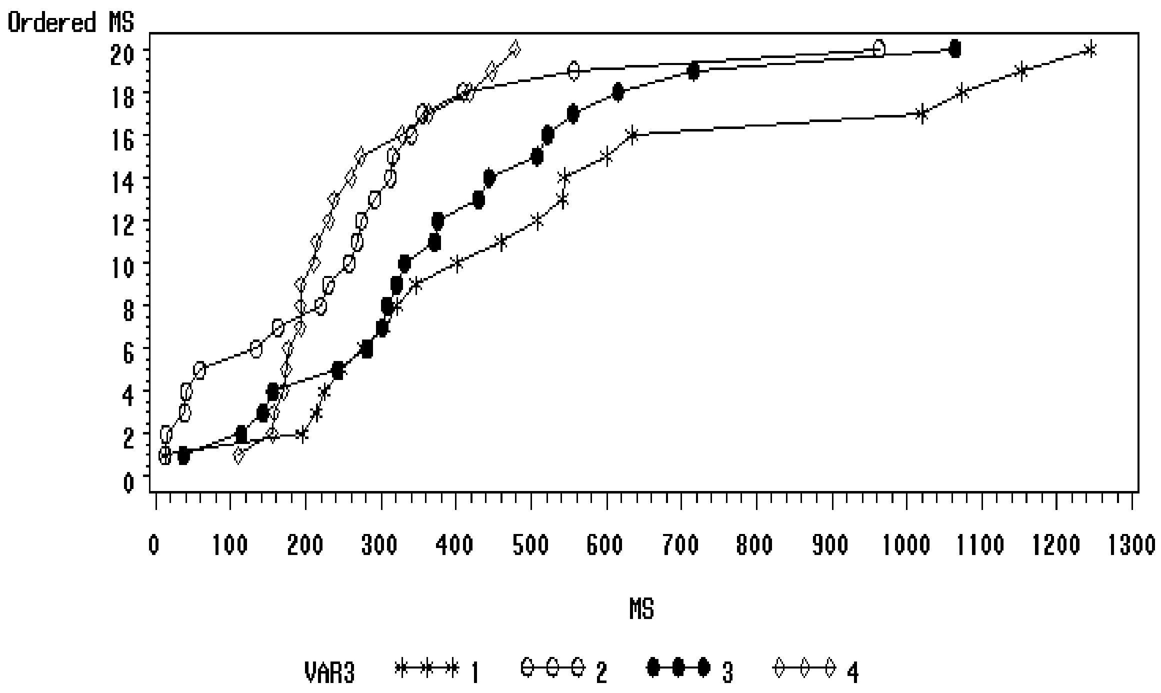
The observation for the closeness between the cycle variations, error and within farm variations, inevitably led to a decision to exclude the cycles factor from further investigation of effects on hatchability. Another set of MS for the farm, hen and error was obtained by fitting model hatch = farm + hen, excluding the cycles. Table 6.3.5 gives a summary of these MS in terms of their ranges and medians. The range values remain as before but the medians have changed slightly, with error and hen MS decreasing and farm MS increasing.

The farm and hen medians are larger than the error median while the median of the farm is larger than that of the hen MS. The hen variation is larger than random and therefore shows a consistent variation due to management.

Table 6.3.4: Range and medians of error, hen, cycle and farm mean squares.

Source of variation	MS range	Median of MS range
Error	110 – 478	234
Hen	37 – 1065	352
Cycle	13 – 963	266
Between Farm	13 – 1245	374
Within Farm	140 – 459	264

Figure 6.3.2. Cumulative distribution for MS of Farm, Cycle, Hen and Error



stars =farmMS
circles =cycleMS
dots =henMS
diamonds =errorMS

Figure 6.3.3 provides a cumulative distribution of these MS. There are distinct differences in the level and pattern of the three types of mean squares suggesting differences in hatchability between the farms and among the hens within farms

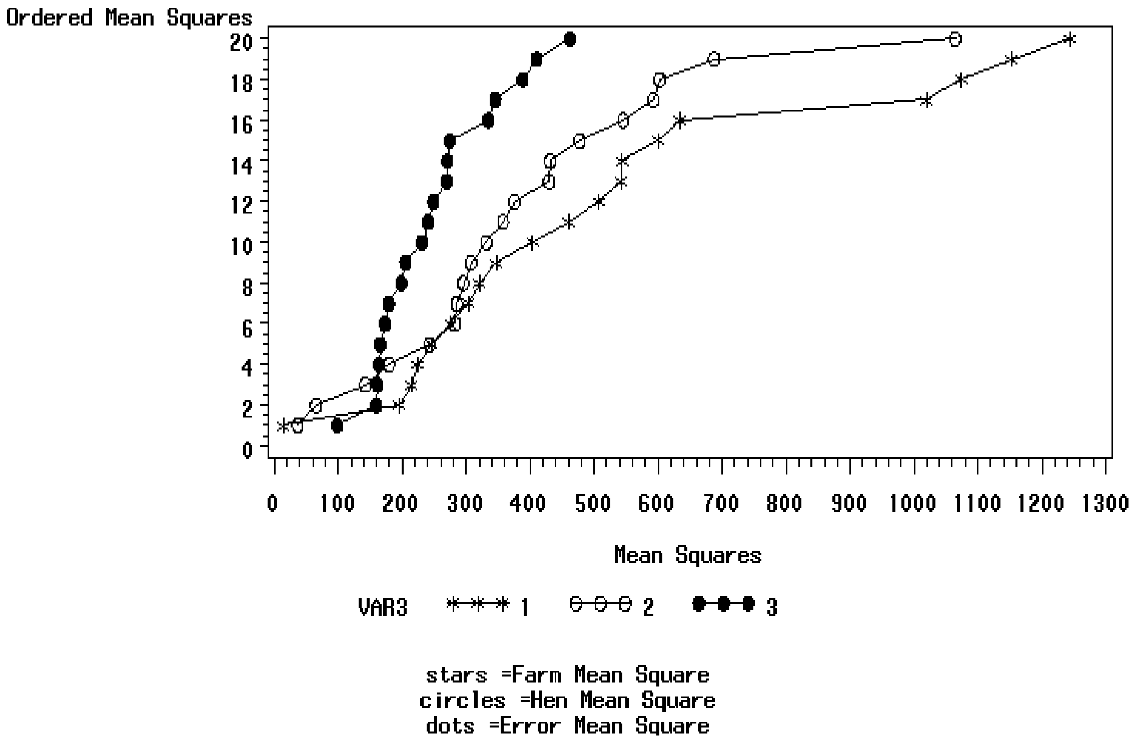
There was more variation between the farms than there were between the hens indicating farm effects on hatchability were more important than the effects of hen differences. The difference between farm and hen though, is smaller than between hens and error. Management had an influence on the hatchability outcome as was the genetic differences between hens.

A summary of the Overall hatchability MS in each region was also determined for village, farm and hen differences and effects, excluding the cycles. These are shown together with mean hatchability in Table 6.3.6. The three variations of village, farm and hen were all larger than the error. The summary provides a further evidence for existence of a farm and hen effect on hatchability.

Table 6.3.5: Range and medians of error, hen, and farm mean squares.

Source of variation	MS range	Median of MS range
Error	99 – 463	237
Hen	37 – 1065	345
Between Farm	14 – 1245	432

Figure 6.3.3. Cumulative distribution of Farm, Hen and Error Mean Squares in 20 Villages



The mean squares in the five regions for farm, hen and error excluding the MS of village and cycle are also shown in Table 6.3.7. The hen and error MS remain unchanged as in the previous table but the farm MS have gone up except in region 2 and 4.

Table 6.3.6: Mean squares and mean hatchability for Village, Farm, Hen and Error in five regions.

Region	Mean Hatchability	Village (df[1])	Farm	Hen	Error
1	72	730 (3)	362 (21)	276 (34)	181 (95)
2	69	378 (3)	1040 (19)	392 (29)	322 (96)
3	70	1387 (3)	441 (23)	454 (31)	197 (105)
4	65	239 (30)	441 (17)	453 (23)	229 (65)
5	70	671 (3)	394 (24)	339 (42)	285 (89)

Table 6.3.7: Farm, Hen and Error Mean squares and mean hatchability in 5 regions.

Region	Mean Hatchability	Farm	Hen	Error
1	72	408 (24)	276 (34)	181 (95)
2	69	950 (22)	392 (29)	322 (96)
3	70	550 (26)	454 (31)	197 (105)
4	65	410 (20)	453 (23)	229 (65)
5	70	440 (27)	339 (42)	285 (89)

There were regional differences in the variations affecting hatchability resulting in different mean hatchability.

In conclusion, the mean hatchability values in twenty villages ranged from 62 – 76 percent while the individual hatch values in each farm had a wider range of

36 – 96 percent in all the 20 villages. The analysis of variation has shown there is an effect of both farm and hen on hatchability. Different farms had different periods and frequency of application of the four treatments interventions as well as different flock demography dynamic characteristics, which might all have had some influence on the observed hatchability levels. Mean hatchability values of all farms in each of the five regions are therefore used in regression analysis to investigate which of these factors had what kind of influence on the hatchability.

6.4 Regression analysis for hatchability

A multiple regression analysis of the effect on hatchability of treatments and of flock demography and dynamic factors was carried out to investigate their effects on hatchability. A multiple regression analysis used the hen-cycle mean hatchability of each farm in a region for combined cycles. The analysis of variation described in the previous section 6.3, had indicated lack of cycle effect on mean hatchability. The regression analysis used all the farm values of mean hatchability in each region. Table 6.4.1 shows a sample of the mean hatchability and values of flock demography and dynamic variables used in the regression illustrated with the data from region 1. A complete recording of the values for all the five regions is provided in appendix 6.1. The regression terms shown in the table include:

- MeanH = mean hatchability in a farm for three cycles and hens with records.
- Tothse (1) = total housing value as sum of periods with housing in each farm
- Totvac (2) = total vaccination value as sum of periods with vaccination in each farm
- Totdwm (3) = total deworming value as sum of periods with deworming in each farm
- TotSPL (4) = total supplementation value as sum of periods with supplementation in each farm
- TotADD (5) = total addition to flock size as sum of additions for five periods
- MaxADD (6) = maximum addition to flock size out of five additions, one at each period in each farm.
- TotRD (7) = total reduction to flock size summed for five periods

- TotURD (8) = total unplanned reduction to flock size summed for five periods

- TotCRD (9) = total controlled reduction to flock size summed for five periods

- FS1totADD (10) = sum of initial flocksize and total addition

- AvgFS (11) = Average flock size for five periods

- BalADD (12) = Balance of addition as difference of total addition and total unplanned reduction (for example in farm LK1 this will be 34 minus 18 = 16)

- Avgfsadd (13) = sum of average flock size and average total addition (in case of farm LK1, 13.2 plus 34/5 = 20)

Table 6.4.1: Mean hatchability and 13 values of treatment and flock demography dynamic characteristics used in regression analysis

Region	Farm	Farmcode	MeanHB	TotHSE (1)	TotVAC (2)	TotDWM (3)	TotSPL (4)	TotADD (5)	MaxADD (6)	TotRD (7)	TotURD (8)	TotCRD (9)	FS1totADD (10)	AvgFS (11)	BalADD (12)	Avgfsadd (13)
1	111	LK1	69	5	0	1	4	34	15	41	18	22	43	13.2	16	20
1	113	LK3	80.1	5	1	1	5	44	20	44	21	24	64	18.4	23	27.2
1	114	LK4	86.4	0	0	1	3	47	14	31	9	23	58	17.8	38	27.2
1	115	LK5	73.6	5	1	2	3	58	19	44	9	33	78	31.2	49	42.8
1	116	LK6	56.7	5	1	2	2	56	15	36	11	27	77	31	45	42.2
1	118	LK8	79.7	0	1	1	2	45	20	47	21	30	55	12	24	21
1	119	LK9	69.2	5	0	2	4	54	20	34	17	20	72	22.2	37	33
1	1110	L10	80	0	1	1	5	79	34	40	16	28	95	31	63	46.8
1	121	LS1	62.5	2	0	2	4	44	15	74	21	53	96	39	23	47.8
1	122	LS2	55	0	0	1	5	44	12	55	14	41	89	43.2	30	52
1	123	LS3	57.5	5	0	1	5	51	23	77	26	51	79	37.2	25	47.4
1	124	LS4	66.5	5	1	1	4	44	16	48	1	47	60	18.8	43	27.6
1	125	LS5	68.1	5	0	2	3	86	30	107	24	83	121	40.4	62	57.6
1	126	LS6	78.8	0	1	3	3	71	25	97	57	40	99	21.2	14	35.4
1	128	LS8	68.2	5	0	2	2	61	18	71	19	52	88	19.8	42	32
1	131	LC1	70.9	5	0	1	5	65	20	66	28	38	77	23.8	37	36.8
1	132	LC2	70.3	0	0	1	5	52	21	51	14	37	61	9.6	38	20
1	135	LC5	68.5	1	2	0	3	48	14	34	3	31	58	16.8	45	26.4
1	136	LC6	80.6	5	2	2	2	41	15	45	22	23	53	15	19	23.2
1	138	LC8	90	0	3	1	4	62	21	59	13	46	78	25.8	49	38.2
1	143	LO3	77	5	1	1	5	45	23	48	21	27	58	17	24	26
1	144	LO4	81.4	5	0	1	5	45	16	44	19	25	70	25.4	26	34.4
1	145	LO5	70.5	5	0	0	5	69	15	49	13	36	81	15	56	28.8
1	147	LO7	76.9	5	0	0	4	100	25	70	25	45	110	27.2	75	47.2
1	148	LO8	50.3	0	1	1	4	60	19	54	20	34	80	24.8	40	36.8

The mean hatchability was first regressed on the four treatments characteristics, total housing, total vaccination, total deworming and total feed supplementation as the independent variables, because the treatment variables are the most interesting. The initial regression results (as provided in Table 6.4.2) were not conclusive and the treatments effect may have been masked by other factors. Therefore, to unmask the treatment effect, nine flock demography and dynamic variables were varyingly added in the regression to check for the most promising to define hatchability regression model generally and specifically for each region.

The 13 independent variables were therefore used in these hatchability multiple regressions in an attempt to determine the ones with potential to form most generally useful models for interpreting the observed hatchability. The variables as shown in the Table 6.4.1, are numbered from 1 (total housing - tothse) to 13 (sum of average flock size and average addition - AvgfsAdd) for ease of describing the models.

The fitted hatchability values are calculated from the general fitted equation of the line

$Yij = \alpha + \beta 1X1 + \ldots \beta nXn$,

where Yij is fitted hatchability values of region j for model i, α is the intercept (mean hatchability), β is slope or the parameter estimate and X is the regressor variable.

The regression on the mean hatchability of all farms in each of the 5 regions was first done with the 4 treatment variables – total housing, total vaccination, total deworming and total feed supplementation. The results for this regression are given in Table 6.4.2 and it is only in region 2 that F ratio was nearly two. All the F-ratios in the other four regions were less than one. The housing treatment had small parameter estimate, including two negative values.

Table 6.4.2: Regression of four treatment variables on mean hatchability in five regions

Region	Intercept	Parameter estimate				F ratio
		Tothse	Totvac	Totdwm	Totspl	(Pr > F)
1	69	0.03	4.34	-0.60	0.18	0.70 (0.60)
2	59	1.54	3.56	2.86	-1.82	1.91 (0.15)
3	70	0.88	-0.85	1.51	-1.21	0.25 (0.91)
4	71	-0.52	-3.93	3.65	-0.98	0.42 (0.79)
5	79	-0.27	-1.54	-1.75	-0.86	0.49 (0.74)

Vaccination had the largest values of parameter estimate but positive only in regions 1 and 2. The deworming treatment on the other hand had relatively large and positive parameter estimates for regions 2, 3 and 4. The feed supplementation was the worst in terms of parameter estimate values, which were mainly small and negative.

Hence, other additional factors were included in models to improve on the regressions results. From among several possible regressions, 10 models were found to be more promising after non-useful variables were dropped. These are listed below with their respective variables:

1) 1, 2 3 4
2) 1 - 12
3) 1, 2,3,4,11
4) 1,2,3,4,5,7,12
5) 1,2,3,4,5,7,10,11
6) 1,2,3,5,7,11
7) 1,2,5,7,11
8) 1,2
9) 2,6,13
10) 2,3,4,6,13

The 10 models were compared with each other and four of them selected for being the most suitable regressions to explain hatchability. The four models in order of the overall best fit as indicated by F-ratio values are:

1) 1,2,3,4,11 – tothse (total housing), totvac (total vaccination), totdwm (total deworming), totspl (total feed supplementation), avgfs(average flock size))
2) 2,3,4,6,13 – totvac, totdwm,totspl,maxadd (maximum addition), avgfsadd(sum of average flock size and average total addition)
3) 1,2,5,6,13 – tothse, totvac, totadd, maxadd, avgfsadd
4) 2,6,13 – totvac, maxadd, avgfsadd

Table 6.4.3 shows the regression details of the four chosen models for each of the five regions including intercept values, parameter estimate of the model variables and the F-ratio. The selected model 1 (1, 2, 3, 4, 11) contrasts quite clearly with the initial regression with only the four treatment factors involved. The addition of the flock demography variable, average flock size, contributed in the unmasking of the treatment effect with regions 1, 2 and 4 having an F-ration greater than 1.

Region 2 had the best fit of the 4 regression models with high F-ratios and more positive parameter estimates on treatment characteristics housing, vaccination and deworming and demography dynamic variables average flock size (avgfs) and sum of average flock size and average addition. Regions 1 and 4 with equally high F-ratios had a mix of positive and negative parameter estimates of the same variables in different models. Region 4 had high vaccination parameter estimates values but they were all negative, hence contradicting the general observation. Region 5 had generally small and negative parameter estimate values for all the four treatments, though the vaccination estimate value in model 3 was large but again, negative. The demography variables, average flock size (avgfs), maximum addition (maxadd) and the sum of avgfs and average addition (avgfsadd) had small but positive estimates in region 5.

Table 6.4.3: Best 4 most useful hatchability regression models with parameter values defining mean hatchability levels in regions 1 – 5 (R1 – R5)[1].

Regression model	Intercept					Parameter estimate						[2]F-ratio				
	R1	R2	R3	R4	R5	Variables	R1	R2	R3	R4	R5	R1	R2	R3	R4	R5
1.	73	51	67	65	77							1.36	1.97	0.27	1.80	0.41
(1,2,3,4,11)						Tothse	-0.04	1.57	1.15	-0.38	-0.29					
						Totvac	3.68	5.23	-0.64	-5.60	-1.53					
						Totdwm	1.48	1.51	1.84	3.15	-1.63					
						Totspl	1.18	-2.23	-0.33	-1.49	-0.90					
						Avgfs	-0.44	0.36	-0.09	0.40	0.12					
2.	70	56	62	52	76							1.94	2.02	0.76	2.33*	0.46
(2,3,4,6,13)						Totvac	2.97	5.35	0.81	-2.63	-1.84					
						Totdwm	-0.38	2.78	0.04	0.61	-1.32					
						Totspl	-0.2	-0.78	0.08	1.78	-0.79					
						Maxadd	0.78	-0.63	0.85	-0.51	0.21					
						Avgfsadd	-0.41	0.36	-0.28	0.50	-0.06					
3.	68	52	62	59	88							2.09	2.30*	0.93	2.02	1.66
(1,2,5,6,13)						Tothse	0.02	1.33	-0.10	0.22	-1.46					
						Totvac	3.18	5.83	1.13	-3.06	-4.69					
						Totadd	0.13	0.15	-0.18	-0.02	-0.64					
						Maxadd	0.56	-0.96	1.32	-0.36	1.13					
						Avgfsadd	-0.48	0.37	-0.24	0.49	0.07					
4. (2,6,13)	69	53	62	60	70							3.6*	3.14*	1.42	3.83*	0.59
						Totvac	3.03	6.5	0.80	-2.85	-2.38					
						Maxadd	0.77	-0.54	0.85	-0.44	0.31					
						Avgfsadd	-0.42	0.439	-0.28	0.48	-0.07					

[1](R1 – R5): means regions 1 – 5; [2]F ratio: significant values are shown by the traditional asterisks (*s)

The treatment characteristic vaccination seems to have had a greater influence on hatchability than any other variable especially in regions 1, 2 and 3 and appears in all the four regressions with positive parameter estimate values in regions, 1, 2, and 3. The vaccination was done specifically against Newcastle disease, which is a major cause of high mortalities among indigenous chicken flocks in sub-Saharan Africa (Musharaf *et al*., 1990; Ndegwa and Kimani, 1997; Ndegwa *et al*., 1998a; Gueye, 2000a). The disease has a high morbidity and is endemic in many regions in Kenya, though there would be differences in severity and time of occurrence. This is probably the reasons for the differences observed between regions.

The housing treatment had a small and positive influence on hatchability in regions 1-4 as evidenced by regression models 3 and 1. However, the housing estimate values in region 2 are appreciably large and positive and there is a significant F-ratio with regression model 3. Region 2 (Ol Kalou) is the coldest of the five regions and housing helps to maintain incubation temperatures at required levels, which would explain the observed effect. In the other four regions, high temperatures prevail and housing may have not had the same effect on hatchability.

The treatment variable deworming, appears in two of the four chosen final models and seem to have had some influence on hatchability in regions 1 – 4.

The treatment variable feed supplementation had hardly any effect on hatchability, contrary to our expectations. This could have been because there was little variation in the uptake between the five regions as shown in Table 6.4.4. Almost all the farms had done feed supplementation possibly to a level enough to meet requirements for brooding hens and it would therefore be very difficulty to detect variations between or within farms and consequently the effect on hatchability will be masked. However, model 1 has produced positive parameter estimates of 1.18 and an F-ratio of 1.36 in region 1 indicating there is some effect of feed supplementation, possibly still masked by other factors.

Table 6.4.4: Mean values per farm of the variables of the chosen hatchability regression models in five regions.

Regression variable	Region				
	1	2	3	4	5
Tothse	2.8	2.7	3.1	2.6	2.6
Totvac	0.7	1.7	1.6	1.6	0.7
Totdwm	1.4	2.5	2.1	2.0	1.9
Totspl	3.9	3.8	4.4	3.7	3.4
Totadd	56.2	73.2	61.2	75.3	51.8
Avgfs	23.9	27.8	30.2	29.9	21.9
Maxadd	19.4	23.5	20.5	24.1	18.5
Avgfsadd	35.1	42.4	42.4	45.0	32.2

On the other hand, model 2 has a positive parameter estimate of 1.78 with a significant F-ratio ($p<0.1$) in region 4. Therefore, despite the poor results with other models and in other regions, the effect of feed supplementation seemed to be appreciably unmasked in these two regions.

The flock demography and dynamic variables had low influence on hatchability but their presence improved the regressions fitting in regions 1 – 4. However, there is enough evidence to suggest that both treatments and flock demography dynamic characteristics in the four regression models played a role in the outcome of the hatchability values to a varying degree in the five regions. Region 2 seems to have the best fit and region 5 the poorest for all the four regression models.

The mean values in each region of all the 8 variables appearing in the 4 chosen regression models given in Table 6.4.4 were used to calculate fitted hatchability values shown in Table 6.4.5 for all the 4 models in the 5 regions.

The fitted hatchability values calculated from the four best fitting regression models are nearly the same within each region. The fitted model 4 has the best fit and hence the hatchability values are more precise. All the fitted values have a narrow range of 66 – 76 percent in all the five regions. The observed mean hatchability and the fitted values were also nearly the same as expected if regression models have a better fit. However, in region 5, the fitted hatchability value from model 2 was too large and peculiar compared with the other fitted values and the observed mean hatchability. This is probably an indication that the model is not suitable to interpret or use in this particular region and that, regression models should not be taken wholesome to represent variables under investigation such as hatchability in this case.

Table 6.4.5: Fitted hatchability (percent) values from the 4 chosen regression models and the observed mean hatchability in regions 1 – 5.

Regression model	Region				
	1	2	3	4	5
1. (1,2,3,4,11)	71.6	69.4	69.2	67.8	71.6
2. (2,3,4,6,13)	71.5	68.8	69.9	65.8	76.5
3. (1,2,5,6,13)	71.6	69.6	69.5	66.5	70.9
4. (2,6,13)	71.3	70.0	68.8	66.4	71.8
Observed Mean hatchability	72	69	70	65	70

The four chosen regression models are therefore our best functions defining the hatchability values, depending on the level of the various variables making up the particular models.

We have done the statistical analysis for hatchability using two approaches, variation analysis and regression analysis. The analysis of variation has produced evidence for no cycle effect on hatchability while showing large enough variations within and between farms and consequently between regions. The regression analysis provided evidence that a number of variables in four different combinations influenced hatchability levels in different regions.

Housing was an important factor in region 2 (Ol Kalou) which, as indicated above, happens to be one of the coldest areas in Kenya and hence housing is required to improve on hatchability. The region had also the lowest hatchability levels. Vaccination against Newcastle disease was certainly an important factor influencing hatchability except in regions 4 and 5. Supplementation seemed to have some small effect on hatchability in regions 1 and 4 though not convincingly so, while deworming seemed only to have some effect in region 2 but again this was not convincing.

6.5 Statistical analysis of eggs laid in hen-cycles

The eggs laid as a parameter of production in our study was measured in terms of a typical hen-cycle as expounded in detail in chapter 5 in the descriptive analysis. The data used in the statistical analysis is for hens in each farm and for three consecutive cycles. The analysis on eggs laid is similar to the one on hatchability and is based on two methods – analysis of variation and regression analysis. In this analysis, a model for farm and cycle effects was fitted and the resulting predicted eggs values in cycle 2 were used as the dependent variable in the multiple regression analysis.

6.6 Analysis of variation of eggs laid

The analysis of variation was meant to investigate the effects of farm, cycle and hen as factors affecting egg production by understanding characteristic and level of variation. The aim was to compare the variation of egg production between farms in a region, between hens within farms and between the cycles. Three different models were fitted to obtain the following sets of mean squares:

Between and within farm mean squares
Farm, hen, cycle, and error mean squares

As was the case with the hatchability analysis of variation, type I mean squares of the eggs laid were obtained for the farm variable, while type III mean squares were obtained for the cycle and hen variables. The three fitted models were thus:

Farm

Farm, hen, cycle – type I farm and type III cycle MS

Farm, cycle, hen - type I farm and type III hen MS

The patterns of the MS were analysed for the two sets of MS, the between and within farm MS and farm, hen, cycle and error MS in 20 villages. Tables 6.6.1 provides the 'between and within farm' MS which were then ranked in an ascending order as shown in Tables 6.6.2.

Table 6.6.1: Between and within farm egg production mean squares and least squares mean range for eggs laid among farms in each of the 20 villages.

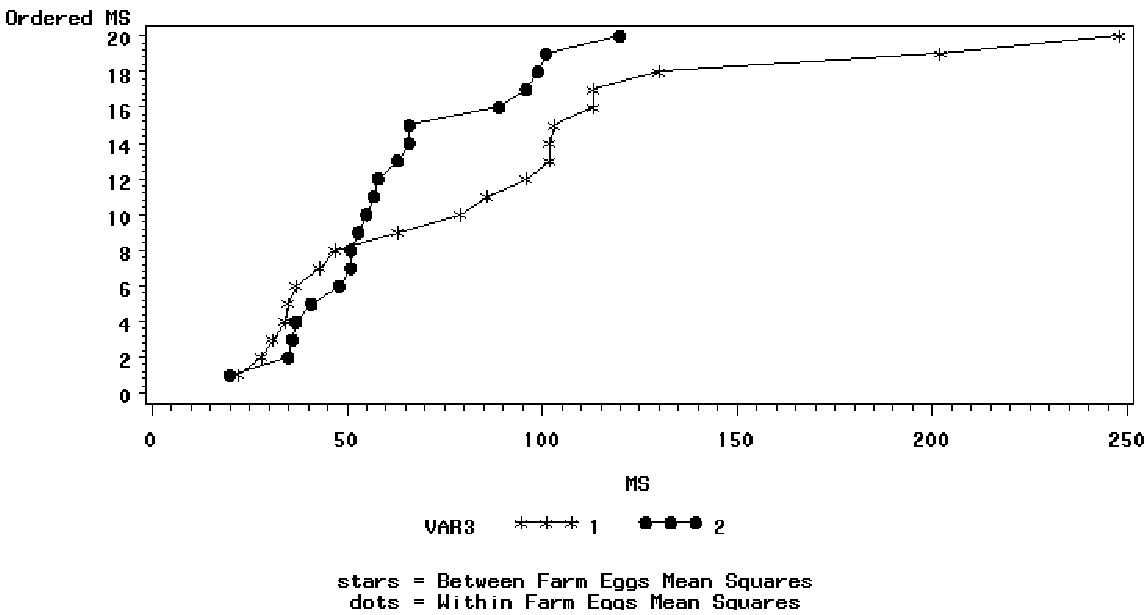
Region	Village	Between farm Mean Squares (df)[1]	Within farm Mean Squares (df)	Eggs LSmean range	F-ratio[2]
1	1	103 (7)	48 (52)	11 – 25	2.14*
1	2	31 (6)	96 (33)	20 – 29	0.32
1	3	102 (4)	20 (23)	15 – 24	4.43*
1	4	87 (4)	120 (25)	21 – 32	0.72
2	1	130 (5)	57 (21)	13 – 27	2.28
2	2	248 (5)	41 (48)	16 – 27	5.17**
2	3	43 (5)	37 (33)	16 – 22	1.3
2	4	34 (4)	36 (28)	19 – 23	0.94
3	1	37 (4)	66 (29)	14 – 23	0.56
3	2	113 (5)	89 (39)	14 – 23	1.27
3	3	96 (7)	35 (36)	13 – 23	1.97
3	4	102 (7)	101 (37)	17 – 26	1.01
4	1	22 (4)	53 (22)	20 – 24	0.41
4	2	28 (5)	51 (15)	15 – 22	0.55
4	3	113 (4)	58 (22)	11 – 23	1.95
4	4	47 (3)	66 (33)	19 – 24	0.71
5	1	79 (4)	51 (25)	16 – 24	1.55
5	2	35 (5)	55 (36)	18 – 24	0.64
5	3	63 (5)	63 (27)	16 – 27	1.0
5	4	202 (5)	99 (32)	10 – 27	2.04

[1]df: degrees of freedom, [2]F-ratio: the traditional asterisks indicate significant values

Table 6.6.2: Ranking of between and within farm egg production mean squares

Rank	Between	Within
1	22	20
2	28	35
3	31	36
4	34	37
5	35	41
6	37	48
7	43	51
8	47	51
9	63	53
10	79	55
11	86	57
12	96	58
13	102	63
14	102	66
15	103	66
16	113	89
17	113	96
18	130	99
19	202	101
20	248	120

Figure 6.6.1. Cumulative distribution of Between and Within Farm Eggs Mean Squares



The ranked MS were themselves used to make a cumulative frequency distribution by plotting the MS against their rank order to provide a graphical overview of their patterns and characteristics. Figures 6.6.1 show the cumulative frequency distributions of the 'between and within farm' MS.

Additionally, Table 6.6.3 shows a summary of the between and within farm set of MS in 20 villages.

Table 6.6.3: Ranges and medians of between farm and within farm MS for mean hatchability in 20 villages

Source of variation	MS range	Median of MS range
Between Farm	22 – 248	83
Within Farm	20 – 120	56

Looking at the three tables and Figure 6.6.1, there is a clear indication that the between farm MS are larger than the within farm MS. The same argument used in the hatchability section may apply here also, i.e. that there is less variation in the eggs laid within farms than between the farms because of similar conditions prevailing within farms in terms of management, localised environmental factors and genetically close hens due to high chances for inbreeding. Crucially, F ratios were less significant because the within farm MS included cycle and hen effect. A decomposition of the variability between the farms on village-by-village basis shows that 11 out of 20 villages had F values of more than one and 4 of the 11 F ratios were significant (villages 1/1, 1/3, 2/1 and 2/2).

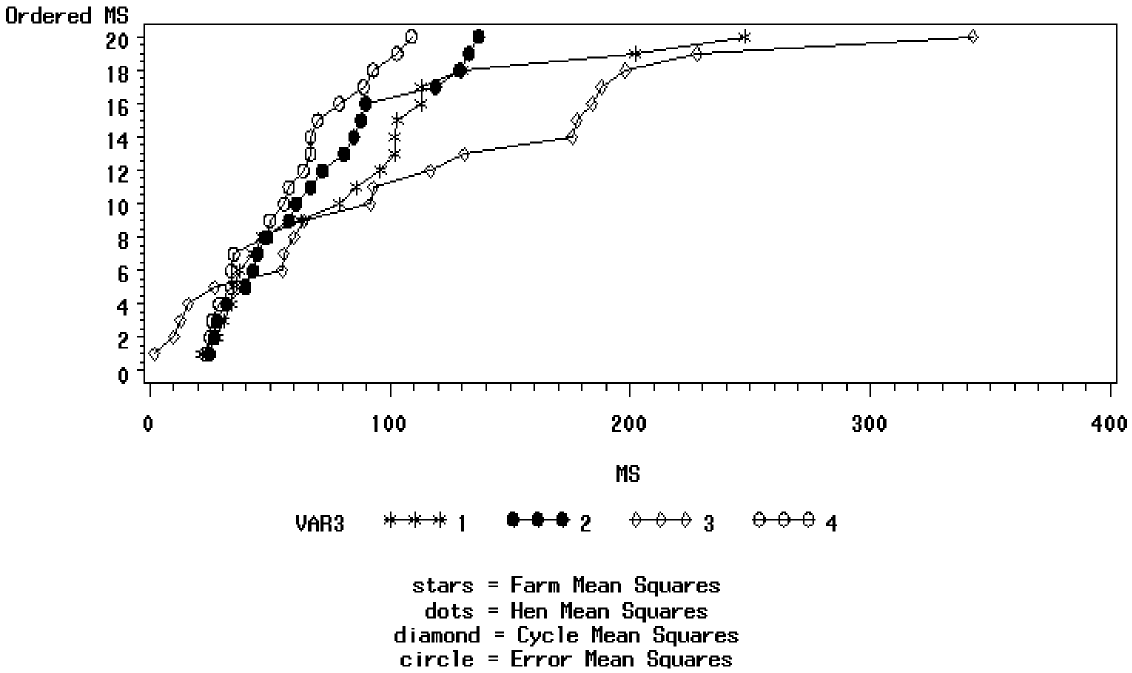
A comparison of the farm, hen, and cycle, and error variation provides a better and clearer picture of the effects on eggs laid, in each village. Table 6.6.4 provides an illustration of the investigation of the variations using the farm, hen, cycle and error set of MS in each village. Cumulative frequency distributions of these MS are shown by Figure 6.6.2.

Table 6.6.4: Farm, hen, cycle and error MS with F-ratios in 20 villages

Region	Village	Farm			Hen			Cycle			Error	
		MS-I	df	F-ratio[1]	MS-III	df	F-ratio	MS-III	df	F-ratio	MS	df
1	1	103	7	**2.94***	81	22	**2.31***	64	2	1.83	35	35
1	2	31	6	0.35	61	13	0.68	178	2	2	89	24
1	3	102	4	**4.08***	40	11	1.6	13	2	0.52	25	14
1	4	87	4	0.84	90	9	0.87	343	2	3.33	103	18
2	1	130	5	2.32	119	8	2.12	2	2	0.03	56	16
2	2	248	5	**5.06***	88	17	1.79	27	2	0.55	49	34
2	3	43	5	1.48	32	12	1.1	176	2	6.07*	29	24
2	4	34	4	1	27	10	0.79	93	2	2.73	34	20
3	1	37	4	0.55	25	13	0.37	228	2	3.4	67	18
3	2	113	5	1.69	133	13	**1.98***	198	2	2.95	67	29
3	3	96	7	**4.17***	67	14	**2.91***	184	2	8.0*	23	27
3	4	102	7	1.29	137	13	1.73	188	2	2.38	79	29
4	1	22	4	0.65	58	8	1.7	117	2	3.44*	34	16
4	2	28	5	0.48	28	5	0.48	10	2	0.17	58	13
4	3	113	4	1.21	43	15	0.46	56	2	0.6	93	9
4	4	47	3	0.73	72	14	1.12	16	2	0.25	64	20
5	1	79	4	1.58	48	11	0.96	131	2	2.62	50	16
5	2	35	5	1.35	85	16	**3.27***	55	2	2.11	26	23
5	3	63	5	0.9	45	10	0.64	92	2	1.31	70	20
5	4	202	5	**20.2****	129	13	1.18	60	2	0.55	109	22

[1]F-ratio: significant values are shown by the traditional asterisks

Figure 6.6.2. Cumulative distribution of Farm Hen Cycle and Error Mean Squares



The farm, hen, cycle and error MS provide a clear indication, from both the significant levels and the cumulative frequency distribution, that all the three factors; farm, hen and cycle have larger MS than the error with the exception of a few villages. In the case of the farm and cycle MS, thirteen villages had F ratios greater than one, and six of these were significant for both factors. Similarly, with the hen MS, twelve villages had an F ratio greater than one, seven of which were significant. The hen MS values were, however, smaller than those of both the farm and cycle factors in most villages.

Looking at the cumulative distributions of the MS, the cycle MS are larger than the error, hen and farm in most villages and have a tapering distribution that is least symmetrical of all the four sets of MS distributions with a few extreme values at the beginning and at the end. This is obviously due to the small number of its degrees of freedom. This contrasts with the other distributions, especially the error and hen MS that display a more symmetrical distribution with their larger numbers of degrees of freedom.

The hen MS were more or less intertwined with those of the farm, mainly because the hen factor was always fitted with the farm. Hence, further investigation to compare variation within villages was done using the farm factor.

In terms of the further analysis of egg production, the important factors are farm and cycle, and the cumulative distribution of MS for the farm/cycle model is shown in Figure 6.6.3. The investigation on the variation among villages on the eggs laid then focused on two factors, the farm and the cycle. The MS were obtained by fitting only the farms and cycles using a GLM procedure. The two factors have clearly MS values greater than the error in majority of the villages.
A summary of the MS values of the factors from each set of MS category is provided in Table 6.6.5 in terms of ranges and medians among all the twenty villages. The cycle factor has the widest range (2 – 343) and the largest median (103) with the fourth MS set from fitting farm and cycle.

Figure 6.6.3. Cumulative distribution of Farm Cycle and Error Eggs Mean Squares

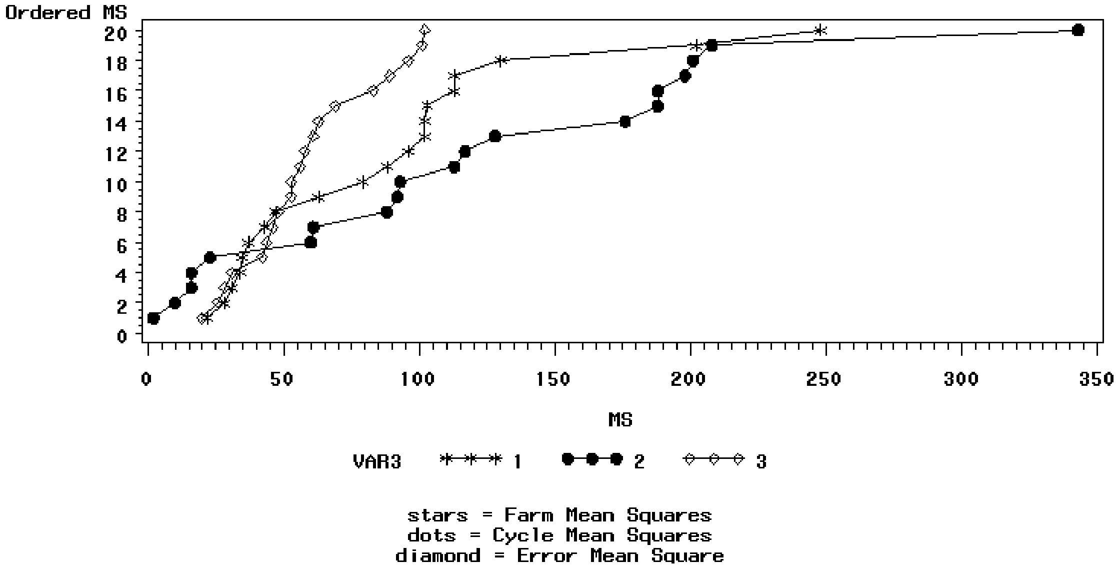


Table 6.6.5: Ranges and medians for three sets of mean squares used in the investigation of variations in twenty villages

MS Set	Source of variation	MS range	Median of MS range
Between and within farm	Between Farm	22 – 248	84
	Within Farm	20 – 120	56
Farm, hen, cycle and error	Error	23 – 109	57
	Cycle	2 – 343	93
	Hen	25- 137	64
	Farm	22 - 248	84
Farm, cycle and error	Error	20 – 102	55
	Cycle	2 – 343	103
	Farm	22 – 248	84

The MS values of farm have a wider range than the remaining factors. While both the within farm and hen factors have larger MS values than the error, all three are close to each other.

Having established that there is a cycle effect, we must see if it is consistent across villages. Summaries of the MS values in each region are given in Tables 6.6.6 and 6.6.7. Among the overall MS values from the fitting of farm and cycle, the error MS is larger than cycle in region 5. The farm MS and degrees of freedom change when village is not included. There are indications of regional differences in the analysis of cycle effects, with little effects in regions 2 and 5 and a particularly strong effect in region 3. Hence, further required statistical analysis is based on all farms in each region.

Table 6.6.6: Regional type I village and type III, farm and cycle mean squares in regions 1 – 5.

Region	Village	Farm	Cycle	Error
1	254 (3)[1]	71 (21)	345 (2)	64 (131)
2	43 (3)	118 (17)	38 (2)	42 (128)
3	32 (3)	86 (23)	737 (2)	64 (138)
4	110 (3)	52 (16)	184 (2)	56 (90)
5	44 (3)	94 (19)	22 (2)	69 (118)

[1]: numbers in brackets are respective degrees of freedom

Table 6.6.7: Regional type I farm and type III cycle mean squares

Region	Farm	Cycle	Error
1	101 (24)[1]	345 (2)	64 (131)
2	108 (22)	38 (2)	42 (128)
3	84 (26)	737 (2)	64 (138)
4	61 (19)	184 (2)	56 (90)
5	89 (22)	22 (2)	69 (118)

[1]: numbers in brackets are respective degrees of freedom

Table 6.6.8 shows least square means or predicted mean egg production in each of the 20 villages in five regions for three typical hen-cycles obtained from the fitting of the farm and cycle using the general linear model procedures. There seems to be a general rise in the number of eggs laid from cycle 1 to cycle 3 in each region. There are not many differences between cycle 2 and 3 looking at the number of eggs shown in the table. The range of the predicted mean egg production in all the 20 villages was 15 – 23 in cycle 1; 16 – 33 in cycle 2, 18 – 25 in cycle 3. Most values in cycle 1 were less than 20 eggs per hen-cycle with only six villages having values larger than 20. On the other hand, only six and two villages had predicted mean egg values less than 20 in village 2 and 3 respectively. The predicted mean egg values in cycle 1 were lowest in regions 3 and 4 and ranged from 15 – 18 eggs per hen-cycle. A value of 33 in cycle 2 for village 4 in region 1 might seem to be an outlier compared with the rest. However, looking back at the original data it seems to be a genuine outlier.

Table 6.6.8: Least square means egg production in cycles 1-3 in 20 villages in 5 regions.

Region	Village	Cycle		
		1	2	3
1	1	17	20	20
1	2	18	25	24
1	3	18	19	21
1	4	22	33	22
2	1	20	20	20
2	2	23	21	23
2	3	15	22	21
2	4	21	24	18
3	1	17	25	23
3	2	16	23	20
3	3	16	23	21
3	4	18	23	25
4	1	17	23	23
4	2	18	19	20
4	3	15	18	22
4	4	15	18	22
5	1	19	15	23
5	2	18	22	22
5	3	22	16	21
5	4	21	22	18

Comparing the egg production figures for each cycle, strengthens the evidence provided by the MS distributions and tabulations that there is a cycle effect. The figures also provide some indication of the presence of farm effect, given the differences in the egg production figures between and within regions. A more complex analysis of variation using only the farm, cycle and error MS in each village was carried out to examine the patterns and consistency of farm and cycle effects. The analysis also used MS values from a combined fit of all villages in a region. The village, region and overall observations were used to determine which factor had a significant effect on egg production and at what level.

Tables 6.6.9 – 6.6.13 show the procedure used to calculate significant levels of the variations - between farm, between village, overall cycle effect and cycle effect within village separately for each region.

Table 6.6.9: Analysis of variations for the overall farm, and cycle effects in Region 1.

Type of variation	Source	RSS[1]	DF[2]	MS	F-ratio[3]
Combined fit	Farm	2424	24		
	Cycle	689	2		
	Error	8443	131	64	
Variation of farm:					
	Total farm	2424	24	101	
	Village 1	721	7	105	
	Village 2	185	6	31	
	Village 3	407	4	102	
	Village 4	350	4	83	
Between farm within village	Sum(v1-v4)	1663	21	79	(79/64) = 1.2
Between village	(2424-1663)	761	3	254	(254/64) = 4*
Variation of cycle:					
Single cycle effect		689	2	344	(344/64) = 5.4**
Separate cycle effect	Village 1	121	2		
	Village 2	402	2		
	Village 3	32	2		
	Village 4	687	2		
	Sum	1442	8		
	Difference (variation of cycle difference)	(1442 - 689) =753	(8-2) = 6	125	(125/64) = 1.9

[1]RSS: Residual sum of squares; [2]DF: Degrees of freedom; [3]F-ratio: significant values are shown by the traditional asterisks (*s)

Table 6.6.10: Analysis of variations for the overall farm, and cycle effects in Region 2.

Type of variation	Source	RSS[1]	DF[2]	MS	F-ratio[3]
Combined fit	Farm	2366	22		
	Cycle	76	2		
	Error	5319	128	42	
Variation of farm:					
	Total farm	2366	22	108	
	Village 1	648	5	180	
	Village 2	1239	2	620	
	Village 3	216	5	43	
	Village 4	136	4	34	
Between farm within village	Sum(v1-v4)	2239	16	140	3.3*
Between village	(2366-2239)	127	6	21	0.5
Variation of cycle: 1. Single cycle effect		76	2	38	0.9
2. Separate cycle effect	Village 1	3	2		
	Village 2	54	2		
	Village 3	352	2		
	Village 4	186	2		
	Sum	592	8	74	1.8*
	Difference (variation of cycle difference	516	6	86	2.1**

[1]RSS: Residual sum of squares; [2]DF: Degrees of freedom; [3]F-ratio: significant values are shown by the traditional asterisks (*s)

Table 6.6.11: Analysis of variations for the overall farm, and cycle effects in Region 3.

Type of variation	Source	RSS[1]	DF[2]	MS	F-ratio
Combined fit	Farm	2101	26		
	Cycle	1474	2		
	Error	8940	139	64	
Variation of farm:	Total farm	2101	26		
	Village 1	146	4		
	Village 2	567	5		
	Village 3	671	7		
	Village 4	714	7		
1. Between farm within village	Sum(v1-v4)	2098	23	91	1.4
Between village	(2424-1663)	3	3	1	0.02
Variation of cycle:					
1. Single cycle effect		1474	2	737	11.5**
2. Separate cycle effects	Village 1	417	2		
	Village 2	397	2		
	Village 3	376	2		
	Village 4	376	2		
	Sum	1566	8		
	Difference (variation of cycle difference	92	6	15	0.23

[1]RSS: Residual sum of squares; [2]DF: Degrees of freedom; [3]F-ratio: significant values are shown by the traditional asterisks (*s)

Table 6.6.12: Analysis of variations for the overall farm, and cycle effects in Region 4.

Type of variation	Source	RSS[1]	DF[2]	MS	F-ratio
Combined fit	Farm	1154	19		
	Cycle	367	2		
	Error	5030	90	56	
Variation of farm:					
	Total farm	1154	19		
	Village 1	86	4		
	Village 2	140	5		
	Village 3	454	4		
	Village 4	142	3		
Between farm within village	Sum(v1-v4)	822	16	51	0.9
Between village	(1154-822)	332	3	111	1.98
Variation of cycle:					
1. Single cycle effect		367	2	184	3.3*
2. Separate cycle effect	Village 1	234	2		
	Village 2	21	2		
	Village 3	227	2		
	Village 4	31	2		
	Sum	513	8		
	Difference (variation of cycle difference	146	6	24	0.4

[1]RSS: Residual sum of squares; [2]DF: Degrees of freedom; [3]F-ratio: significant values are shown by the traditional asterisks (*s)

Table 6.6.13: Analysis of variations for the overall farm, and cycle effects in Region 5.

Type of variation	Source	RSS[1]	DF[2]	MS	F-ratio
Combined fit	Farm	1951	22		
	Cycle	44	2		
	Error	8084	118	69	
Variation of farm:					
	Total farm	1951	22		
	Village 1	317	4		
	Village 2	173	5		
	Village 3	316	5		
	Village 4	1012	5		
Between farm within village	Sum(v1-v4)	1818	19	96	1.4
Between village	Difference (1951-1818)	133	3	44	0.6
Variation of cycle:					
1. Single cycle effect		44	2	22	0.3
2. Separate cycle effect	Village 1	567	2		
	Village 2	177	2		
	Village 3	184	2		
	Village 4	121	2		
	Sum	879	8		
	Difference (variation of cycle difference	835	6	139	2*

[1]RSS =Residual sum of squares; [2]DF: =Degrees of freedom; [3]F-ratio: significant values are shown by the traditional asterisks (*s)

Table 6.6.14: Summary of the significance levels for the farm, and cycle effects in five regions.

Variation	F-ratios[1]				
	R1[2]	R2	R3	R4	R5
1. Between Farm within village	1.2	3.3*	1.4	0.9	1.4
2. Between village within region	4**	0.5	0.02	1.98	0.6
3. Overall cycle effect	5.4**	0.9	11.5**	3.3*	0.3
4. Cycle effect between village within region	1.9	2*	0.23	0.4	2*

[1]F-ratio: significant values are shown by the traditional asterisks (*s)
[2]R: regions 1 - 5

Table 6.6.14 gives a summary of the significant levels in all the five regions. As was noted before, there is strong cycle effect in regions 1, 3 and 4 and little evidence of variation between the villages within the regions. In region 2 and 5, there is no overall cycle effect though there is some evidence of cycle effects between villages within region.

The analysis of variation as given in the tables therefore provides clear evidence for the presence of cycle effect and some evidence of small farm effects on the number of eggs laid in a typical hen cycle in each of the five regions. Hence, it is necessary to consider the two factors in our further statistical analysis of the eggs laid.

Cycle differences in the number of eggs laid in a typical hen-cycle were determined from the predicted mean egg production values to get actual cycle effects. The differences were, (1) cycle2-cycle1; (2) cycle3–cycle 1; and (3) cycle3–cycle1. These are shown in Table 6.6.15. The two differences of cycle 1 with either cycle 2 or cycle 3 had the largest positive values, with only four and five negatives for the first and second difference respectively. All the eight cycle3 - cycle1 differences in regions 3 and 4 were unusually large and positive. This is probably an indication of improvement in egg production because of application of the treatment interventions by the farmers.

The actual difference between cycle3 and cycle1 together with the predicted mean eggs laid in cycle 2 were used in regression analysis as the response variables to investigate effects of the treatment interventions and other factors on egg production. This was because the predicted mean values for cycle 2 presents the best estimate of average values for each farm, while cycle 3 – cycle 1 difference tells us about improvement for each farm.

Table 6.6.15: Cycle effects as difference in egg production between cycle 1 and cycles 2 and 3 and, between cycles 3 and 2.

Region	Village	Cycle difference[1]		
		C2-C1	C3-C1	C3-C2
1	1	2.8	3.1	0.3
1	2	7.4	5.5	-1.8
1	3	0.9	2.6	1.7
1	4	10.1	-0.1	-10.2
2	1	-0.1	-0.8	-0.7
2	2	-2.0	0.2	2.2
2	3	7.0	5.0	-1.5
2	4	3.1	-2.7	-5.8
3	1	8.5	5.7	-2.8
3	2	7.1	4.8	-2.3
3	3	6.9	4.7	-2.2
3	4	5.3	6.7	1.5
4	1	6.6	5.9	-0.7
4	2	0.4	2.3	1.9
4	3	3.7	7.7	4.0
4	4	3.7	7.7	4.0
5	1	-3.9	3.7	7.6
5	2	4.5	4.4	-0.1
5	3	-5.4	-0.8	4.5
5	4	1.2	-3.2	-4.3

[1]C3-C1= difference between cycles 3 and 1; C2-C1= difference between cycles 2 and 1; C3-C2= difference between cycles 3 and 2.

The cycle3-cycle1 difference in regions 3 and 4, show a consistency value of two between the lowest and largest. Regions 2 and 5 have an inconsistency value of eight between the lowest and largest difference. Looking at the significance levels of variations in Table 6.6.14 and the cycle3-cycle1 differences in Table

6.6.15 explains the reasons for the significant values of the overall cycle effect in regions 1, 3, and 4.

6.7 Regression analysis for the mean eggs laid

The regression analysis for eggs laid was carried out in two approaches – (1) using the difference between cycles 3 and 1 actual mean values for each farm, and (2) predicted mean values for cycle 2 for each farm. The latter predicted values were obtained from the fitting of only the farm and cycle terms in each region. The regressions were made for each region using values of all the farms in a region.

For both the difference of cycle 3 and cycle 1 (c3-c1), and the predicted cycle 2 mean values, several regressions were done to investigate the influence of the four treatment interventions and a number of flock demography characteristics in each farm.

The treatments were:
Housing (hse),
Vaccination (vac),
Deworming (dwm),
Feed supplementation (spl).

The demography characteristics included:
Average flock size (avgfs),
Total addition (totadd),
Maximum addition (maxadd),
Total reduction (totrd),
Total unplanned reduction (toturd),
Total controlled reduction (totcrd),
Balance of addition (baladd),
Average of sum of flock size and addition (avgfsadd).

Both the difference of cycle 3 and cycle 1 (c3-c1), and the predicted cycle 2 values were first regressed on the four treatments where t-values for each term of the regression and the overall F-ratio value of the regression were determined in each region. This was then followed by addition of each of the demography characteristic to the four treatments and again determining t values for each term and the overall F-ratio value. All the t-values and the overall F-ratio values for each regression in each region were listed down in order to find out which terms to omit and which ones to include in the process of trying to get the best fitting regression model.

6.8 C3-C1 difference regression analysis

Table 6.8.1 shows t-values from the regressions of the cycle 3 and cycle 1 difference (c3-c1) with the four treatments factors on their own, and with each of the eight demography factors in turn in the five regions. A summary of the overall F ratios of these regressions in the five regions is provided in Table 6.8.2. Selection of best fitting terms from both the treatment factors set and the demography set was based on the individual t-values and the F-ratio of the regression in each of the five regions. The t-values are important indicators of effects of the individual treatments on egg production, which at any rate, was a major objective of carrying out this farmer participatory research. The F ratios on the other hand provide an indication for overall effects of treatments.

Looking down the columns of t-values, in all the five regions, provides some initial indication of possible effect of each treatment. The housing treatment seems to have had some effects in regions 4 and 5 while region 3 has very slight indication of housing effect. The vaccination treatment seems interesting in regions 1, 2 and 4 while showing relatively large but negative values in region 5. The negative sign makes it hard to believe the large values. The t-values for the deworming treatment were mainly negative in regions 1, 2, 4 and 5 or very small in region 3. With feed supplementation treatment, there seems to be some effects in regions 2 and 4 with small positive values in regions 1 and 3. Region 5 had mainly negative t-values.

Table 6.8.1: Regression of c3-c1 difference on treatments and, demography factors in regions 1-5.

Demo factor			t-values			F ratio
	Hse	Vac	Dwm	Spl	Demo	
Region1:						
None	-0.63	1.75	-0.41	0.45	-	1.09
Avgfs	-0.61	1.83	-0.61	0.3	0.7	0.94
Totadd	-0.61	1.54	0.45	0.37	-0.58	0.91
Maxadd	-0.62	1.7	-0.36	0.45	-0.5	0.88
Totrd	-0.62	1.46	-0.18	0.45	-0.5	0.88
Toturd	-1.01	1.8	0.84	1.04	-2.35	2.18
Totcrd	-0.66	1.91	-0.5	0.56	0.81	0.98
Baladd	-0.69	1.82	-0.07	0.61	0.69	0.94
Avgfsadd	-0.61	1.76	-.05	0.38	0.42	0.89
Region2:						
None	-1.22	2.01	-0.51	2.06	-	2.32
Avgfs	-1.2	2.25	-0.18	1.94	1.02	2.07
Totadd	-0.45	1.96	1.01	2.98	-1.99	2.95
Maxadd	-0.91	1.9	0.39	2.51	-1.37	2.32
Totrd	-1.02	1.9	0.39	2.51	-1.37	2.32
Toturd	-0.88	1.45	-0.22	1.85	-1.47	2.41
Totcrd	-1.2	1.94	-0.53	1.67	0.19	1.76
Baladd	-0.84	2.15	0.42	2.24	-1.13	2.14
Avgfsadd	-1.24	1.98	-0.68	1.75	0.49	1.83
Region3:						
None	0.61	0.21	0	0.39	-	0.15
Avgfs	0.97	0.28	0.33	0.46	-1.17	0.39
Totadd	0.65	0.15	0.12	0.32	-037	0.14
Maxadd	0.54	0.20	-0.02	0.38	0.03	0.11
Totrd	0.76	0.25	0.26	0.41	-0.69	0.21
Toturd	0.51	0.36	-0.4	0.65	1.15	0.38
Totcrd	0.92	0.36	0.36	0.55	-1.22	0.42
Baladd	0.72	0.13	0.17	0.32	-0.72	0.24
Avgfsadd	0.91	0.22	0.32	0.39	-1.03	0.33
Region4:						
None	1.52	0.98	-1.4	1.32	-	1.09
Avgfs	2.05	1.08	-2.17	1.96	2.53	2.52
Totadd	1.14	0.67	-1.4	1.27	1.85	1.72
Maxadd	1.11	0.58	-109	0.91	1.56	1.46
Totrd	1.36	0.97	-1.49	1.3	0.9	1.02
Toturd	1.81	0.82	-1.49	1.16	-0.98	1.06
Totcrd	1.47	0.96	1.53	1.29	1.05	1.1
Baladd	1.35	0.61	-1.45	1.25	2.01	1.89
Avgfsadd	1.81	0.91	-2.08	1.86	2.73	2.79
Region5:						
None	2.0	-2.37	-3.21	-1.82	-	4.20
Avgfs	2.17	-2.61	-2.3	-2.34	1.47	4.07
Totadd	1.92	-2.3	-2.98	-1.67	0.34	3.17
Maxadd	2.06	-2.32	-2.7	-1.84	0.68	3.33
Totrd	1.98	-2.07	-3.13	-1.47	0.41	3.20
Toturd	2.02	-2.21	-3.2	-1.79	0.69	3.33
Totcrd	1.87	-2.14	-3.09	1.45	0.04	3.12
Baladd	1.75	-2.27	-2.78	-1.7	0.01	3.12
Avgfsadd	2.27	-2.56	-2.35	-2.3	1.35	3.92

Table 6.8.2: **Regression models of treatments with each of eight demography factors and their F ratios.**

Model terms	F ratios				
	R1	R2	R3	R4	R5
Hse, vac, dwm, spl,	1.09	2.32	0.15	1.09	4.20
Hse, vac, dwm, spl, avgfs	0.94	2.07	0.39	2.25	4.07
Hse, vac, dwm, spl, totadd	0.91	2.95	0.14	1.72	3.17
Hse, vac, dwm, spl, maxadd	0.83	2.32	0.11	1.46	3.33
Hse, vac, dwm, spl, totrd	0.88	1.82	0.21	1.02	3.20
Hse, vac, dwm, spl, toturd	2.18	2.41	0.38	1.06	3.33
Hse, vac, dwm, spl, totcrd	0.98	1.76	0.42	1.1	3.12
Hse, vac, dwm, spl, baladd	0.94	2.14	0.24	1.89	3.12
Hse, vac, dwm, spl, avgfsadd	0.87	1.83	0.33	2.79	3.92

Our investigation of the individual t-values (Table 6.8.1), for each factor and F-ratios for the whole model (Table 6.8.2), led to a decision to try eight regression models in each of the five regions using a combination of the treatment factors. Each model also contained two demography factors, the maximum addition (maxadd) and total unplanned reduction (toturd), both selected based on their t-values in all the five regions. The demography factors were hoped to unmask any effect of the treatment factors. These were then investigated to find out which terms should be included in the best fit to define the cycle 3 and cycle 1 difference (c3-c1) in each region. Terms with large and positive t-values and from regression models with large F-ratios were considered as possible factors for the best-fit regression.

Table 6.8.3: Selected regression models terms and respective F-ratios in five regions.

Model	Terms	F ratio				
		R1	R2	R3	R4	R5
1	Hse, vac, dwm, spl, maxadd, toturd	1.90	2.28	0.31	1.25	2.59
2	Vac, dwm, spl, maxadd, toturd	2.08	2.74	0.33	1.10	2.09
3	Hse, vac, spl, maxadd, toturd	2.19	2.81	0.37	1.20	1.60
4	Hse, vac, dwm, maxadd, toturd	2.17	1.44	0.3	1.41	2.16
5	Vac, spl, maxadd, toturd	2.54	3.44	0.36	1.40	0.85
6	Vac, dwm, maxadd, toturd	2.48	1.76	0.29	1.42	2.43
7	Hse, vac, maxadd, toturd	2.78	1.74	0.4	1.62	1.17
8	Vac, maxadd, toturd	3.42	2.32	0.39	2.0	0.98

The terms included in each of the eight regressions models are shown in Table 6.8.3 together with respective overall F-ratios resulting from the fitting of these terms of the model.

Results from the fitting of the eight models showing the individual model terms t-values and overall model F ratios are illustrated using model 1, which is a full model with all the four treatments factors and the two selected demography factors and is given in Table 6.8.4. In this illustration, the t-values of individual terms were also investigated alongside their respective overall model F-ratios to decide on the ones to include in the best-fit regression model for each region that will hopefully define the cycle 3 and cycle 1 difference (c3-c1).

Table 6.8.4: Regression t-values for four treatments (hse, vac, dwm, spl), with or without two demography factors (maxadd and toturd) and overall F ratios.

Demo	Treatments t-values				Demo t-values	Overall [1]F ratio
	Hse	Vac	Dwm	Spl		
Region 1:						
None	-0.63	1.75	-0.41	0.45	-	1.09
Toturd	-0.99	1.69	0.81	0.85	-2.47	1.90
Maxadd					0.83	
Region 2:						
None	-1.22	2.01	-0.51	2.06	-	2.32*
Toturd	-0.65	1.41	0.48	2.20	-1.28	2.28*
Maxadd					-1.17	
Region 3:						
None	0.61	0.21	0	0.39		0.15
Toturd	0.53	0.30	-0.29	0.63	1.13	0.31
Maxadd					-0.18	
Region 4:						
None	1.52	0.98	-1.4	1.32	-	1.09
Toturd	1.31	0.49	-1.17	0.83	-0.73	1.25
Maxadd					1.36	
Region 5:						
None	2.0	-2.37	-3.21	-1.82	-	4.20*
Toturd	1.81	-1.71	-2.25	-1.75	0.30	2.59*
Maxadd					0.28	

[1]F-ratio: significant values are shown by the traditional asterisks (*s)

Region 5 shows contradictory results with relatively large t-values and a significant F ratio but the t-values of the treatment factors vaccination, deworming and feed supplementation, are negatives, making it difficult to believe the results. There was hardly any effect of factors in region 3, though total unplanned reductions had a positive t-value greater than one.

Comparison of all the eight regression models produced final selected best fitting regression model in each region based on the t-values of individual terms and overall F-ratios of the models are shown in Table 6.8.5.

Table 6.8.5: Selected best-fit regression terms for c3-c1 difference in regions 1 - 5.

Region	Best fit regression	Intercept	Parameter estimate	[1]F ratio	Actual mean c3-c1 difference
1	Vac (t1.78), Maxadd(t1.03), Toturd(t=-2.48)	0.75	Vac =4.17 Maxadd =0.33 Toturd =-0.40	3.42*	1.90
2	Vac(t1.63), Spl(t2.29), Maxadd(t= -1.2), Toturd(t=-1.47)	-5.62	Vac =2.27 Spl =3.85 Maxadd=-0.29 Toturd =-0.27	3.44*	0.92
3	Hse(t0.71), Maxadd(t=-0.27), Toturd(t1.11)	-0.01	Hse= 0.64 Maxadd=-0.05 Toturd =0.17	0.56	4.63
4	Hse(t0.99), Maxadd(t1.87), Toturd(t=-0.66)	-5.48	Hse =1.53 Maxadd =0.43 Toturd =-0.25	2.32	4.77
5	Hse(t1.3), Dwm(t=-2.55), Spl(t=-1.38),	10.08	Hse =1.29 Dwm =-3.84 Spl =-1.82	2.85*	1.04

[1]F-ratio: significant values are shown by the traditional asterisks (*s)

The fitted mean cycle 3 and cycle 1 difference (c3-c1) was calculated using mean values of the model factors in each region. There were differences in treatment effects in different regions resulting in different best-fit regression models. In regions 1 and 2, there were particularly strong effects of vaccination. Region 2 was the only region with a feed supplementation effect. Although region 5 has the supplementation included in the best-fit model, the sign is negative and cannot be interpreted as an effect. Housing seemed to have some effect in regions 4 and 5 while also appearing as the only treatment factor in the best-fit regression in region 3 without any effect. There was hardly any effect of deworming in all the five regions probably because it might have been associated with vaccination effect. Generally, therefore, it could be surmised that the three treatments had some effect on egg production variously in different regions. There was however no noticeable effect of any treatment factor in region 3.

Finally, a regression analysis of the cycle3-cycle1 difference was done using combined data from all the five regions in order to find out which factors would provide an overall best fit model. This was done first by trying out seven models containing only the treatment factors. Then nine models with different combinations of the treatment factors plus two demography factors, maxadd and toturd, were considered using similar procedures as for individual regions. Four models of these models with the best-fit regressions were selected and are shown in Table 6.8.6 with respective t and F ratio values. In all the four models, vaccination had the largest treatment effect. There was no indication of any housing effect since its t-value in the full model where it appears only, is very small and negative. There was some appreciable amount of effect of supplementation in two models but deworming was always negative despite its relatively large t-values.

The overall best-fit model for combined data from all the five regions contained the factors vaccination, deworming, and maximum addition and a significant F ratio of 2.65. Vaccination factor in this model had an indication of strong effect on egg production with a t-value of 1.91. However, deworming had a negative t-value and hence a negative parameter estimate making it difficulty to believe that there is an effect from deworming on egg production, contrary to our expectation. Based on this overall model, vaccination was the only treatment with a large enough effect overall in all the regions. Deworming might have been associated with the vaccination and hence not possible to discern its effect.

Table 6.8.6: Most promising overall c3-c1 difference regressions for selecting best-fit regression from combined data of five regions.

Regression model terms	Intercept	Parameter estimate	[2]F ratio
1. Hse (t=-0.09), Vac (t=1.81), Dwm (t=-1.67), Spl (t=1.03), Maxadd (t=1.70), Toturd (t=-1.20)	-1.42	Hse =-0.04 Vac =1.35 Dwm =-1.24 Spl =0.75 Maxadd =0.18 Toturd =-0.11	1.78
2. Vac (t=1.84), Dwm (t=-1.68), Spl (t=1.04), Maxadd (t=1.71), Toturd (t=-1.22)	-1.47	Vac =1.34 Dwm =-1.24 Spl =0.74 Maxadd =0.18 Toturd =-0.11	2.16*****
3. Vac (t=1.75), Dwm (t=-1.61), Maxadd (t=1.87), Toturd (t=-1.3)	1.29	Vac =1.29 Dwm =-1.19 Maxadd =0.20 Toturd =-0.12	2.43*****
4[a]. Vac (t=1.91), Dwm (t=-1.97), Maxadd (t=1.63)	0.01	Vac =1.40 Dmw =-1.41 Maxadd =0.17	2.65*****

[a]4: the selected best-fit overall regression for combined data from five regions;
[1]F-ratio: significant values are shown by the traditional asterisks (*s)

As was stated earlier, cycle 3 and cycle 1 difference (c3-c1) tells about improvement for each farm. The mean values in each of the 20 villages were provided in Table 6.6.15 and showed a generally positive improvement in majority of the villages. This change may be associated in one way or another to the various interventions applied by the farmers. Our regression analysis of the cycle 3 and cycle 1 difference (c3-c1) has indicated that the treatment interventions had some effects on this change.

6.9 Predicted cycle 2 mean eggs laid regression analysis

A similar approach to the one used above in the regression analysis of the cycle 3 and cycle 1 difference (c3-c1) was also used with the predicted mean eggs in cycle 2 which have been described as the best estimate of average values for each farm. The four treatment factors, together with each of the eight demography factors, were used in the initial regressions to find out effects of individual treatments with and without a demography factor. Table 6.9.1 provides the t ratios of the individual factors and the F ratios of overall models of predicted mean eggs. A summary of these models with their overall F-ratios for each region is provided in Table 6.9.2.

From the initial regression results with all treatments included, vaccination and feed supplementation treatments in region 1 had their t ratios, with and without demography, positive and close to or greater than one. In region 2, deworming treatment had large t-ratios but all of them were negative while those of the other three treatments were mostly less than one and negative as well. There seems to have been, therefore, no treatments effects in region 2 probably due to strong masking by unidentified factor/s. Vaccination in region 3 was the only treatment with positive t-ratios and very close to or above one. On the hand, housing treatment had many t-values nearly 1 and all positive in region 4, while the vaccination t-values were all negative even though greater than 1. In region 5, only vaccination had positive t-values close to one. Hence, except for deworming, there is some indication that the other three treatments seem to have had some effect on egg production with the exception of region 5.

Table 6.9.1: Regression of predicted cycle 2 mean eggs production on treatments and demography factors in regions 1-5.

Demo factor	t-values					F-ratio
	Hse	Vac	Dwm	Spl	Demo	
Region1:						
None	0.66	1.46	0.24	1.18	-	0.71
Avgfs	0.69	1.68	-0.15	0.96	1.14	0.84
Totadd	0.64	1.45	0.26	1.18	0.30	0.56
Maxadd	0.63	1.44	0.31	1.19	-0.30	0.56
Totrd	0.71	1.91	-0.31	1.18	1.50	1.06
Toturd	0.78	1.50	-0.27	0.93	0.90	0.73
Totcrd	0.62	1.79	0.11	1.35	1.14	0.83
Baladd	0.67	1.34	0.11	1.05	-0.23	0.55
Avgfsadd	0.68	1.68	-0.05	1.04	1.07	0.81
Region2:						
None	-0.08	-0.03	-1.73	-0.63	-	0.86
Avgfs	-0.10	-0.39	-1.34	-0.53	-0.86	0.83
Totadd	-0.33	0.03	-1.68	-0.9	0.66	0.75
Maxadd	-0.06	-0.04	-1.30	-0.48	-0.08	0.65
Totrd	-0.42	0.1	-2.08	-1.01	1.14	0.96
Toturd	-0.64	0.75	-2.34	-0.31	2.31	1.92
Totcrd	-0.15	-0.04	-1.62	-0.68	0.31	0.67
Baladd	0.1	0.05	-0.79	0.02	-0.61	0.74
Avgfsadd	-0.01	-0.33	-1.09	-0.03	-0.67	0.76
Region3:						
None	0.11	1.02	-0.75	-0.33	-	0.69
Avgfs	0.14	1.0	-0.66	-0.32	-0.11	0.52
Totadd	-0.14	1.2	-1.14	-0.2	1.34	0.93
Maxadd	-0.49	1.42	-1.43	-0.33	1.66	1.16
Totrd	-0.11	0.94	-0.99	-0.37	0.79	0.66
Toturd	0.02	1.15	-1.04	-0.09	0.99	0.75
Totcrd	-0.02	0.92	-0.84	-0.39	0.47	0.57
Baladd	-0.05	1.09	-0.93	-0.31	0.99	0.74
Avgfsadd	0.02	1.0	-0.77	-0.32	0.24	0.53
Region4:						
None	0.99	-1.66	-1.05	-0.07	-	1.55
Avgfs	1.0	-1.59	-1.0	-0.04	-0.73	1.3
Totadd	1.05	-1.49	-0.95	-0.26	0.69	1.29
Maxadd	1.14	-1.4	-1.07	-0.18	-1.1	1.50
Totrd	0.92	-1.64	-0.71	-0.32	-0.48	1.21
Toturd	0.6	-1.53	-0.93	-0.01	0.31	1.18
Totcrd	0.84	-1.63	-0.67	-0.33	-0.53	1.23
Baladd	0.99	-1.46	-0.93	-0.25	-0.72	1.30
Avgfsadd	1.03	-1.55	-0.98	-0.13	-0.8	1.33
Region5:						
None	0.12	0.77	-0.27	-0.8	-	0.46
Avgfs	-0.06	0.67	-0.04	-0.82	0.4	0.38
Totadd	-0.09	0.68	-0.36	-0.82	-0.57	0.42
Maxadd	-0.2	1.19	-0.67	-0.97	-1.2	0.67
Totrd	-0.03	0.6	-0.22	-0.8	-0.33	0.37
Toturd	0.18	0.77	-0.29	0.81	0.35	0.37
Totcrd	-0.30	0.28	-0.21	-1.03	-1.02	0.58
Baladd	0.06	0.70	-0.48	-0.92	0.88	0.52
Avgfsadd	0.07	0.73	-0.15	-0.79	0.16	0.35

Table 6.9.2: **Regression models of treatments with each of eight demography factors and their F ratios.**

Model terms	F-ratios				
	R1	R2	R3	R4	R5
Hse, vac, dwm, spl,	0.71	0.86	0.69	1.55	0.46
Hse, vac, dwm, spl, avgfs	0.84	0.83	0.52	1.3	0.38
Hse, vac, dwm, spl, totadd	0.56	0.75	0.93	1.29	0.42
Hse, vac, dwm, spl, maxadd	0.56	0.65	1.16	1.50	0.67
Hse, vac, dwm, spl, totrd	1.06	0.96	0.66	1.21	0.37
Hse, vac, dwm, spl, toturd	0.73	1.92	0.75	1.18	0.37
Hse, vac, dwm, spl, totcrd	0.83	0.67	0.57	1.23	0.58
Hse, vac, dwm, spl, baladd	0.55	0.74	0.74	1.30	0.52
Hse, vac, dwm, spl, avgfsadd	0.81	0.76	0.53	1.33	0.35

Based on the analysis of the individual t-ratios and model F-ratios for the full regression models with or without demography factors, eight similar promising models as the ones that had been established and investigated to determine the best-fit regressions for the cycle 3 and cycle 1 difference, were also used. They investigated factors with greater influence on the predicted cycle 2 mean eggs in each region. Out of these, the most promising best-fit regression was selected in each region and is shown in Table 6.9.3.

In region 1, the most promising best-fit model was for the vaccination (t=1.53) and feed supplementation (t=1.39) with demography factors, maximum addition and total unplanned reduction. However, for this model, F-ratio was just about one and non-significant. The best-fit regression in region 2 was composed of vaccination (t=0.65) and deworming (t=-1.9) with the two demography factors. The deworming treatment in this model was negative and not quite believable despite its larger t-ratio. Hence, no treatment effect has been established in region 2 even with a significant overall F-ratio. Region 3 had a similar best-fit regression to that of region 2 but with the vaccination treatment being positive and near significant. However, deworming was also large and negative. The model for region 4 had an overall F-ratio of two but the only treatment factor in the model, the vaccination, had a negative though large t-ratio. In region 5, the best-fit regression had three treatment factors, vaccination, deworming and feed supplementation with t-ratios close to or more than one. However, only the vaccination treatment was positive with a t-value of 1.42 that was close to being significant.

Generally, the best-fit regression models among the five regions provide some evidence for presence of the treatment effect of vaccination on egg production represented by the predicted cycle 2 mean eggs.

Table 6.9.3: Selected best-fit regression terms for predicted mean eggs values in regions 1 - 5.

Region	Best fit regression	Intercept	Parameter estimate	[1]F ratio	Observed mean eggs laid values
1	Vac (t=1.53), Spl (t=-1.39) maxadd (t=-0.74), toturd (t=1.09)	18.81	Vac =2.29 Spl =-1.22 Maxadd =-0.14 Toturd =0.10	0.92	23.94
2	Vac (t=0.65), Dwm (t=-1.9), Maxadd (t=-0.71), Toturd (t=2.43)	23.18	Vac =0.48 dwm =-1.66 Maxadd =-0.09 Toturd =0.22	2.52*****	21.65
3	Vac (t=1.76), Dwm (t=-1.70), Maxadd (t=1.43) Toturd (t-0.81)	20.19	Vac =0.98 Dwm =-0.96 Maxadd=0.12 Toturd =0.05	1.61	23.57
4	Vac (t=-1.80), Maxadd (t=-0.86), Toturd (t=0.97)	22.53	Vac =-1.48 Maxadd =-0.06 Toturd =-0.09	2.02	20.41
5	Vac (t=1.42), Dwm (t=-0.93), Spl (t=-1.14), Maxadd (t=-1.53), Toturd (t=0.97)	26.35	Vac =1.72 Dwm =-0.84 Spl =-0.79 Maxadd =-0.33 Toturd =0.09	0.89	19.53

[1]Fitted predicted mean eggs: calculated from mean values of the independent variables in each region; [1]F ratio: significant values are shown by the traditional asterisks (*s)

Table 6.9.4 shows the most promising overall best-fit regressions from combined data of all the five regions. Based on similar criteria to that used previously for selection of best fit regressions in each region, the selected overall best fit regression model for predicted eggs using combined data, is the one with only vaccination, deworming and total unplanned reductions (model 5) and has a significant F ratio of 4.80. The model had t-ratios of 1.42, -3.03 and 2.88 for vaccination; deworming, and total unplanned reduction respectively. The corresponding parameter estimates were 21.2 for the intercept, 0.5 for vaccination, -1.02 for deworming and 0.11 for the total unplanned reduction. In the other models, vaccination had also larger and positive t-ratios compared with the other treatments. Housing had also positive t-ratios mostly closer to one while supplementation had very small but positive t-ratios.

Table 6.9.4: Most promising overall predicted eggs regressions for selection of best-fit regression from combined data of 5 regions

Model	Model terms	[1]F-ratio
1. Hse, vac, dwm , spl, maxadd, toturd	Hse(t=0.79), Vac(t=1.41) Dwm(t=-2.85), Spl(t=0.06), Maxadd(t=-0.62), Toturd(t=2.88)	2.51*****
2. Vac, dwm, spl, maxadd, toturd	Vac(t=1.46) Dwm(t=-2.84) Spl(t=0.09) Maxadd(t=-0.57) Toturd(t=2.91)	2.90*****
3. Hse, vac, dwm, maxadd, toturd	Hse(t=0.79) Vac(t=1.42) Dwm(t=-2.86) Maxadd(t=-0.61) Toturd(t=2.89)	3.04*****
4. Vac, dwm, maxadd, toturd	Vac(t=1.46) Dwm(t=-2.86) Maxadd(t=-0.56) Toturd(t=2.93)	3.65*****
5[a] Vac, dwm, totu rd	[1]Vac(=t1.42), Dwm(=t-3.03), Toturd(=t2.88),	4.80******

[1]F ratio: significant values are shown by the traditional asterisks (*s)

The selected overall regression model with combined data for predicted cycle 2 eggs compares well with the selected overall model for the cycle 3 and cycle 1 differences comprising vaccination, deworming and maximum addition. The treatment factor, deworming, appears with a negative sign in both the cycle 3 and cycle 1 difference and the predicted cycle 2 eggs regressions. Vaccination comes out as the single most important factor influencing the level of egg production but the effect seems better when combined with the demography characters, maximum addition and/or total unplanned reduction. Housing and possibly feed supplementation had also some effect based on their influence on the value of the overall model F-ratios. However, their real effect on egg production seems to have been masked by unexplained factors and hence not easily discernable from our analysis.

6.10 Conclusion

A summary of mean values in each farm of both dependent and independent factors for the best-fit regressions in each region, are shown in Table 6.10.1.

Table 6.10.1: Mean values of predicted eggs and c3-c1 and treatment and demography factors in the best-fit regressions in regions 1 – 5

Region	Mean Predicted Eggs	Mean c3-c1	Mean hse	Mean vac	Mean dwm	Mean spl	Mean maxadd	Mean toturd
1	23.94	1.90	3.25	0.54	1.25	3.83	19.33	18.71
2	21.65	0.92	2.65	1.78	2.74	3.78	23.52	19.30
3	23.57	4.63	3.43	1.91	2.17	4.61	20.78	20.39
4	20.41	4.77	2.94	1.44	1.78	4.05	23.27	17.11
5	19.53	1.04	3.05	0.89	1.68	3.58	16.05	14.26

6.10.1 Treatments effects and regions comparisons

The aim of this farmer participatory research was to investigate the treatment effects of housing, vaccination, deworming and feed supplementation on production characteristics of indigenous chicken in different farms. This chapter has dwelt on the inferential statistical analysis of production characteristics hatchability and egg production using two approaches, variation analysis and regression analysis.

With hatchability the analysis of variation has produced evidence for no cycle effect on hatchability while showing large enough variations within and between farms and consequently between regions. Lack of cycle effects on hatchability could possibly be associated with the fact that the characteristic was more or less man-controlled. The regression analysis provided evidence that a number of variables in four different combinations influenced hatchability levels in different regions. Housing was an important factor in region 2 (Ol Kalou) which is probably associated with the fact that it is one of the coldest areas in Kenya. The region had also the lowest hatchability levels. Supplementation seemed to have some small effect on hatchability in regions 1 and 4 though not convincingly so while deworming seemed only to have some effect in region 2 but the data was also not convincing. Vaccination against Newcastle disease was certainly the most important factor influencing hatchability except in regions 4 and 5

6.10.2 Eggs production

In case of egg production, the analysis of variation provided clear evidence for the presence of cycle effect and some evidence of farm effects on the number of eggs laid in a typical hen cycle in each of the five regions. Hence, it was necessary to consider the two factors in our further statistical analysis of the eggs laid. The actual difference between cycle3 and cycle1 together with the predicted mean eggs laid in cycle 2 were used in regression analysis as the response variables to investigate effects of the treatment interventions on egg production. This was because the predicted mean values for cycle 2 presents the best estimate of average values for each farm, while cycle 3 – cycle 1 difference tells us about improvement for each farm.

6.10.3 c3-c1 difference

Differences in treatment effects on cycle 3 and cycle 1 difference in different regions inevitably produced different best-fit regression models. Vaccination had the greatest effects (regions 1 and 2). There was some indication of a feed supplementation effect in region 2. Housing seemed to have some effect in regions 4 and 5 while also appearing as the only treatment factor in the best-fit regression in region 3 without any noticeable effect. There was hardly any effect from deworming in all the five regions, possibly because it might be connected in someway to vaccination. The three treatments therefore had some effect on egg production variously in different regions.

The overall best-fit regression of the cycle 3 and cycle 1 difference using combined data from all the five regions consisted of vaccination, deworming, and maximum addition. Generally therefore, vaccination was the only treatment with a large enough effect overall in all the regions. Deworming had large t-values but with negative signs.

The cycle 3 and cycle 1 difference shows improvement for each farm, which was generally positive in the majority of the villages. This change may be associated in one way or the other, with the various interventions applied by the farmers. Our regression analysis of the cycle 3 and cycle 1 difference has provided evidence that the treatment interventions had some effects on this change.

6.10.4 Predicted cycle 2 mean eggs

Generally, the selected best-fit regression models in the five regions provide some evidence for the presence of vaccination effect on the predicted cycle 2 mean eggs. Housing had also positive t-ratios mostly closer to one while supplementation had very small but positive t-ratios. The presence of vaccination effect was also evident from the selected overall best-fit regression model for predicted eggs using combined data from all the five regions. This consisted of only the vaccination, deworming and total unplanned reductions factors.

Vaccination therefore comes out as the single most important factor influencing the level of egg production in our farmer participatory research. The effect being seen better when combined with the demography characters - maximum addition and/or total unplanned reduction. Housing and possibly feed supplementation had also some effect based on their influence on the value of the overall model F-ratios. However, their real effect on egg production seems to have been masked by unexplained factors and hence not easily discernable from our analysis.

Egg production in our case was measured in hen-cycles. These were different from the recording of treatments applications, which was done for each period of our visit to the farm. Hence, some hen-cycles would have been recorded long before a treatment application. This probably explains to some extent, the difficulty we experienced in trying to get best-fit regressions.

The results of our analysis indicate that there is strong evidence that farmers' actions, (management), animal behaviour (indigenous chicken hens genetic potential) and environment (regions) all have some influence on the performance of indigenous chicken flocks.

6.10.5 Station research V Farmer Participatory Research

There are some commonalities in the concepts and modalities of carrying out both on-station experimentation and farmer participatory research including on-farm experimentation. However, there are also very distinct and significant differences between the two.

In the on-station experimentation for instance, the initiative, design, planning and implementation, analysis and reporting are made by the research team and follow some standard layout that can be replicated many times over and in different places by other research teams. The on-station experimentation is in many ways less costly while the data collected more precise and dependable. Hence, random variation would be expected to be appreciably small. On-station experimentation is somehow a straightforward undertaking to generate information on specific issues. The downside of this process is that the information so generated usually needs to undergo another process of repackaging and testing among target end users to access its applicability in different specific conditions before it is widely disseminated. On the other hand, farmer participatory research entails active involvement of farmers as the primary stakeholders in most of the stages of the research process.

The participatory concept is an exciting and effective approach to development of, and transfer of knowledge. This was evidenced by the level of involvement of farmers in our research project and the take up of the various treatments interventions. Great enthusiasm was created and sustained all through the process. There was a build-up of strong linkages among the farmers involved and between the farmers and the team of research and development professionals. More importantly, as a scientific research method, the farmers demonstrated that they themselves can record observations in a FPR process at farm level. The data then is analysable through application of a variety of conventional statistical approaches such as graphs, frequency distributions, analysis of variations and regressions. However, it would be important to develop expertise in this field, which may be limited in institutions only familiar with conventional on-station research. Again, a lot of thought should be put into the type of data to be recorded and when it is recorded bearing in mind the capacity and ability of the farmers in this respect. Compromises on this are inevitable in order to allow for illiteracy and innumeracy among participating farmers and to sustain enthusiasm. This calls for frequent farm visits by researchers involved in a project to assist and encourage data recording, which more often than not, is seen as a side issue that is time-consuming, tedious with no tangible and immediate benefit to the poor farmers. All the same proper and timely data recording is a crucial component of FPR if the potential benefit of understandings based on quantitative data are to be achieved.

There is therefore the need for the development of strategies that would maximise opportunities offered by these approaches to create and enhance sustainable livelihoods among poor rural people, especially women.

CHAPTER 7

ANALYSIS OF FLOCK SIZE PATTERNS USING DEMOGRAPHIC INFORMATION

7.1: Introduction

A demographic analysis was carried out using available flock size data for each farm and for each of the five periods of the study. A hundred and seventy three farms were included in this analysis. Dealing with each farm separately and comparing 173 different patterns is intricate and probably not desirable. It would be unlikely to produce useful outputs. The objective of this analysis was therefore to try to find groups of farms with similar patterns so that comparison could be carried out to identify similarities and differences between the groups so identified. These comparisons were done for three sets of characteristics as shown in Table7.1.1. Demography characteristics on additions, reduction, unplanned reductions and controlled reductions were considered as totals in the 5 periods. Treatments were similarly considered as totals in the 5 periods.

Table 7.1.1: Demography, treatment and production characteristics for investigation of similarities and differences between farm groups.

Family of Characteristics	Description of characteristics
Demography[1]	1. Farm flock size at each period
	2. Total flock additions
	3. Total flock reductions
	4. Total unplanned reductions
	5. Total controlled reductions
Treatments[2]	1. Total housing
	2. Total vaccination
	3. Total deworming
	4. Total supplementation
Production	1. Mean hatchability
	2. Predicted egg production per hen cycle

[1, 2]: totals refer to sum value of a character observed or calculated over 5 periods.

Production characteristics of hatchability and egg production were based on a hen's laying and brooding cycle. Mean hatchability per hen over 3 cycles and predicted egg production per hen per cycle were used in our investigation.

7.2 Constituting groups of similar farms in each village

Demographic analysis was carried out to classify farms according to their flock size trends in five periods within and across villages and regions into similar or dissimilar groups. The purpose of this analysis was to summarise flock size categories among a large number of farms into a few identifiable groups with distinct characteristics. The analysis involved the use of a dissimilarity index (DI) defined as the sum of squared differences of flock size values for a pair of farms from period 1 to period five as shown below:

$$\sum (fs_{AP} - fs_{BP})^2$$
$$p=1\text{-}5$$

Where A could be farm 1 and B farm 3 in village 4 region 1. Table 7.2.1 illustrates flock size data used in the calculation of dissimilarity index between farm pairs. The rest of the data from other villages is provided in appendix 7.1.

Table 7.2.1: Flock size of farms illustrated by farms in village 1 and region1 (R1V1).

Farm	Period				
	1	2	3	4	5
LK1	9	13	14	12	18
LK2	21	24	32	30	36
LK3	20	13	14	23	22
LK4	11	13	17	27	21
LK5	20	26	24	38	43
LK6	21	26	29	37	39
LK7	22	26	31	44	55
LK8	10	10	6	10	22
LK9	18	18	13	29	33
LK10	16	20	17	50	52

The square root of this dissimilarity index should correspond with flock size distance between farms or clusters.

The farm DI tabulation includes outlier farms. A farm was considered an outlier if all DI from it are larger than all other DI of farms in the same village as was the case for farm 9 in R1V4 shown in Table 7.2.2.

Table 7.2.2: DI values for pairs of farms in village 4 in region 1 (R1V4) including outlier farm LO9.

Farm	LO3	LO4	LO5	LO7	LO8	LO9[1]	LO10
LO3	0	516	62	899	555	**4627**	222
LO4	516	0	682	519	131	**2335**	438
LO5	62	682	0	1069	617	**5053**	302
LO7	899	519	1069	0	254	**2134**	283
LO8	555	131	617	254	0	**2234**	257
LO9	**4627**	**2335**	**5053**	**2134**	**2234**	**0**	**3387**
LO10	222	438	302	283	257	**3387**	0

[1]LO9: Outlier farm

The farm DI values were calculated from the flock size data on farms in each of the 20 villages as illustrated with village 1 in region1, in Table 7.2.3. Every farm in each village was compared with the rest of the farms individually by their DI value.

Tables 7.2.3: DI values for pair of farms in village 1 in region 1 (R1V1).

Farm	LK1	LK2	LK3	LK4	LK5	LK6	LK7	LK8	LK9	LK10
LK1	0	1013	258	247	1816	1703	3020	86	581	2707
LK2	1013	0	467	504	143	126	611	1187	164	746
LK3	258	467	0	107	1060	979	1992	334	191	1703
LK4	247	504	107	0	999	918	1931	413	258	1564
LK5	1816	143	1060	999	0	27	188	2050	517	421
LK6	1703	126	979	918	27	0	307	2011	542	624
LK7	3020	611	1992	1931	188	307	0	**3210[1]**	1149	313
LK8	86	1185	334	413	2050	2011	**3210[1]**	0	587	2721
LK9	581	164	191	258	517	542	1149	587	0	910
LK10	2707	746	1703	1564	421	624	313	2721	910	0

3210[1]: Maximum DI

To construct groups of farms, a formal method is needed and a set of four concepts were developed and used to identify similar and dissimilar farms in a stepwise order. These concepts are outlined below:

1. Maximum DI - pairs of farms with large DI values were identified and classified as dissimilar and hence to be in different group. In the case of DI illustration for village R1V1 (Table7 2.3), pairs with large DI are:

- LK1 & LK7 (DI=3020), LK1 & LK10 (DI=2707), LK1 & LK5 (DI=1816), LK1 & LK6 (DI=1703)
- LK3 & LK7 (DI=1992), LK3 & LK10 (DI=1703)
- LK4 & LK7 (DI=1931), LK4 & LK10 (DI=1564)
- Lk5 & LK8 (2050), LK6 & LK8 (DI=2011), LK7 & LK8 (DI=3210), LK8 & LK10 (DI=2721)

2. Minimum DI – pairs with smaller DI values were considered similar and had to be in the same grouping. This included the following pairs:

- LK1 & LK8 (DI=86)
- LK5 & LK6 (DI=27)
- LK3 & LK4 (DI= 107)
- LK2 & LK5 (DI=143)
- LK2 & LK6 (DI=126)

Based on these two concepts, groups can already be discerned though they are made more distinct through two follow-up concepts. Thus group1includes (LK-1, 8…), group 2 includes (LK-5, 6...), and group 3 includes (LK-10).

3. Acceptable 20% of maximum DI or 500 – 600 minimum DI – this is the level of DI above which pairs of farms were considered dissimilar or below which they are taken as similar. This was set at 20 percent of maximum DI or 500 – 600 minimum DI depending on the general level of farm DI across villages. In our illustration with village R1V1, 20% of the maximum DI of 3210 was 642. The remaining farms were then placed in the groups where they closely fitted with a few fitting into more than one group. Thus, group 1 (LK-1, 8, 3, 4, 9); group 2 (LK-5, 6, 2, 7, 9); group 3 (LK-10, 7).

4. Average DI – When a farm appeared to fit reasonably into two groups, a criterion was defined to make final group decision. Average DI was used for this purpose where farms LK7 and LK9 were eventually allotted to specific groups. This being the group whose average of individual group members' DI was the smallest paired with farm LK7 or LK9. In our illustration, DI of group 1 farms paired with farm LK9 was:

LK1&LK9 – DI=581

LK8&LK9 – DI=587

LK3&LK9 – DI=191

LK4&LK9 – DI=254

Average DI=403

Similarly, DIs in group 2 farms paired with LK9 were also averaged –

LK2&LK9 – DI=164

LK5&LK9 – DI=517

LK6&LK9 – DI=542

Average DI=408

Thus, farm LK9 just marginally fits into group 1 better than it does in group 2. Similarly, calculation of average DI to distinguish which of the groups 2 and 3, farm LK7 is better fitted placed it in group 3 as shown below.

Group2:

LK2&LK7 – DI-611

LK5&LK7 – DI=188

LK6&LK7 – DI=307

Average DI-369

Group 3:

LK10&LK7 – DI=313

5.Grouping – this was the final step of listing groups as discerned from the above principles. Three clear and distinct farm groups were identified in our illustration village 1 in region 1 (R1V1). Ten farms in the group were then reduced to only three farm groups with distinct characteristics. These are listed below in no specific order, each with its sets of farms:

Group 1: - LK1, LK3, LK4, LK8 and LK9.

Group 2: - LK2, LK5 and LK6.

Group 3: - LK7 and LK10.

This process of grouping and distinction between similar and dissimilar farms respectively was done for all the 20 villages involved in the study based on dissimilarity index values between pairs of farms as outlined above. A standard coding of the resultant groups was adopted and used in further grouping across regions. Hence, from the above illustration, groups 1, 2 and 3 were coded as 111, 112 and 113 respectively, representing region 1, village 1 and group number.

In some cases, a few farms could not fit in any of the identified groups and were regarded as outliers. Some of these outliers were eventually combined into other groups from a different village in subsequent stages. Table7.2.4 gives an illustration of demographic groups for region 1 that were thus, identified and coded, while a summary of all identified groups from the 5 regions is provided in Table7.2.5.

Table 7.2.4: Similar farm groups in each of the 4 villages of region 1 resulting from dissimilarity index identification principles

Region	Village	Groups and farms	No of farms
1	R1V1	111 – (LK1, LK3, LK4, LK8, LK9)	5
		112 – (LK2, LK5, LK6)	3
		113 – (LK7, LK10)	2
	R1V2	120 – LS3 (Outlier)	1
		121 – (LS4, LS6, LS7, LS8)	4
		122 – (LS1, LS2, LS5)	3
		123 – (LS9, LS10)	2
	RIV3	130 – LC2 (Outlier)	1
		131 – (LC1, LC3, LC7, LC8)	4
		132 – (LC4, LC5, LC6, LC9, LC10)	5
	R1V4	140 – LO9 (Outlier)	1
		141 – (LO3, LO5, LO10)	3
		142 – (LO4, LO7, LO8)	3

Table7.2.5: Farm groups formed from the five initial clustering principles in five regions.

Region	Village	Identified Farm Groups[1]	No of farms
1	1	111(5), 112(3), 113(2)	10
	2	120(Outlier farm-1), 121(4), 122(3), 123(2)	10
	3	130(outlier farm-1), 131(4), 132(5)	10
	4	140(outlier farm-1), 141(3), 142(3)	7
2	1	210(Outlier-1), 211(4), 212(2), 213(3)	10
	2	221(2), 222(4), 223(2)	8
	3	231(4), 232(4)	8
	4	240(Outlier-1), 241(4), 242(2)	7
3	1	310(Outlier-1), 311(4), 312(5)	10
	2	320(outlier-1), 321(4), 322(3), 323(2)	10
	3	331(5), 332(4)	10
	4	340(Outlier-1), 341(3), 342(3)	7
4	1	411(4), 412(3), 413(3)	10
	2	420(outlier-1), 421(outlier-1) 422(outlier-1), 423(5)	8
	3	431(3), 432(2), 433(3)	8
	4	440(outlier-1), 441(3)	4
5	1	510(outlier-1), 511(2), 512(7)	10
	2	521(3), 522(5), 523(2)	10
	3	531(5), 532(3), 533(2)	10
	4	540(outlier-1), 541(6), 542(3)	10

[1]Identified Farm Groups: number in brackets represents number of farms in a group.

7.3 Combining village groups in each region

Average flock size among the identified farm groups in each village was determined as illustrated in Table 7.3.1 for group 111 in village 1. Table 7.3.2 shows the average flock sizes of all the identified groups among the four villages in region 1. Appendix 7.2 provides plots on average flock sizes of all the identified farm groups and outlier farms in the five regions.

In classification of groups using flock size values, village average would be unsuitable when identified groups are distinctly different as was the case here.

Table 7.3.1: Average flock size determination illustrated for farm group 111 in village R1V1

Farm	Period				
	1	2	3	4	5
LK1	9	13	14	12	18
LK3	20	13	14	12	22
LK4	11	13	17	27	21
LK8	10	12	6	10	22
LK9	18	20	13	27	33
Average Flock size	14	14	13	20	25

Table 7.3.2: Average flock size for farm groups in four villages in region 1.

Village	Farm Group	Period					No of farms
R1V1	111	14	14	13	20	25	5
	112	21	25	28	35	41	3
	113	19	23	24	47	54	2
R1V2	120 (OTL)[1]	28	33	39	53	33	1
	121	28	25	21	16	15	4
	122	44	50	40	42	28	3
	123	37	33	33	20	40	2
R1V3	130 (OTL)	9	2	12	13	12	1
	131	14	25	26	30	32	4
	132	13	19	10	17	23	5
R1V4	140 (OTL)	44	48	53	43	38	1
	141	12	18	12	19	28	3
	142	18	32	25	25	30	3

[1]OTL: outlier farms

In our illustration of farm classification with the four villages in region 1, thirty seven (37) farms were aggregated into 10 groups and 3 outliers. Formation of similar farm groups and outliers within villages was then followed by further identification and grouping of similar groups across villages within, and latter on, across regions. Some of the outliers were eventually aggregated with one or the other of the farm groups within or across regions.

A classification system with the new farm groups and outlier farms within regions followed the above process and was based on characteristic patterns of groups. Table 7.3.3 provide an illustration of the new classification across villages within region 1. Groups with similar and dissimilar patterns were identified using a criteria that considered: (1) level of flock size, whether low (L: 10 - 20), medium (M: 20 – 35), or high (H: >35) and (2) direction of flock size trend, either increasing, decreasing or level at start, middle or end of period.

Table 7.3.3: Groups classification and categorisation by flock size level and trend illustrated for Region 1.

Within Region group	Village farm groups	Level and trend of flock size	Description and category	No. of farms
1	111,132, 141	10–20 LLM (↑↓↑)	Hyper group 1 (HG11)	13
2	131, 142	20-30 LMM (↑→↑)	Hyper group 2 (HG12)	7
3	122, 140(OTL)[1], 240(OTL, R2V4)[2]	40-50 HHH (↑↑↓)	Large group 1 (LG11)	4 +1
4	121	30-15 MML(↓↓↓)	Large group 2 LG12	4
5	112	20- 40 LMH (↑↑↑)	Small group SG11	3
6	113	20–55 LMH (↑↑↑)	Small group SG12	2
7	123	20-40 HMH (↓↓↑)	Small group SG13	2
8	120 (Outlier)	25-50 MHM (↑↑↓)	OTL11	1
9	130 (Outlier)	2-15 LLL (↓↑→)	OTL12	1

[1]OTL: means outlier farm, [2]240 (OTL, R2V4): outlier farm brought from region 2 village 4

The resulting groups were categorised depending on the number of farms and villages they come from as: (1) Hyper groups (with more than 1 village and more than 5 farms); (2) Large groups (with 1 village and more than 4 farms); (3) Small groups (with 1 village and more than 3 farms); and (4) Outliers (with only 1 farm).

There was also clustering with groups across regions as shown by the composition of the larger group, LG11 that included an outlier farm numbered 240 from region 2 village 4. This large group LG11 seems more of a hyper-group based on the criteria provided of more than one village but since there were only five farms – 4 from region 1 and an outlier brought from region 2, a decision was made to categorise it as a 'large group'.

The classification process in this stage therefore, resulted in seven groups and 2 outliers for region 1 which we have used here to illustrate the process of grouping farms. These groups were, two hyper-groups (HGs), two large groups (LGs), three small groups (SGs) and two outliers (OTLs). Hence, we have managed in this stage to reduce farm groups from the 10 groups and 3 outliers in the previous stage to the 7 groups and 2 outliers. The same procedure in this stage was applied in the other four regions resulting in further reductions in the number of farm groups categories per region.

Confirmation of the validity to this new classification of village farm groups to regional farm groups was based on dissimilarity index values between respective pairs of village farm groups as illustrated below for regional groups 1, 2 and 3 in region 1 from Table 7.3.3 and calculated using average flock size for each group at each of the five periods. Pairs of village farm groups with small DI values (less than 200) were put in the same regional group.

1). Hyper-group HG11 (111, 132, 141) dissimilarity index values:

111v132 – (1 + 25 + 9 + 9 + 4) = 48,

111v141 – (4+ 16 + 1 +1 + 9) = 31,

132v141 – (1 + 1 + 4 + 4 + 25) = 35

2) Hyper group HG12 (131, 142) dissimilarity index values:

131V142 – (16 + 49 + 1 + 25 + 4) = 95

3) Large group LG11 (122, 140, 240) dissimilarity index values:

122v140 – (0 + 4 + 49 + 1 + 100) = 154

122v240 – (0+4+25+64+1) = 94

140V240 – (0+0+64+49+81) = 194

Small groups and outliers in the illustrated region 1 had single villages and farms respectively and no dissimilarity index within group was calculated at this stage.

A summary of the number of regional farm groups in each region is provided in Table 7.3.4 together with their respective number of farms. The categories of regional farm groups were identified from village groupings of farms and coded as HGs, LGs, SGs, and OTLs and indicated with the number for respective regions. One important observation was that, in each of the five regions, there were two hyper-groups, represented by HG11 and HG12 for region 1 as have already shown in our illustration. On the other hand, the LG category was represented only in regions 1 (two LGs) and 3 (one LG)

Table 7.3.4: Summary of type and number of regional farm groups in 5 regions

Regional farm group category	Region				
	1, (farms)	2, (farms)	3, (farm)	4, (farms)	5, (farms)
HG	2, (20)	2, (26)	2, (27)	2, (21)	2, (31)
LG	2, (9)	0, (0)	1, (5)	0, (0)	0, (0)
SG	3, (7)	3, (6)	1, (2)	2, (6)	3, (8)
OTL	2, (2)	1, (1)	2, (2)	3, (3)	1, (1)

Table 7.3.5, shows a summary of the number of cluster groups and outliers in all the five regions both at village and regional level. In region 1 for instance, from a total of about 40 farms in 4 villages, 10 village farm groups and 3 outliers were identified at village level, and across villages, 7 regional farm groups and 2 outliers were identified at the region level.

The process of classification from 40 farms to village and then regional groups was relatively easy as there were large enough differences to discern similar and dissimilar groups. However, the follow-up stage proved more challenging as it was difficult detecting similarities. The process involved development of concepts into which groups had to be fitted.

Table 7.3.5: Summary of number of groups and outliers at village and region level in five regions, identified by initial demography analysis.

Region	Level	
	Village (Groups, Outliers)	Region (Groups, Outliers)
1	10, 3	7, 2
2	10, 2	5, 1
3	9,3	4, 2
4	10, 2	4, 3
5	9, 2	5, 1
Total	48, 12	25, 9

Table 7.3.6 provides the average flock size of all identified groups in our illustration with region 1.

Table 7.3.6: Average flock sizes of regional farm groups for region 1 over 5 periods.

Regional farm group	Period					No. farms
	1	2	3	4	5	
HG11	13	17	12	19	25	13
HG12	16	18	25	27	31	7
LG11	44	50	43	42	30	4
LG12	28	25	20	16	15	5(1 from R2)
SG11	21	25	28	35	41	3
SG12	19	23	24	47	53	2
SG13	37	33	33	20	40	2
OTL11	28	33	39	53	33	1
OTL12	9	2	12	13	13	1

Average flock sizes of regional farm groups in all the five regions are provided in appendix 7.3. DI values between groups in the same category in region 1 are shown in Table 7.3.7. These DI values are clearly large enough for pairs to be in separate groups.

Table 7.3.7: DI between groups from same category in region 1

Group pairs	DI between groups
HG11 vs HG12	(9+1+169+144+36)=359
LG11 vs LG12	(256+625+529+676+225)=2311
SG11 vs SG12	(14+4+16+144+64)=242
SG11 vs SG13	(256+64+25+225+1)=571
SG12 vs SG13	(324+100+81+729+169)=1403
OTL11 vs OTL12	(361+961+729+1600+400)=4051

7.4 Combining groups across regions

The regional farm groups in all the five regions were the basis for a further classifying in the next and final stage of identification of similar and dissimilar groups. This stage involved combining groups across regions. As was the case in the earlier classification, flock size average of each group was taken using individual farms in each group.

The criterion used in the final classification stage focused on how large a group was and the flock size level and trend. These groups were codenamed final groups (FINALGPs). The first final group (FINALGP1) comprised all the HG1s from the five regions. Confirmation of group cohesiveness among regional farm groups making up the finalgps was also done by calculation of dissimilarity index values as in the previous group confirmations. The final farms classification procedure therefore produced seven distinct farm groups and three outliers (10 FINALGPs) as shown in Table 7.4.1 which provides a profile of these final groups with their distinct characteristics and number of farms. The outliers were single farms entities that could not fit with any other farms.

Table 7.4.1: Final farm groups (FINALGPs) formed by combining regional farm groups across regions.

Final Farm Groups (Finalgp)	Regional farm groups	Characteristics	No of farms
1	HG11, HG21, HG31,HG41, HG51	Small flock size level (15-25) increasing slowly	76
2	HG12, HG22, HG32, HG52, SG11, SG41, SG52	Small to medium flock size (15-30)	50
3	HG42, SG12, SG51, OTL31	Small to high flock size (15-60) differ with finalgp2 at period5	13
4	SG21, SG42, OTL11, OTL21	Medium to high flock size (25 - 60) varying	7
5	LG12, SG13, SG22	Medium flock size decreasing to low (35 – 15)	8
6	LG11, LG31, SG23, OTL22, OTL42, OTL51	High and steady flock size (35-45)	14
7	SG31, SG53, OTL12	Very low flock size levels (0-15)	5
8	OTL32	Unusually very High flock size levels (110-140)	1
9	OTL41	Very low to high flock size (0-50)	1
10	OTL43	Medium to unusually very high flock size (25-160)	1

Tables 7.4.2 and 7.4.3 illustrate regional farm groups flock sizes and dissimilarity index values respectively for the final farm group 1 (FINALGP1). The flock sizes among the hyper-groups in the FINALGP1 were close and similar in their trend as the low dissimilarity indices demonstrates. They also increased from low levels of 13 in period 1 to a near medium level of about 23 in period 5.

Table 7.4.2: Average flock sizes of regional farm groups in FINALGP1 over 5 periods.

Regional farm group	Period					No. farms
	1	2	3	4	5	
HG11	13	17	12	18	25	13
HG21	15	20	13	18	16	15
HG31	15	18	12	17	23	11
HG41	16	20	13	17	25	14
HG51	14	17	16	18	24	23
Average flock size total farms	14.5	18.3	13.4	17.7	22.7	76

Table 7.4.3:Dissimilarity index values between pairs of constituents hyper groups in FINALGP1

Group	HG11	HG21	HG31	HG41	HG51
HG11	0	96	13	31	19
HG21		0	55	83	83
HG31			0	10	20
HG41				0	24
HG51					0

Table 7.4.4 provides the average flock sizes of the seven final groups of farms and three outliers with a description of their levels and trends. The different flock size categories vary from very low (FINALGP7), to small and increasing (FINALGP1)) with many farms falling into this category, and upwards to 'high and steady' (FINALGP6). The DI between pairs of the seven FINALGPs shown in Table 7.4.5 provide clear evidence for distinctiveness of each of these seven groups from one another with many values being quite large and much greater than the DI values of constituents hyper groups of FINALGP 1 we have just looked at in the previous paragraph.

Table 7.4.4: Average flock size for seven final farm groups and three outlier farms (OTL) over 5 periods.

Final farm group	No of farms	Period 1	2	3	4	5	Description
1	76	15	18	13	18	23	Small increasing
2	50	19	26	29	34	34	Small to medium
3	13	18	25	28	44	53	Small to high
4	7	29	37	47	61	44	Medium varying
5	8	29	25	22	15	26	Medium decreasing
6	14	39	44	42	40	36	High steady
7	5	13	8	10	8	11	Very low
8 (OTL)	1	123	135	116	113	112	
9(OTL)	1	52	21	2	0	4	
10(OTL)	1	25	32	75	11	162	

Over 70 percent of the farms fall in the category of final groups 1 and 2 with a characteristic flock size level of small and increasing to medium. Group 7 had the least number of farms, ignoring the three outliers as they were single entities and had also, the lowest flock size levels. Generally, the flock size values are particularly a function of the interventions and hence a response to our influence as research team.

Table 7.4.5: Dissimilarity index values between pairs of seven final groups (FINALGPs)

FINALGP1	1	2	3	4	5	6	7
1	0	713	1890	3423	344	2746	357
2		0	464	1274	575	1093	1926
3			0	996	1727	1303	3671
4				0	3209	679	6364
5					0	1279	843
6						0	4020
7							0

The largest two final groups, 1 and 2 were fairly evenly distributed among the regions as shown in Table 7.4.6. The two groups also comprised the largest proportion of farms in each region (mostly 10 and above) compared to the other final groups.

In summary, the demography analysis used dissimilarity index as a tool for differentiating, and confirming groups classified from among individual farms through to village clusters and on to regional groups and lastly down to the final farms grouping. The one hundred and seventy three farms with varying flock size trends over 5 periods were reduced first into 48 village groups and 12 outliers as shown in Table 7.4.7. The village groups were further classified into a smaller number of 25 regional groups and 9 outliers. Finally, a further elaboration of classification reduced regional groups into seven final groups and 3 outliers each with a distinct characteristic pattern defining it.

Table 7.4.6: Distribution of farms among the final groups in five regions

Final Farm Group	Region				
	1	2	3	4	5
1	13	15	11	13	23
2	10	10	16	3	11
3	2	0	2	7	3
4	1	3	0	3	0
5	6	2	0	0	0
6	4	3	4	1	1
7	1	0	2	0	2
8 (outlier)	0	0	1	0	0
9 (outlier)	0	0	0	1	0
10 (outlier)	0	0	0	1	0
Total farms	37	33	36	27	40

Table 7.4.7: Summary of distribution and number of farm groups at village and regional level

Region	Village farm groups & outliers	Regional farm groups & outliers
1	10 & 3	7 & 2
2	10 & 2	5 & 2
3	9 & 3	4 & 2
4	10 & 2	4 & 3
5	4 & 2	5 & 1

7.5 Comparison between final groups

The final groups were then investigated for their differences on the levels of the following factors:

- Average farm flock sizes at five different periods
- Treatment characteristics (housing, vaccination, de-worming, and supplementation)
- Demography characteristics (total flock additions, total flock reductions, total unplanned reductions and total controlled reduction)
- Production characteristics (mean hatchability and egg production per hen per cycle based on predicted egg production).

The investigations involved analysis of variance done only for the seven final farm groups excluding the three outliers and used standard general linear models (GLM) statistical procedures of SAS. To check for significant differences between groups, a two-way Duncan-Dunnett sample test was done to separate different means. The analysis of the average flock sizes of the final groups was done at each of the five periods for the treatment and demography characteristics. Totals for the five periods were used while in the case of the production characteristics, the average mean hatchability and egg production per hen-cycle were used. The outlier farms were left out due to the obvious distortion of information they were likely to introduce.

Table 7.5.1 shows a summary of the analysis of variance model or between groups mean square on 6 degrees of freedom because there were only seven final groups. The three outliers were excluded to avoid distortion of statistical analysis result by exaggerating mean values of the groups. The analysis was done for each period.

Table 7.5.1: Analysis of variance for average flock size among 7 final farm groups in five periods

Period	Between/Model MS (df)	Within/Error MS (df) [1]	F – ratio
1	1513 (6)	28 (166)	54.5
2	1915 (6)	32 (166)	60.1
3	3208 (6)	47 (166)	68.7
4	4462 (6)	61 (166)	73.0
5	2428 (6)	94 (164)	26.9

[1]df: the degrees of freedom of error MS in period 5 reduced by removal of 2 farms with flock sizes values of zero and 3.

Overall, the results from the analysis indicate significant differences between the final groups hence confirming the distinctness of the groups as categorised, as well as affirming the validity of our classification procedures using the dissimilarity index values. Only the comparisons 1v5, 1v7 and 2v3 were non-significant twice in five periods. No comparison was non-significant more than twice. In case of groups 1 and 5, both had close flock size values at periods 4 and 5. Groups 1 and 7 were close to each other flock size-wise at periods 1 and 3, as was the case with groups 2 and 3.

Table 7.5.2 shows significance comparisons of flock sizes between the final groups in periods 1 to 5. Almost all the differences were significant at 1 percent level. There was a rise in differences of the between and within groups mean squares from period 1 to 5 as a result of the flock sizes levels also increasing with period. This is better shown using pair-wise comparison standard errors for final group pairs with large differences in their number of farms provided by Table 7.5.3 which also includes the flock size differences between the pairs.

Table 7.5.2: **Significance comparisons between groups on average flock sizes in period 1-5**

Group Comparison	Period significant level[1]				
	1	2	3	4	5
1v2	***	***	***	***	***
1v3	*	***	***	***	***
1v4	***	***	***	***	***
1v5	***	**	***		
1v6	***	***	***	***	***
1v7		***		*	*
2v3		*		***	***
2v4	***	***	***	***	*
2v5	***		**	***	*
2v6	***	***	***	*	
2v7	*	***	***	***	***
3v4	***	***	***	***	*
3v5	***		*	***	***
3v6	***	***	***		***
3V7	*	***	***	***	***
4v5		***	***	***	**
4v6	***	*		***	
4V7	***	***	***	***	***
5v6	***	***	***	***	*
5v7	***	***	**		*
6v7	***	***	***	***	***

[1]Period significant level: 3 stars refers to significant level at 0.1%, 2 stars, 1% and 1 star at 5%

Table 7.5.3: Pairwise standard errors comparisons on flock size of large groups at 5 periods

Group Pairs	No of farms (n1, n2)	Period[1]														
		1 (s^2=28)			2 (s^2=32)			3 (s^2=47)			4 (s^2=61)			5 (s^2=94)		
		Diff	SE	CIW	Diff	SE	CIW	Diff	SE	CIW	Diff	SE	CIW	Diff	SE	CIW
1v2	76, 50	4.3	0.96	3.8	9.9	1.03	4.1	16.1	1.24	4.9	16.7	1.42	5.6	11.2	1.76	7.0
1v3	76, 13	3.6	1.59	6.2	6.5	1.70	6.7	14.8	2.06	8.1	26.8	2.34	9.3	30.0	2.91	11.5
1v4	76, 7	14.3	2.09	8.2	18.7	2.23	8.8	33.2	2.71	10.7	43.3	3.08	12.2	20.9	3.83	15.1
2v3	50, 13	0.78	1.65	9.63	3.4	1.76	6.8	1.3	2.13	12.4	10.0	2.43	9.6	18.8	3.02	11.9
2v4	50, 7	10.0	2.13	8.4	8.8	2.28	9.0	17.2	2.77	10.6	26.6	3.15	12.5	9.7	3.91	15.4
3v4	13, 7	10.8	2.48	9.8	12.2	2.65	10.4	18.5	3.21	12.6	16.5	3.66	14.5	9.1	4.54	17.9

[1]Period: Diff = difference in flock size between pairs of final groups; SE = standard error; CIW = confidence interval width

The standard errors (SE) provide the precision with which the difference is determined, and as such are standard errors of the difference. The larger they are, the less the precision and hence the lower the significant level of the difference. This implies that pairs with similar differences might have different significant levels depending on their SE values, as was the case between the pairs, 1v2 and 1v3. The differences, SE, and confidence interval width all increased with period.

Summaries of the treatment, demography, and production parameter mean values for the final groups are given in Tables 7.5.4, 7.5.5 and 7.5.6 respectively.

Table 7.5.4: Average levels of treatment characteristics and number of farms in each final farm group category.

Final Farm Group	No of farms	Total Housing	Total Vaccination	Total Deworming	Total Supplementation
1	73	2.82	1.21	1.94	3.67
2	48	2.56	1.10	1.80	4.06
3	13	3.08	1.54	1.77	3.85
4	8	4.25	1.25	2.0	3.87
5	8	2.25	1.75	2.37	3.75
6	14	3.0	1.36	2.14	3.86
7	5	1.6	1.0	3.2	4
8	1	5	2	5	5
9	1	5	2	3	5
10	1	4	2	2	4

NB: Values are average totals in each farm in 5 periods for each character.

The number of farms used in the investigation with egg production parameters, was less than for the other categories of characteristics mainly because not all farms whose flock size information was available had also records on egg production.

The treatment characteristics application levels (Table 7.5.4) had little differences between groups but housing and feed supplementation had larger values than the other two characteristics. Treatment characteristics were much influenced by our intervention as a research team and were more or less uniformly applied due probably to the near equal coverage access of all participating farmers to our information and expertise.

The demography characteristics, total addition and total reduction values (Table 7.5.5) were close to one another among the groups. Inevitably, the flock sizes in period 1 would also be expected to be close to flock sizes at the end of period 5 (start of period 6), which has not been included in our presentation but was used to determine demography values in period 5. For instance, in the case of the final group 1, the difference between the two, which is 4.2, added to flock size value of 15 in period 1, is 19.2.

Table 7.5.5: Average levels of demography characteristics and number of farms in each final farm group category.

Final Farm Group	No of farms	Total Addition	Total Reduction	Total Unplanned Reduction	Total Controlled Reduction
1	73	55.1	50.9	17.7	33.4
2	48	62.4	53.8	18.8	35.0
3	13	72.5	53.4	15.6	37.9
4	8	68.3	68.1	16.1	52.0
5	8	66.2	72.9	27.3	45.6
6	14	47.7	68.8	17.1	51.7
7	5	52.0	51.8	23.0	28.8
8 (outlier)	1	195	199	26	173
9 (outlier)	1	157	198	26	172
10 (outlier)	1	213	178	14	164

NB: Values are totals in 5 periods for each character.

The demography characteristics had little influence from the research team but were mostly a reflection of individual farm decision and activities. On the other hand, the production characteristics (Table 7.5.6) reflected more both the farmer’s action and the hen potential. The final group 7 with the lowest flock size trends had production values close to those of other groups. This would suggest that low flock size level in a farm is not a reflection of poor production dynamics.

Table 7.5.6: Average values of production characteristics among 7 final groups and outlier farm 8

Final Farm Group	Number of farms	Mean Hatchability	Predicted Eggs/hen/cycle
1	48	70.3	21.8
2	36	68.3	22.7
3	9	71.4	21.1
4	6	73.5	23.5
5	5	73.6	21.3
6	8	71.9	20.9
7	3	74.6	20.5
8	1	85.7	15.5

Table 7.5.7 provides the between and within mean squares with F values from the analysis of variance on treatment, demography and production characteristics differences of the final groups. The pair-wise significant comparisons for these characteristics are shown in Table 7.5.8.

Table 7.5.7: Analysis of variance summary with treatment, demography and production characteristics

Characteristic	Between Groups / Model Mean squares (df)	Within Groups / Error Mean Squares (df)	F-ratio
1. Treatments:			
Housing	5.1 (6)	4.8 (162)	1.1
Vaccination	0.78 (6)	1.3 (162)	0.6
Deworming	1.84 (6)	1.4 (162)	1.31
Supplementation	0.78 (6)	1.3 (162)	0.6
2. Demography:			
Total Addition	1194 (6)	281 (162)	4.2
Total Reduction	1326 (6)	277 (6)	4.8
Total Unplanned Reduction	156 (6)	93 (162)	1.7
Total Controlled Reduction	1155 (6)	185 (162)	6.25
3. Production:			
Mean Hatchability	58 (6)	124 (108)	0.47
Predicted Eggs	8.7 6)	7.9 (99)	0.47

The treatments application differences between the final groups were not significant and could be a consequence of influence from the research team being more or less the same in all the farms. Hence, less variation between farms would be expected, and in practice, there were only four significant differences for housing, 3 for deworming, 1 for supplementation. On the other hand, the demography characteristics, total addition, total reduction and total controlled reduction had significant differences between groups.

As was the case with flock sizes levels, the demography characteristics, total addition, total reduction and total controlled reduction were a manifestation of individual farmer's management decisions. Farmers would have had little influence on the total unplanned reduction. In the significant levels comparison of final farm groups (Table 7.5.8), there was no single significant difference among the groups on vaccination and production characteristics – mean hatchability and egg production. Production characteristics may have been more influenced by hen factors, which may not have been different among the different final groups. The flock demography dynamic characteristics were under direct influence of farmers' actions and these varied from farm to farm which might explain the reason behind the observed effects. The demographic characteristics differences between farms compares well with significant levels on flock size differences between farms shown earlier, especially the total additions, total reductions and total controlled reductions.

Table 7.5.8: Pairwise standard errors comparisons[1] of final farm groups on treatment and production parameters

Group Pairs	Treatments			Demography			
	Housing	Deworming	Supplementation	Total Additions	Total Reductions	Total Unplanned Reductions	Total Controlled Reductions
1v2			*(p=0.07)	*			
1v3				**			
1v4	*(p=0.08)			*	*		***
1V5				p(0.10)	***	*	*
1v6					***		***
1v7		*					
2v3				*			
2v4	*				*		**
2v5					**	*	*
2v6				**	**		***
2v7		*					
3v4					*		*
3v5					*	*	
3v6				***	*		*
3v7		*		*			
4v5	* p(0.0697)					*	
4v6							
4v7	*						**
5v6				*		*	
5v7					*		*
6v7		*(p=0.09)			*		**

NB: p is the probability associated with the F-statistics level of significance and the smaller the value the higher the significance level. It is advisable to indicate value of p for single star levels (>5%).

[1]significant level: 3 stars refers to significant level at 0.1%, 2 stars, 1% and 1 star at 5%

7.6 Conclusions

A striking observation emerging from clustering of farms across villages and within regions is the predominant hyper-groups (HG1 and HG2), being represented in all the 5 regions with almost equal abundance. The HG1s from all five regions constituted the final farm group 1 (FINALGP1) with characteristic low flock size levels that increased slowly over the periods. Inevitably, this was also the group with the largest number of farms (76).

Flock size trends of the final farm groups and outliers were plotted and are shown in Figures 7.6.1(a-d). The final farm groups 1, 2, 3 and 6 are considered large farm groups (with high number of farms) and 3, 4, 5, 6 and 7 (small number of farms) as small farm groups for the purpose of having clearer observation and better understanding of specific groups trends.

Group 7 had characteristically very low flock size all along in contrast to the first outlier farm (group 8) with unusually very high flock size all along. The second outlier farm (group 9) started with a high flock size level but progressed rapidly downwards to zero at period 4 while the third outlier farm (group 10) started at medium level and increased to unusually very high levels.

The flock sizes levels in the group with a large number of farms (Figure 7.6.1c) went down between period 2 and 3. This could be attributed to the fact that there was a longer phase between the two visiting periods than was normal between other visits occasioned by parliamentary electioneering campaigns period that coincided with the visits, which had to be postponed. There was also a problem of ethnic conflict in some sections of regions 1 and 4 forcing many farmers to abandon recording of information. In extreme cases, some farmers moved out of their farms altogether, abandoning the project.

Generally, the process used to classify farms into similar groups based on the level and trend of the flock sizes was a great success given the establishment of the 7 distinct farm groups categories and 3 outlier farms. The dissimilarity index technique though, is very sensitive to small changes in the number of entries and care should be taken to check the data for any possible mistakes.

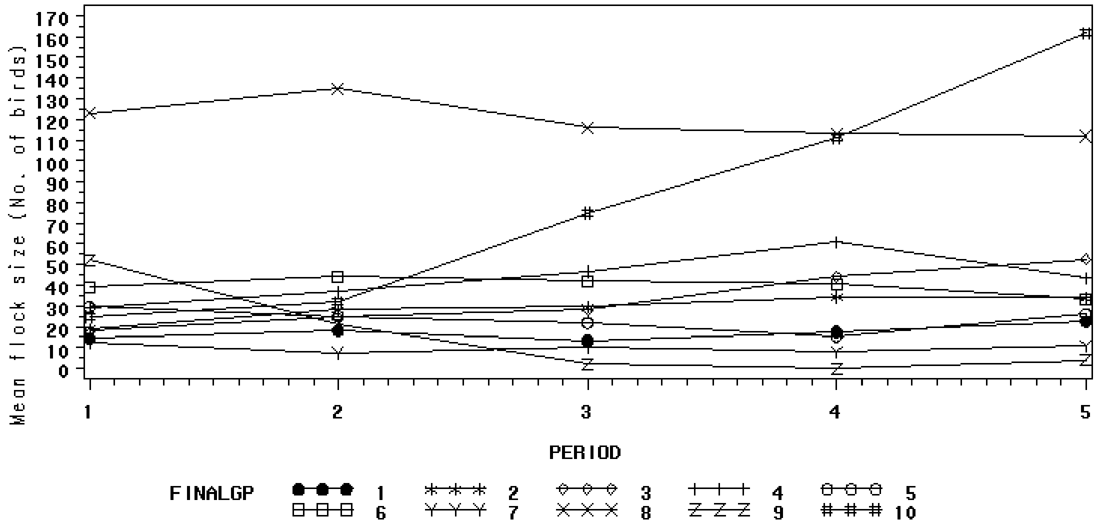
This kind of analysis provides a better insight of the structure in the larger flock size data. The process of “mathematisation” in cluster analysis guarantees objectivity in that the same results are reproduced independently of the experimenter if the same data set and the same procedures are used (Godehardt, 1988).

In classification of groups using flock size values, village average would be unsuitable when identified groups are distinctly different as was the case here.

The analysis of variance made it possible to validate the flock size classification using values of dissimilarity group index between farms.

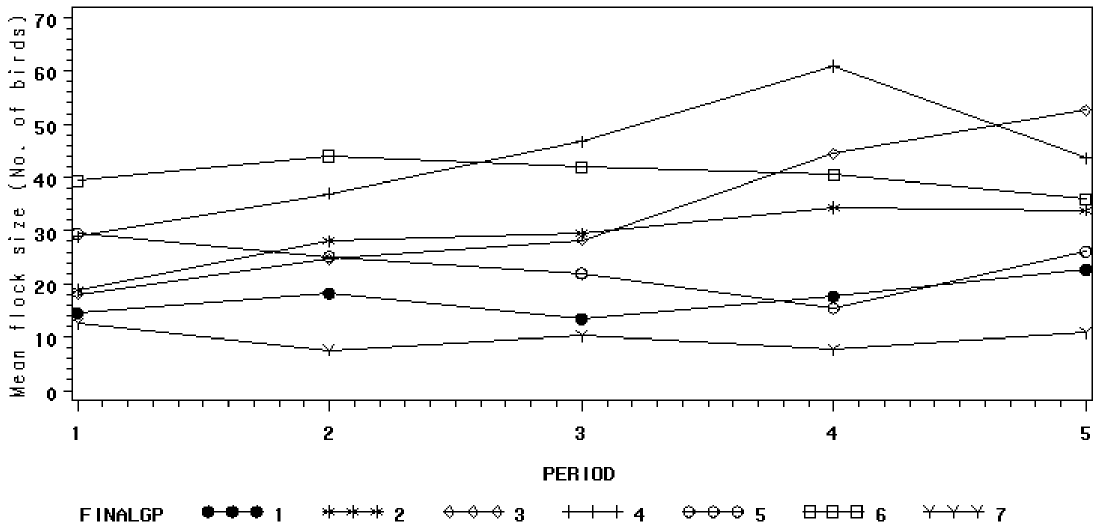
The flock sizes levels and demography characteristics were a manifestation of the individual farmer’s management decisions, which varied from one farm to another. On the other hand, the treatments application levels were more than anything else influenced by the research team and were almost similar among the participating farmers. The production characteristics values had much influence from hen factors.

Figure7.6.1a. FLOCK SIZE OF FINAL FARM GROUPINGS PLOTTED AGAINST PERIOD



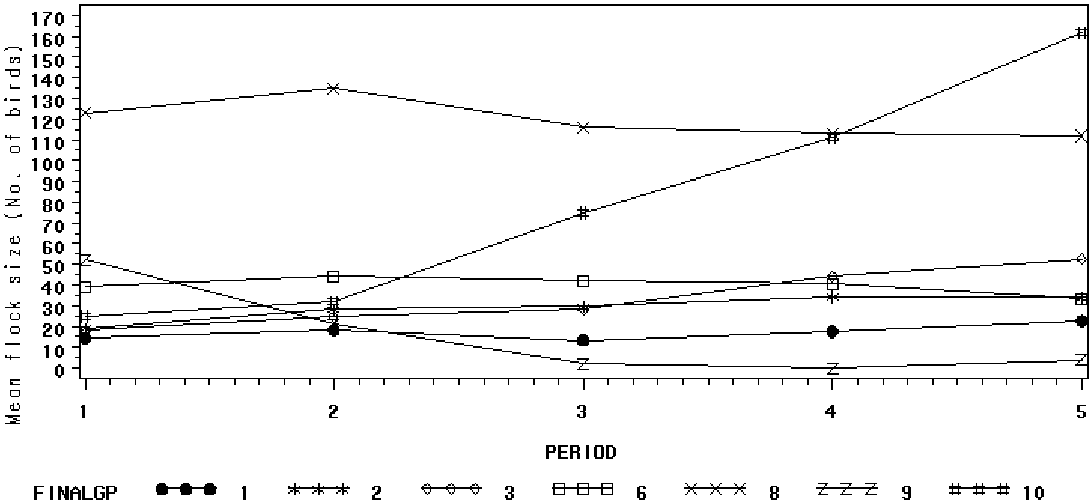
FINALGP=8, 9, 10 are outlier farms (OTLS)

Figure 7.6.1b. FLOCK SIZE OF FARM GROUPS EXCLUDING OTLS PLOTTED AGAINST PERIOD



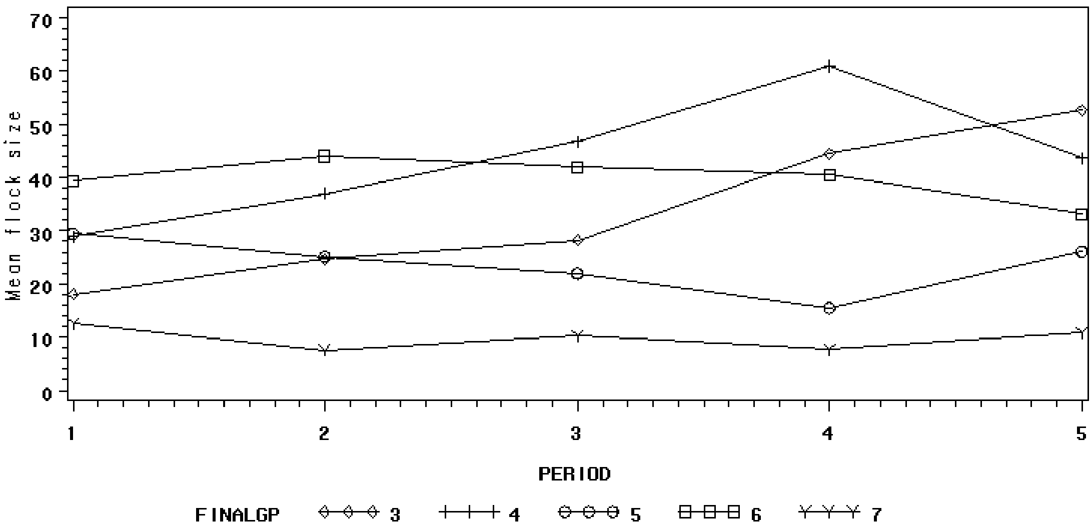
FINALGP=3, 4, 5, 6, 7 make up a cluster of groups with smaller number of farms

Figure 7.6.1c. FLOCK SIZE OF LARGE FARM GROUPS AND OTLS PLOTTED AGAINST PERIOD



FINALGP=8, 9, 10 are outlier farms (OTLS)
FINALGP=1, 2, 3, and 6 contain the largest number of farms

Figure 7.6.1d. FLOCK SIZE OF SMALL FARM GROUPS PLOTTED AGAINST PERIOD



FINALGP=3, 4, 5, 6, 7 contain smallest number of farms

CHAPTER 8

DISCUSSIONS, CONCLUSIONS AND SUGGESTIONS FOR FURTHER WORK

8.1 General remarks

The study combined sets of approaches in a research process to investigate the status and performance of Kenyan indigenous chickens, and their potential in poverty alleviation and a sustainable livelihood strategy, and to evaluate the effect of improved management practices or technological interventions. These approaches included:

- Carrying out of a number of on-station conventional experiments that were entirely researcher designed and managed.
- Gathering and sharing of information and experiences from and with stakeholders (through workshops, visits, surveys and literature review.).
- Undertaking farmer participatory research (FPR) to evaluate improved management practices in production of indigenous chickens at the farm level.

The research served to demonstrate the extent to which indigenous poultry systems in Kenya and elsewhere mostly in sub-Saharan Africa, are now considered an important strategy with considerable potential as a livelihood opportunity for poor people. There has been substantial attention focusing on these systems in the recent past and in a variety of ways from stakeholders in trying to understand their character and to devise strategies to maximise their potential. The work of this thesis describes and analyses strategic approaches applied in the development of improved indigenous poultry systems in Kenya. The research process was a mix of conventional or traditional on-station contractual type research and more recent participatory research approaches at farm level. The latter could be termed to be in the mode of a collaborative and to some extent, collegial type research, as described in chapter 2, with a substantial proportion of stakeholder consultations. Farmer Participatory Research has gained a lot of attention and seems to be the method of choice for many development-oriented research projects in the recent past. However, universally applicable guidelines on statistical methodologies in the design, implementation and analysis of FPR are yet to be developed. This thesis has attempted to provide an example of a methodology for conducting FPR with application of a combined set of both descriptive and inferential statistical tools to analyse information and data collected from such a process.

Some pertinent issues from the analyses of the data and information gathered, from the review of literature, from on-station experimentation, and farmer participatory studies, as well as suggestions on the way forward, are considered in this concluding chapter.

8.2 Information gathering and sharing

Information gathering and sharing was undertaken using a set of approaches of which the stakeholders' workshops, field visits to a number of selected key individuals and organisations and farm-level baseline surveys involving adaptation of some participatory rapid appraisal (PRA) tools were the major components. Additionally, important information was sourced from available literature.

The process created an opportunity for learning from different people with divergent views, experiences and knowledge about indigenous poultry systems and strategies to tap their livelihood potential. Some of the important outcomes of these activities included:

- Establishment of strong linkages among various stakeholders was an important precondition for effective partnerships.
- The experience from baseline surveys, like that of the on-station research, informed the subsequent on-farm farmer participatory research activities. They served to enlighten the research team by providing valuable insights into the real situations and circumstances surrounding the farmers and an understanding of how to interact and deal with the farmers, the agricultural extension personnel and other stakeholders.

- The stakeholders workshops brought together individuals, representatives of farmer groups, government extension services, local universities, non-governmental organisations, the animal feed industry, drug manufacturers and suppliers, commercial poultry producers and chick multiplier/suppliers, who explored the status of the poultry industry in general, its challenges and opportunities, and made suggestions for improvement as a strategy to combat poverty.
- The workshops brought about a greater understanding of divergent views of the different stakeholders, which was useful in the development of the farmer participatory research project and helped to avoid duplications. The contributions included, among others, information on major local production systems, production constraints and farmers solutions to the researchable constraints at farm level.
- Consultations and sharing of information and experiences brought about close interaction among the various stakeholders (mainly farmers, extension personnel, researchers, policy makers and donors) and helped to break up the walls of individualistic approaches that had been the norm for a long time over the years in the way research and development projects were carried out.

Following the consultation process, the on-farm farmer participatory research proposal was formulated differently from approaches used previously in the priority-setting workshops where farmers, as the primary stakeholders, would not have been as intensively involved in research processes at farm level. In our later approach however, farmers were actively involved in the whole research process from selection through implementation to monitoring. Farmers' own resources were the main inputs. Major decisions made on project sites involved consulting with the extension team. The extension people were also fully aware of the project objectives and were at the forefront in supporting the farmers through all the project phases. Without their indispensable contributions, this project would not have been as successful as it was.

Leaving the research process to move at the pace and discretion of the farmers, as a result of the information gathered from the field visits and from the survey experience, was a radical change of attitude on the part of the research team. The research process with indigenous chicken has brought a new dimension in the way various stakeholders view this category of chicken. They are now taken to be a valuable asset of rural farmers, particularly women who normally have little if any access to, and control of, local resources and benefits. A more friendly and accommodating working relationship was established in which farmers' abilities and capacities were made indispensable for the success of the research project.

Involvement of rural farmers, especially women and their resources and incorporation of their knowledge in a research process, ensured sustainability and successful undertaking of the project.

Mutual understanding between parties, respect and trust in other peoples' knowledge, ability and importance in the project was developed as 'social capital' that helped 'fund' the project and drove it to the extent that data and information was generated with full involvement of the parties concerned, specifically the rural farmers.

The research process had a wide range of participatory perspectives as provided in the preceding chapters. The farmer participation strategy in particular was a means of empowering the poor rural farmers to believe in themselves and develop a sense of self-worth.

Recent literature documentation and reports on FPR practices provide strong support for our research strategies and evidence that we have been part of a sector of those who are pioneering the making of FPR a practical reality. This is considered further later in the chapter in the context of the now current participatory paradigms.

8.3 On-station research

The on-station research on indigenous chicken provided the impetus for our thrust into the farmer participatory on-farm research due to the interest it attracted from people in positions of influence, thereby obtaining necessary financial and other support. Information and data generated from on-station research provided important knowledge and confidence necessary to engage with the farmers at farm level. A number of on-station studies to investigate characteristic performance of the indigenous chickens under standard management regimes and the dietary effects on their growth patterns were undertaken. Four different experimental studies have been concluded as part of this thesis as described in chapter 4. Two of the papers are published in internationally recognised journals - (1) Tropical Animal Health and Production – Growth performance of indigenous Kenyan chicken fed diets containing different protein levels and (2) Tropical Agriculture (Trinidad) – 'Hatching characteristics of eggs from six reciprocal crosses of indigenous Kenyan chickens artificially incubated'. The third paper – 'Growth characteristics of indigenous chicken lines and a cross with Rhode island red in Kenya' has been accepted for publication in the Tropical Agricultural (Trinidad). The fourth – 'Growth characteristics of six reciprocal crosses of Kenyan indigenous chicken', has also been submitted for possible publication (see appendix 3.7, Box 3.9). The highlights of the findings from the four pieces of experimental studies include the following:

- During the early stages of growth (up to 10 weeks) of indigenous chicken, there are no major differences between male and female birds. However, thereafter, male birds gain more weight and therefore require more nutrients than the female birds.

- In early stages of growth of indigenous chicken, high protein content in their diets is suitable and hence farmers should feed their chicks and grower birds separately from older birds. Locally available protein-rich materials vary with regions. They could be in form of legume plant seeds or young vegetative plant parts or animal products like egg white, fermented blood, termite moulds and rumen contents to mention but a few.

- There are distinct differences in growth patterns of indigenous chickens originating from different regions in Kenya. This diversity is a good and important characteristic that can be exploited in breeding strategies to improve genetic potential of indigenous chicken and ultimately productivity. It is also an indication of how valuable indigenous chickens are as a local resource readily and abundantly available to rural households.

- Investigation of the hatching characteristics of eggs revealed differences in fertility, hatchability, reproductive capacity and embryo mortality among the reciprocal crosses. There were consistent patterns of differences in the parameters in the two consecutive batches of hatching eggs used in the investigation.

- Use of growth models such as Gompertz allows utilisation of all data of body weight collected continuously over time from hatching, in a statistical analysis that improves accuracy of predictions made.

- Covariance analysis is a powerful statistical tool that allows simultaneous evaluation of a main factor effect and effect/s from other hidden factors that would interfere with accuracy of any deduction made from an experiment. The analysis allows for correction of such interference.

- The chi-square analysis used to investigate differences on the hatching characteristics of eggs from indigenous Kenyan chicken crosses was a useful tool that provided strong evidence for the presence of differences between the crosses.

8.4 Farmer participatory research

Farmer Participatory Research was carried out with a primary objective of evaluating effects of improved management practices on performance of indigenous chickens at farm level and most importantly, the consequences for farmer participation in the implementation of the research activities. We were highly enthusiastic about working directly with farmers in their own surrounding, situations and circumstances and were not only able to impart our ideas and visions, but also learnt from their rich experiences. Training and sensitisation sessions were held within and around farmers' localities prior to the onset of research itself and attended by the farmers in the project and others not involved, as well as the local extension representatives. Farmers themselves collected and recorded a lot of information and data with some guidance from their local extension persons. The research team counter-checked and collected additional data and information during regular visits to the farms. These were mainly on treatment applications characteristics (housing, vaccination, de-worming and feed supplementation); flock demography and production characteristics (egg production, eggs set and hatchability).

8.5 The Farmer Participatory Research process in the context of current development paradigms

Little knowledge of the now current development paradigms informed the undertaking of the participatory research process described in section 3.5. The impressionable involvement of farmers in the research process came about just from the intuition and desire for a real and sustainable change by the author and his team given the limited experience and understanding at the time. This section endeavours to present the process within the context of current development parameters and standards as a way of making the experiences of the research process available for reference by anyone involved with similar objectives, especially in livestock based activities.

8.5.1 Project outline

Chapter 2 has an extensive presentation of farmer participatory research and related concepts. This section looks at the extent to which the research process with indigenous chickens in Kenya encompass the concepts based mainly on the suggestions and criticisms put forward by Okali and colleagues (1994).

Our research studies and processes with indigenous chickens have attempted to have active participation of various stakeholders and in particular, farmers and local extension service personnel. There was, in a sense, 'drama and sense of negotiation' in the design, implementation and monitoring components that involved a lot of farmer participation. The aim was to create a sense of ownership of the research process by the farmers and the extension service. This was also a means of overcoming the problems of limited resources available to undertake the project. The process of site selection involved various levels of participation of stakeholders. Researchers used agro-ecological zone (AEZ) profiles to select five regions. Local extensionists in turn selected villages within each region with guidance from the researchers based on farm size and AEZ profiles. The farmers selected depended on individual farmer's willingness to participate in the research process in the knowledge that there would be no handouts as inducements. Some of the farmers contacted did not wish to participate. Some innovations and practices by farmers were incorporated into the project as part of the options of interventions available for participating farmers to choose from.

Contacts were made and links established early in the project period with several NGOs such as the Catholic Docese of Nakuru's agricultural department, National Council of Churches of Kenya (NCCK) sustainable agriculture programme Farming Systems Kenya, local universities (private and public) such as Egerton, Nairobi, JKUAT, and Baraton. In addition, visits were made to government departments (Livestock, Agriculture, Veterinary, and Administration) at district and village levels. Other visits were to projects working with government departments such Arid and Semi-arid Lands (ASALs) project in Laikipia and West Pokot, and GTZ'S goats and poultry improvement project in Nyeri. These extensive consultations aimed at securing involvement of as many stakeholders as possible and to strengthen linkages especially among farmers, extensionists and researchers, and to accelerate the flow of information. This was also a way of sensitising others on the importance of indigenous chicken and their potential role in rural development. Hence, the indigenous chicken project had inputs of various stakeholders whose views and experience were instrumental in the planning and implementation of project activities. Another important factor is that this interaction ensured a co-ordinated approach to research and development activities on indigenous chickens within the project area. An illustration of this is the notable point that, the ASAL project in Laikipia engaged the services of one of the researchers in the indigenous chicken project to do an evaluation of a poultry exchange project (Ngunjiri *et. al*., 1998).

The design of the project wholly depended on the choice individual farmers made of the available intervention options. The challenge to the researchers was how to analyse statistically information from this kind of research set-up. There is less control and routines than that associated with the conventional approach of strict data and information recording by researchers, in monitoring this kind of project. Farmers themselves did most of the activities especially the recording. Records taken included, egg production and utilisation, mortality, broody hens and hatched chicks, and flock structure dynamics. Other recording was on feeds and feeding (feed supplementation) and medication. The farmers identified five or six hens to monitor individually and gave them names for easier identification.

The indigenous chicken project was part of a wider Kenya Agricultural Research Institute (KARI) poultry research programme and had some elements of approaches defining steps in the process of technology development similar to the CIMMYT model (Okali, et al., 1994). The project methodology also had approaches focusing on level, character or mode of participation in programme or activity similar to the Biggs participatory framework (Okali, et al., 1994). The project criterion was as an agricultural research programme as opposed to community or general development programmes.

Close to 500 farmers attended the training sessions across the project area with slightly less than fifty percent of them being women.

8.5.2 Innovations

The farmers' innovations and practises incorporated into the project's technological options included the following:

- Usage of various herbal materials for medication

- Portable chick brooding pen or basket
- Synchronised and consecutive hatching as a strategy for the production of chicks.
- Use of larger poultry species (ducks and turkeys) for brooding and guarding against predators.

A strong case for inclusion of farmers' own innovations in the indigenous chicken project was a realisation by researchers of the fact that farmers have been experimenting with various innovations as a survival strategy for a long time. The fact that farmers had indigenous chickens which they had introduced in various regions, made their consideration as research partners appropriate, if not essential.

8.5.3 Research approach rationale

The research process encompassed some principles of Farming System Research (FSR) but mostly those of the FPR. There was more decision-making by farmers and a broader or wide range of options and parameters observed. The farmers' organisation as groups helped to access some external inputs that would otherwise be difficult for individual farmers to access on their own. The project was researcher-conceptualised (FSR approach) but research-extension-farmer designed (approach of both FSR and FPR) and largely farmer implemented (FPR approach). The project incorporated both research and farmer innovations.

Most reported FSR focuses on high yielding varieties and breeds. The methodology used by the indigenous chicken project placed great emphasis on the use of local resources with minimal reliance on external inputs. This is an important strategy for poor farmers especially in marginal areas cut off from centres of inputs and services. The technologies involved in the project were suitable and appropriately designed for farmers in such areas. The subjects of the research project, the indigenous chicken, are also well adapted to marginal environments. Almost every household would have some birds. The indigenous bird is itself a local resource, but more significant is its association with the most marginalised group, the women.

The project on indigenous chickens was conceptualised to be both research and development focused. In addition to observing the different ways various farmers try out the available technological options and their effects on production characteristics, there was also a focus on poverty reduction and the issue of empowerment especially of the most disadvantaged section of the rural population, mainly the women. These are the issues central to most development organisations' agenda.

The indigenous chicken project activities were in three categories looking at the framework of the relationship between actors in the research process. The first category of activities was in the consultative mode, and included the baseline surveys involving the use of semi-structured and unstructured interviewing, as well as seeking to establish the farmers' willingness to participate. Other activities included farmer training and sensitisation workshops where they actively participated in discussions and identification of priority constraints and opportunities. During the training sessions, group members agreed to the pooling of resources together among themselves for a common course. Some external inputs such as vaccines and roofing materials were thus to be jointly acquired. The second category of activities fell under a collaborative mode. Farmers actively participated in deciding and selecting type of innovation(s) and time of starting the experiment(s). Farmers were also responsible for taking records. Another example under this mode of participation was the way in which farmers selected a number of hens among their flocks and gave them individual names for identification during monitoring of egg production and other reproductive characteristics. In the collegial mode, farmers were encouraged to use their own indigenous knowledge in bringing in some innovations to add to the options of interventions available from formal science. It involved use of local herbs for disease control and treatment in their chicken flocks, brooding of chicks using locally made baskets, use of larger birds such as ducks and turkeys for hatching and protection from predators and use of local non-conventional feedstuffs.

Concerning the aspect of sustainability, the indigenous chicken project had as its hallmark, emphasis and focus, the use of locally available resources in undertaking the research activities. Pooling of efforts by farmers was encouraged for those inputs that had to be sourced from outside. The formation of clusters (groups) of ten farmers each for every village selected aimed to achieve this objective. In several clusters, farmers were able to acquire Newcastle disease vaccine, roofing iron sheets and contributed labour for construction of chicken houses. Most of the clusters that adopted this strategy had a majority of female membership. These strategies and focus seemed to have ensured a sustained interest in and a continuation with, the various activities of the research process among the farmers as they had learnt how to progress without much dependence on outside support and with less external inputs. The records farmers kept and observation made during visits to a number of farms after the project was phased out was evidence of this.

The indigenous chicken project methodology had both qualitative and quantitative aspects. The aspect of focusing on attitudinal change of the way indigenous chicken are viewed by farmers and researchers, the process of involving farmers, use of their knowledge and resources and observing effects these would elicit, could be seen in a qualitative perspective. On the other hand, involvement of different regions and villages and the recording of observations enabled a quantitative analysis.

The indigenous chicken project, pursued as a research project albeit with an implicit development agenda, was mainly in the domain of FPR as opposed to development per se. However, this included interactions that promoted 'empowerment' of the rural people through raising awareness of their self-worth and the importance of their actions and choices in harnessing local resources to improve their livelihoods.

The indigenous chicken project adapted an approach that encompasses both agricultural research and community development approaches in the sense that it had a 'technical' component and focused on group organisation and process of farmer participation. The project farmers were organised into groups (clusters) of ten farmers each in the four locations (villages) within each region selected. They shared knowledge and often pooled their resources and efforts together for a common good as indicated above. The organisation of farmers in such a manner developed a spirit of competitiveness as individuals strived to excel over their compatriots. This was deliberately encouraged as a way of increasing farmers' confidence in their abilities and capacities.

Key issues often associated with FPR include selection of participants, sustainability of the investigation process, consideration of an agro-ecological perspective, effects on research agendas and information needed prior to project implementation. The indigenous chicken project, had some similar considerations, including for example; selection of farmers based on their willingness to participate in the research. Selection of five different regions and four villages per region met the agro-ecological criteria of a FPR process. Use of farmer's own local resources and adaptation of technologies to suit farmers' situations was encouraged.

As regards groups or individual farmers' approach, the project adapted the strategy of forming new groups even where old groups formed for other purposes existed, but focused on individual farmers within the groups and monitored them. This was to avoid biases by existing groups focused on a certain issue or objective. This could influence their perception and undertaking of the new project and thus affect its outcome.

From the literature on FPR the indigenous chicken project falls within the domain of a FPR project involving groups/clusters of farmers with much attention given to activities of individual farmers in addition to focusing on their collective actions.

Characterising participation in the indigenous chicken project includes information sharing, consultation, decision-making and initiating action. The indigenous chicken project started on the concepts of FSR approach but went further into more emphasis on farmer involvement in the project activities. The focus was on farmer empowerment and sustainability. There was much faith placed on participant farmers and a belief in their abilities to harness their capacities with little dependency on external inputs.

From the environmental aspect of FPR, some of the indigenous chicken project sites were in arid and semi arid zones - ASALs (Laikipia and Naivasha). Farmers in these sites have been experimenting with various types of innovations and strategies to tame the often harsh and difficult environment. An example was the harvesting and storing of surface rain run-off, used for growing vegetables, and enabling some agro-forestry activities on farmers' smallholdings.

8.5.4 Information gathering and project undertaking

Gathering of information is vital for successful programme planning. In our case, extensive visits and consultations undertaken in addition to the workshops, yielded important knowledge, information and experience that was used to inform the subsequent proposal formulation and the research process that followed it.

Both the information gathering process and project implementation involved much farmer participation. During farmer training seminars, the problems were discussed with the farmers and opportunities identified. The subsequent on-farm trials involved farmers virtually in every stage from, planning, design and implementation to monitoring.

The farmers' knowledge and experience in coping with harsh environments was recognised and informed decisions made during the research process. This included the growing of drought resistant and drought-escaping (have short growing period, an advantage with short rain periods) crop varieties such as sorghum, millet and a number of pulses recommended for use in chicken diets. Others were the use of herbal medication such as *Aloe spp*. and pepper, chick-brooding pens and baskets, non-conventional feedstuffs such as wild berries and *Cucurbitae spp*., and hatching and brooding management.

The recognition of, and respect for, the indigenous or local knowledge by researchers facilitated creation of mutual trust and acceptance. This was also a way of creating social capital (Narayan, 1997; Pretty, 1995) and an enhanced sense of ownership of the research process by the farmers, thereby enabling sustained project activities and enthusiasm. The information gathered from farmers' knowledge and experiences spread to other areas during project implementation.

The deliberate effort made to allow farmers to choose which intervention to try out and when, was part of the processes of empowerment of farmers seen as fundamental in the indigenous chicken project. Both the farmers' own knowledge and researchers' formal scientific expertise used in the project reflected the collegial and contractual modes of participation adopted.

8.5.5 Other crucial project highlights within participatory paradigm context

As noted earlier in chapter two, research activities take place within a political, social, economic and agro-climatic context. The political situation was volatile between periods one and two and disrupted research activities in some villages where a number of farmers had fled their homes and farms due to fear of attack. This was particularly serious in two villages, Olmoran in Laikipia and Likia in Njoro.

Despite the general lack of attention by and support from the service providers, the traditional indigenous chicken production system has withstood the test of time. The presence of indigenous chicken in virtually every homestead in rural areas albeit in small numbers as part of poor people’s livelihood assets is evidence of this. This is despite the myriad problems hindering development of this system. The indigenous system of production is sustainable and well adapted to a variety of agro-climatic conditions. The system has a rich array of local knowledge and is less reliant on external inputs. The low regard of the system, as evidenced by much emphasis on exotic chicken by development agents while discouraging rearing of the local chickens has among other causes, contributed to low productivity in the traditional system. The initiation of the indigenous chicken project was motivated by the above realities.

In line with the notion that rural farmers innovate and adapt in changing circumstances, the indigenous chicken project took an approach focusing on individual farmers as well as their groups in different locations. Farmers were left free to choose interventions from a basket of options they felt best suited an individual's abilities and capacity.

On the issue of gender, the indigenous chicken project targeted the rural women who have traditionally been involved in rearing chicken. Many women have more access to and control of the indigenous poultry system compared to other enterprises where men dominate in decision-making. Over sixty percent of selected farmers in the indigenous chicken project were women. The farmer-training sessions were organised in different locations at sites convenient to the farmers, and especially the women. The sites were usually a farmer's compound, a local school, a church or social hall with sessions lasting 3 to 4 hours. The teaching of improved management practices appropriately modified to fit farmers' situations and circumstances, used visual aids including photos, drawings, feeding materials, assorted equipment, live birds, and eggs among others. The medium of communication was a mixture of the national language, Kiswahili, and the local dialect, Kikuyu, with technical reading materials provided written in simple and easily understood format, style and language. The training sessions were on group basis.

Even being a FPR concept, the indigenous chicken project did not divorce itself wholly from a FSR approach. It was initially conceptualised with ideas from FSR but unlike the focus and approach in FSR, FPR allowed farmers to have more voice in decision making thus being more farmer empowering. During the training and sensitisation activities of the project, farmers became aware of their responsibilities and the control they had over the project's activities. The farmers were motivated to undertake and sustain the experimentation process. The effect of this was that for over a period of one year the farmers were able to carry on with the project, monitoring independently of either extension or research personnel.

The project took into account the importance of traditional knowledge systems and incorporated such practices as the use of herbal materials as a disease management strategy. This was in the realisation of the fact that farmers have used herbs to manage their flocks with varying degrees of success for a long time. This use of herbs both as a curative and prophylactic strategy aimed to give confidence to the farmers in their traditional practices and to forge mutual trust between them and researchers, and hence create some social capital. While most of the farmers were initially shy to admit their use of herbs, they later readily showed off their collections of herbal materials and the purpose for which they used them. Despite lack of any scientific information on the efficacy of such herbs and procedures of their application, we encouraged their usage but cautioned that farmers should use conventional disease control measures in addition to herbs.

One specific limitation of local knowledge and its practice in the indigenous chicken project was a prevalence of inbreeding within the flocks of birds because farmers tended to use the same cocks over long periods. This resulted in small sized and weak birds due to concentrations of lethal genes.

Local knowledge needs therefore, be complemented by researcher's scientific knowledge. This can enhance rather than undermine farmers’ confidence in their abilities and capacity. In one example, a farmer in one project area felt disappointed by the research team's insistence on the importance of local resources and knowledge during a training session. He was of the opinion that researchers’ scientific knowledge is important. Generally, there should be respect for, and recognition of those IKS with a potential of improving the farmers' conditions. They may however, need to be more thoroughly understood and modified to be effective and suitable.

The indigenous chicken project also placed a lot of importance on the use of local resources (local chicken, non-conventional feeding materials such as amaranth, herbs in disease management and building materials (earth floor, mud wall, grass thatch) an issue that came up frequently during the farmers training seminars and other forums. This strategy was most empowering and a means of making sense of the participatory paradigm, which was the theme of the project. This meant that the poorest of the poor among the project farmers would be able to take up or carry on with the project activities without recourse to external sources for inputs. Such a strategy aimed to minimise dropout rate and speed up achievements of the project's goals. Another positive aspect of using local resources is the instilling of confidence on farmers on their resources and their ability to shape their own destiny and to have a sense of self-worth. Farmers changed some negative attitudes they had towards these birds, quickly and proudly showing off their flock and telling of the birds' production performance. Thus, the "inferiority complex" finally disappeared and the indigenous chickens got the status they deserved as valuable livelihood assets for poor people.

Only a minimal use of external inputs was encouraged. In this aspect, a number of farmers pooled their resources to acquire such inputs as Newcastle disease vaccine as advised. Individually, most if not all rural farmers would find it beyond their means to purchase the vaccine besides being uneconomical due to the packaging used. The minimum dosage pack is for about a hundred to two hundred birds while farmers have only 10 to 20 birds on average. This is an example of an input farmers cannot do without but is unaffordable unless they use a strategy of buying the vaccine as a group. Organising the farmers into groups helped to achieve the adoption of such a strategy. The organising into groups was also meant to facilitate farmer-to-farmer learning and create some kind of competition.

A example of how the use of local resources could be empowering especially to rural women, is how a certain landless female farmer who reared indigenous chickens was able to buy a small piece of land where she put up a house for her family. She relied solely on local resources to develop her enterprise. The research team learnt a lot from this woman who became a highly prized asset and a source of encouragement to the project mission.

The indigenous chicken project addressed the issue of the limits of the use of local resources by aiming at progressive advancement of farmers from subsistence through a semi-commercial to a commercial small-scale but sustainable production system and one that is compatible with their environment and circumstances. The focus was to exploit advantages in both indigenous and formal knowledge systems. Flexibility of the project allowed for differences among farmers in their abilities and capacities. Households able to afford some external inputs were encouraged to use them where returns promised some profits without compromising on sustainability in activities such as housing, feeding and disease management. Less endowed households could use their own resources for the same project activities while adapting the same scientific principles as those with more resources. Such farmers would find more use for herbal materials in disease management than would be the case with their relatively well off compatriots. This flexible approach determined choice of an appropriate design structure for statistical analysis of data collected from the project's various activities.

Farmers' seminars aimed at training and sensitising them to acquire some necessary skills and raise their confidence and self-assurance. This information helped the farmers as they implemented various project tasks. The seminars also targeted the extension and research teams with the hope of changing any negative attitude towards indigenous chicken production systems.

The strong research-extension-farmer linkage established helped to concretise the issue of ownership and a sense of belonging. This created mutual trust and understanding among the stakeholders in line with the concept of social capital creation. Extension agents in the project benefited from the farmers' training seminars. The purpose was to enable the extension personnel on the ground to assist and guide farmers in their experimentation with confidence and to give feedback to the research team. Their active participation in the research activities enabled wider and faster coverage in supervision than would otherwise have been possible with limited resources (human, financial and time).

The seminars and workshops focusing on specific issues were also organised as forums where farmers freely discussed and exchanged ideas with researchers and amongst themselves. This allowed them to discover potential solutions existing and practised elsewhere.

The project's activity plan envisaged intra and inter-group visits by farmers to enhance learning and enthusiasm with the project. This would eventually support achievement of the sustainability objective of the project by enabling farmers to experiment with various innovations motivated largely by their peers, and hence rely less on external expertise.

8.5.6 General overview

The study has facilitated recognition and acceptance of indigenous chicken in Kenya as a valuable and potentially important local resource of rural people that could be of immense benefit to their livelihoods if well harnessed.

Farmer participatory research carried out with active participation of rural farmers ensures information generated is immediately available for use by the target beneficiaries. There is a potential for a high rate of adoption or appropriate adaptation.

The farmer participatory indigenous chicken project helped farmers build confidence in their ability and capacity to transform their lives for the better. A realisation that outsiders gave attention to their own local resource, which in most cases they themselves gave little thought to, made them proud and willing to carry out research activities mainly on their own but largely with guidance from research and extension personnel.

The provision of a basket of options rather than specific intervention/s to farmers was a sign of confidence the researchers had on farmers to be able to select an appropriate technology based on individual circumstances. It was also a way of ensuring active participation of farmers and an indication of their level of participation in research process.

Community groups' mobilisation and organisation followed with sensitisation and training were crucial elements in the indigenous chicken participatory research process. This was the basis of the success achieved in carrying out the many research activities that involved a large number of farmers and with limited resources (human, financial and time). We recommend this approach as a priority strategy for other farmer participatory research and development projects.

The training sessions carried out prior to implementation of the research activities brought about an understanding on the side of the farmers as to what formal science had to offer to improve productivity of their birds. Also these sessions provided the research team with the opportunity to get a good understanding of farmers' indigenous technologies and local resources, which they incorporated in the project. It is a possible way of ensuring sustainability through the interest created by acquisition of new knowledge and hence the urge to try it out. Information sharing therefore, is one of the ways through which poor people recognise and take advantage of opportunities to improve their livelihoods.

The indigenous chicken project is an example of a rural project aimed at women's' empowerment where they can realise their self-worth and importance as members of their respective communities. In many instances, development projects are mainly in favour of the men-folk.

Enhancement of productivity of indigenous chicken through adoption of improved management practises that incorporates appropriate interventions adaptable to farmers' circumstances and situations and involvement of target beneficiaries in research process is achievable.

8.6 Farmer Participatory Research analysis

8.6.1 Highlights from descriptive analysis

Housing was easily affordable using locally available materials. The reasons some farmers did not use housing at all may be due to their high level of poverty and hence could not afford to invest in this activity.

Most of the farms had vaccinated only once or twice during the five project periods.

Regular use of deworming was not widely practised with majority of the farms applying it only two or three times.

Feed supplementation had not only high levels of use by all farmers in each region but also a high number of farmers took it up early in the study.

There was a steady increase in flock size and in the number of birds consumed and sold by the household across the project area and over the project period. This is an indication of a positive effect of undertaking the project. The farm flock sizes in all the five regions had generally an upward trend starting with a low level of about 20 or just below 20 birds in each farm and steadily rising to a medium level of just below 30.

The flock sizes did not stay 'high' despite their increase, as there seemed to be a deliberate effort to cull through sales and consumption all across the project area.

The controlled reductions were real benefits and provided evidence of the resource use as a means of livelihood. The relatively low levels of unplanned reductions are a good indicator of a positive effect of treatments and the research process generally, in the improvement in productivity and in the potential of such livelihoods available to the poor farmers.

Selling of birds seemed to occur at particular periods across the project area and this possibly due to market price and demand. This calls for strategic planning to build up flock size before the 'sale' season in order for the farmers to get more benefit.

8.6.2 Highlights from inferential statistical analysis

The regression analysis provided evidence that a number of variables in four different combinations influenced hatchability levels in different regions.

Housing was an important factor in region 2 (Ol Kalou), a cold area that had also the lowest hatchability levels.

Vaccination against Newcastle disease was certainly the most important factor influencing hatchability except in regions 4 and 5.

The cycle3-cycle1 difference show improvement for each farm was generally positive in majority of the villages. The regression analysis has provided evidence that the treatment interventions had some effects on this change.

Generally, the selected best-fit regression models in the five regions provide some evidence for presence of vaccination effect on the predicted cycle 2 mean eggs,

Vaccination therefore comes out as the single most important factor influencing the level of egg production in our farmer participatory research. Housing and possibly feed supplementation had also some effect but their real effect on egg production seems to have been masked by unexplained factors and hence not easily discernable from our analysis.

8.6.3 Highlights from demography structure and dynamic characteristics

Generally, the process used to classify farms into similar groups based on the level and trend of the flock sizes was a great success that led to identification of

7 distinct farm groups categories and 3 outlier farms from among the 173 farms included in this analysis.

There were significant differences between the final groups confirming the distinctness of the groups as categorised as well as affirming the validity of our classification procedures using the dissimilarity index values. Significant comparisons of flock sizes between the final groups in periods 1 to 5 showed that all the differences were significant at 1 percent level.

The final group (group 7) with the lowest flock size trends had production values close to those of other groups. This would suggest that a low flock size level in a farm is not a poor reflection of the production dynamics.

One of the major outcomes from the demographic analysis procedure is that majority of households keeping indigenous chicken tend to maintain a steady flock size level of 15 – 25 birds. An important aspect on this is that looking at the number of birds as a criterion to determine relative 'wealth' of a household may be deceptive. Those households with seemingly small flock size levels had the same or even more 'benefits' in terms of number of total controlled reductions as those with larger flock size levels. The story of '*Wanjiku*' in Box 3.5 is good illustration of this. Flock size level is not therefore the sole criteria to categorise status of a household.

8.7 Final conclusion overview

From the foregoing, both our on-station and the farmer participatory research approaches were important processes that complimented one another in investigating effects of treatment applications on the indigenous chicken production system. These research processes also provided a greater understanding of the system and its position among the livelihood strategies of smallholders in Kenya. The Kenyan national agricultural development policy arena now incorporates the indigenous chicken production system and our research processes have played a role in this institutionalisation.

The on-station research provided more knowledge about the indigenous chickens and created confidence that it would be possible to meet farmers' and other people's expectations and be able to interact with them and address their concerns at farm level. Hence, the on-station research was a precursor of our thrust into the farmer participatory research process. The latter approach on the other hand, offered an opportunity to realise our scientific knowledge in the context of farmers' circumstances and their vast experiences and indigenous knowledge.

The farmer participatory research concept is therefore an exciting and effective approach to development and transfer of knowledge as demonstrated by the level of involvement of farmers in our research project; the take up of the various treatments interventions and the great enthusiasm created and sustained throughout. There was a build-up of strong linkages among the farmers involved and between the farmers and us, and our development partners. More importantly as a scientific research method, the farmers themselves can record observations in FPR process at farm level, and the data can be analysed through the application of a variety of conventional statistical approaches such as graphs, frequency distributions, analysis of variations and regressions. However, it would be important to develop expertise in this area for it to be successful and to generate more information. Again, a lot of thought should be put into the type of data that need to be recorded and when it is recorded bearing in mind the capacity and ability of the farmers to do so. Compromises on this are inevitable in order to allow for illiteracy and innumeracy incapacitation among participating farmers and to sustain enthusiasm. There is therefore a need for regular farm visits by researchers involved in a project to encourage and assist in some of the research activities such as data recording, often considered by farmers to be a side issue that is time-consuming, tedious and without tangible and immediate benefits and hence rarely done.

Proper and timely data recording is a crucial component of FPR as the subsequent analysis and interpretation of results depend on it. This calls for greater thoughts in designing and planning of a project to include details of any relevant information that need recording. Inevitably, the whole process of FPR requires the enlisting of the services of a statistician in design, implementation and analysis stages due to the complex and multiple methodological approaches involved in the analysis as evidently shown in this thesis.

From the perspective of the current study therefore, farmer participatory research is a reliable, effective and an efficient tool for technology testing and transfer at the very point where needed and designed for. It can provide great understanding of circumstances and conditions in which the farmers or target clients live and toil for their livelihoods. The process provides an opportunity for exchange of information and experiences between different actors involved. FPR also promotes a sense of ownership and belonging and by so doing empowers groups that would otherwise be only marginal spectators in their own development activities. That 173 farms out of the 200 originally selected had records on treatments is quite exciting as it is indicative of a strong farmer participation in the implementation activity of the research process. The system however, is dependent on enthusiasm and interest of the farmers to undertake and sustain project momentum and to generate and collect required data. An even greater problem is that it is difficult to control and minimise random variation for ease of statistical analysis and investigations.

Overall, the statistical analysis using regression techniques did not show as much effects of treatments application as was expected. For instance, there was little or no effect demonstrated by housing. This lack of effects may have been because many farmers started applying the improved management practices soon after they were trained and long before monitoring the project activities started. There was no data collected before the start of the on-farm experimentation. This is a weakness in this study.

Another major drawback in our study is that some farmers dropped out which meant loss of important data. The situation was made worse by none recording of some information by those farmers that remained. A major question to ask is whether the original number of farmers we started with of 200 was adequate or what would have been the optimum number. However, a strength is the fact that we had 20 different villages as replicates. Advocating for more rather than less number of farmers seems a logical option given the likelihood of some of them to dropout as evidenced by our case. A large sample of farmers from which observations are made has relatively smaller value of random variations which make it easier to discern effects of some factors that would otherwise be masked.

To understand better the characteristics and potential of individual hens might have been helpful if we had eggs sets coming from the batch of eggs laid for a particular hen. Farmers used the eggs laid by their hens for all manner of purposes without taking note of which hen they came from. To have recorded these connections, however, would have complicated matters for the farmers.

Herbal medication was widely applied across the regions but effects on the production performance on the chicken were not analysed due to lack of proper monitoring and recording. To do so would have required determining quantities used among the flocks and we did not have the resources necessary to do so.

Planning effectively long before commencement of the activities as we did in the indigenous chickens project contributes immensely to its success. This strategy is highly recommended for other similar research and development projects. However, our project lacked expertise on the now widely acknowledged participatory paradigms and statistical expertise which are imperative tools during the early planning stages.

Our research study was about understanding the indigenous poultry production system among smallholder farmers and the effect of introducing improved production management practices. Indigenous poultry are among rural peoples' assets and possibly among the very few in which women, have ownership and control. Hence, the outcome and enthusiasm of this work should hopefully, prompt research and development agencies to develop strategies to make the poultry system a real livelihood opportunity among poor rural people especially, women and the youth.

There is a need to develop organised marketing strategies for indigenous chicken products such as establishment of small-scale abattoirs and egg stalls in trading centres as a way of stimulating greater use of indigenous birds for income-generation. With guaranteed outlets, people might see more opportunities for self-employment.

Consumption of chicken products at household level among rural poor people should be encouraged through sensitisation and education. This will contribute to food security and better nutrition and generate enthusiasm for increased harnessing of indigenous chicken resources to enhance peoples' livelihoods.

Increased utilisation of indigenous chicken and possibly increased production will require more research and development support for which this thesis will be a valuable information resource. This support should mostly focus on aspects that many farmers were not able to take up especially disease control and management such as vaccination against Newcastle disease, deworming and ecto-parasites treatments. Development of dissemination and communication strategies of relevant information based on the experiences of the indigenous chicken research process as a whole and impact assessments need to be carried out through participatory approaches. This will facilitate faster uptake of proven interventions and enhancement of peoples' livelihoods.

Support in form of credit to enable farmers' access to some external inputs in a timely manner and with ease, should be made an imperative. This would hasten implementation of project activities, prevent desperation and loss of hope as well as raise their determination to escape from their predicaments. Organised farmer groups are good channels for delivery of such credit to those who may wish to have it. Such farmers would be accountable to the whole group which ensures that the amount loaned is paid back as per agreed precepts.

Despite the success of our studies using participatory approaches, there is still a widespread conservative attitude and practice among agricultural research community in Kenya and elsewhere in the developing world about the use of this approaches. Probably a major concern is still on the authentication of data and statistical applications to analyse effects. This calls for re-orientation of the statistical service providers to focus attention on this area and to create networking with a number of statisticians already versed in these approaches. It is pleasing to note that the Statistical Services Centre at the University of Reading in UK has embarked on development of statistical tools for use in participatory research projects dealing with natural resources management.

The experiences and lessons learned in the indigenous chickens research project as well as evidence from other authors like Pound *et al.,*(2003), demonstrate that to be successful, interventions to support the development of rural livelihoods need to be based on understandings and opportunities presented by the complementary and synergistic application of conventional and participatory approaches to research and extension.

Through the detailed observations made above, we have successfully shown how both conventional, on-station research and participatory research approaches compliment one another as investigatory tools. This study combined the two sets of approaches to bring about greater understanding and much information on the status and performance of Kenyan indigenous chickens with application of improved management regimes. Their potential in poverty alleviation and use in sustainable livelihood strategies among the rural poor people especially women, was also established. We therefore hope that this study will be a valuable source of information for research and development projects using participatory approaches.

REFERENCES

Adato, M., Hoddinott, J., Besley, T. and Haddad, L., 2000. Participation and Poverty Reduction: Issues, Theory and New evidence from South Africa. *Background paper for the 2000/1 World Development Report on Poverty by the World Bank*. http://www.worldbank.org/poverty/wdrpoverty/background/index.htm.

Aguirre, B. G., 1962. *Regiones de Refugio: El Desarollo de la Comunidad y el Proceso Dominical en Mestzoemrica*, Instituto Nacional Indigenista, Mexico, DF.

Al-Sultan, F. H. 2001. Forward by the President of IFAD to the Rural Poverty Report 2001: *The challenge of ending rural poverty. International Fund for Development.* New York: Oxford University Press Inc., http://www.ifad.org/poverty/index.htm

Altrieri, M. A., 1984. Diversification in agricultural landscape – A vital element for pest control in sustainable agriculture. In Edens, T. C., Fridgen C. and Battenfield, S. (eds), *Sustainable Agriculture and Integrated Farming Systems*: A conference proceeding, Michigan State University Press, East Lansing, pp 166 184.

Amanor, K., 1990. Analytical Abstracts on Farmer Participatory Research, *Agricultural Administration (Research and Extension) Network Occasional Paper 10*, Overseas Development Institute, London.

Anyang' Nyong'o, P., 2000. Urgently wanted: Vision for future. *News_Analysis, Daily Nation on the web 0608200.* http://www.nationaudio.com/News/Dailynation/06082000/comments/News_Analysis7.html

AOAC, 1990. *Official Methods of Analysis, 15th edn*, Association of Official Analytical Chemists, Washington DC.

Ashby, J. A., 1992. Identifying beneficiaries and participants in client-driven on-farm research. *Prepared for the 12th Annual Farming Systems Symposium, Association for Farming Systems Research/Extension., 13 – 18, September*, Michigan State University, USA.

Ashby, J. A. and Sperling, L.,1995. Institutionalising participatory, client-driven research and technology development in agriculture. *Development and Change*, Vol 26, No. 4. pp 753 – 70.

Ashby, J. A., Braun, A., Gracia, T., Guerrero, M. D. P., Hernandez, L. A., Quiros, C. A. and Roa, J. I., 2000. Investing in farmers as researchers: *Experience with Local Agricultural Research Committees in Latin America*. Cali, Colombia: CIAT.

Ashby, J. A., 2003. Introduction: Uniting Science and Participation in the Process of Innovation – Research for Development. In Pound, B., Snapp, S., McDougall, C. and Braun, A. (eds) *Managing Natural Resources for Sustainable Livelihoods – Uniting Science and Participation*, Earthscan Publications Ltd London, pp 1 – 19.

Barahona, C. and Levy, S., 2003. How to generate statistics and influence policy using participatory methods in research: reflections on work in Malawi 1999 – 2002. *IDS Working Paper 212*. Institute of Development Studies, England.

Bebbington, A., Thiele, G. with Davies, P., Prager, M. and Riveros, H., 1993. Non-government Organisations and the State in Latin America: *Rethinking Roles in Sustainable Agriculture Development*, Routledge, London.

Bell, M., 1979. the exploitation of Indigenous Knowledge or the indigenous exploitation of knowledge: Whose use of what for what?. In Rural Development: Whose Knowledge Counts? *IDS Bulletin, Vol 10* (2) pp 44-50.

Bentley, J. W., 1991. The Epistemology of Plants Protection: Honduran Campesino Knowledge of Pests and Natural enemies. In Gibson, R.W. and Sweetmore, A. (eds), *Proceedings of a seminar on Crop Protection for Resource-Poor Farmers*, Isle of Thorns Conference Centre, East Sussex, 4-8 November.

Berlin, B., 1973. Folk systematics in relation to biological classification and nomenclature. *Annual review of Ecology and Systematics*, 4 pp 259-271.

Bhasin, K., 1985. *Towards Empowerment*. Rome, FAO.

Biggs, S. D., 1989. Resource-poor farmer participation in research: a synthesis of experiences from nine agricultural research systems, *OFCOR Comparative Study Paper No 3*, ISNAR.

Biggs, S. D. and Clay, E. J. (1981). Sources of innovation in agricultural technology. *World Development, Vol 9* pp321-326.

Biggs, S. D. and Farrington, J., 1991. Assessing the effects of Farming Systems Research: Time for the Reintroduction of Political and Institutional Perspectives, *Journal of the Asian Farming Systems Association, Vol 1*, pp 113 – 131.

Blair, T. 2000. Forward by British Prime Minister to the White Paper on International Development, '*Eliminating World Poverty: Making Globalisation Work for the Poor'*. Crown Copyright, Norwich, UK. http://www.globalisation.gov.uk

Blalock, H. M. Jr., 1961. *Causal references in nonexperinmental research*, New York, Norton.

Boserup, E., 1970. *Women's Role in Economic Development*, St Martin's Press, New York.

Brammer, H., 1980. Some innovations don't wait for expertise: A report on Applied Research in Bangladeshi peasants, *CERES, 13* (2) pp 24 – 29.

Braun, A., 2003.The Farmer Research Group (CIAL) as a community-based natural resource management organisation. In: Pound, B., Snapp, S., McDougall, C. and Braun, A. (eds) *Managing Natural Resources for Sustainable Livelihoods – Uniting Science and Participation*, Earthscan Publications Ltd London, pp 194 – 197.

Brokensha, D., Warren, D. M. and Werner, O. (eds), 1980. *Indigenous Knowledge Systems and Developments*, University Press of America, New York.

Brown, D., 1991. Methodological considerations in evaluation of social development programmes – an alternative approach, *Community Development Journal, Vol 26* (4).

Brown, D. and Rotherly, P. 1993. *Models in Biology: Mathematics, Statistics and Computing*. John Wiley &Sons Ltd, England.

Bunch, R., 1982. Two Ears of Corn: *A Guide to People-Centred Agricultural Improvement*, World Neighbours, Oklahoma.

Cambell, D. T. and Stanley, J., 1966. *Experimental and quasi-experimental designs for research*. Chicago, Rand McNally.

Cambell, D. T, 1975. Degrees of freedom and the case study. *Comparative political studies, Vol 8*, 178-193.

Chambers, R., 1983. *Rural Development: Putting the Last First*: Harlow, Longman.

Chambers, R., 1987. Sustainable livelihoods, environment and development: Putting poor rural people first. *IDS Discussion paper. No. 240*. Brighton: IDS.

Chambers, R., 1989. Reversals, Institutions and Change. In Chambers, R., Parcey, A. and Thrupp, L. A., *Farmer-First: Farmer Innovation and Agricultural Research*, Intermediate Technology Publications, London.

Chambers, R., 1992. Methods of Analysis by Farmers: The Professional Challenge. *Paper for the 12th Annual Farming Systems Symposium, Association for Farming Systems Research/Extension, 13 – 18 September*, Michigan State University, USA.

Cloud, K., 1987. *Gender issues in AID's agricultural projects: How efficient are we?* United State Agency for International Development, Washington D. C.

Cook, T. D. and Cambell, D. T., 1979. *Quasi-experimentation: Design and analysis issues for field settings*. Chicago: Rand McNally.

Cliffe, 1973. Social Sciences and Agricultural Development in Tanzania. In Mbiling, S. M., *Agricultural Research for Rural Development*, Nairobi, East African Literature Bureau, pp 96 –109.

CIMMYT, 1988. *From Agronomic Data to Farmer Recommendations: an Economic Training Manual*. Manila, CIMMYT.

Cromwell, E. and Wiggins, S., 1993. *Sowing Beyond the state: NGOs and Seed Supply in Developing Countries*, London, ODI.

Dalal-Clayton, B., Dent, D. and Dubois, O. 2002. *Rural Planning in Developing Countries: Supporting natural resource management and sustainable livelihoods*. London, IIED, Earthscan.

Davis-case, D., 1989. Community forests – Participatory Assessment, Monitoring and Evaluation. Rome: FAO/SIDA; *Forests, Trees and People Community Forestry Note 2*, X + 150pp.

Desai, V. and Potter, R. B., eds. (2002). *The companion to development studies*. London, Arnold.

DFID, 1999. *Sustainable livelihoods guidance sheets* (April) London: Department for International Development.

Dommen, A. J., 1975. The bamboo tubewell: A note on an example of indigenous technology, *Economic Development and Cultural Change, Vol 23*(3), pp 483-489.

Ellerston, C., 1991. *The invisible woman. United States Agency for International Development*, Washington D.C: Bureau of AFR/DP,.

ETC, 1992. *Learning for People Centred Technology Development: a Training Guide*, Leusden, The Hague, The Netherlands: ETC.

Fairhead, J., 1993. Representing Knowledge: The New Farmer in Research Fashions. In Pottier, J. (ed), *Practising Development: Social Science Perspectives*, London: Routledge, , pp 187-204.

FAO 1982 Report on the expert consultations on rural poultry and rabbit production. *Animal Production and Health Division Publ No. 59*/3. Rome: FAO.

FAO. 1987. *Report on the expert consultations on rural poultry development in Asia, Dhaka*, Rome: Animal Production and Health Division Publ, FAO.

FAO/INFPD, 2002. International Network for Family Poultry Development. 2nd *FAO/INFPD electronic conference on family poultry: The Bangladesh Model and Other Experiences in Family Poultry Development, 13 May – 6 July, 2002*. http://www.fao.org/ag/aga/e-conf/poultry/default.htm

Farrington, J. and Martin, A., 1987. *Farmer participation in agricultural research: A review of concepts and practices*, London: (ODI).

Farrington J. and Lewis D. J. with Satish, S. and Miclat-Teves, A., (eds) 1993. *Non-governmental organisation and State in Asia: Rethinking roles in Sustainable Agricultural Development*, London: Overseas Development Institute.

Farrington, J., 1997. Farmers' participation in research and extension: lessons from the last decade. *Biotechnology and Development Monitor, 30*: 12 – 15.

Farrington, J., Carney, D., Ashley, C. and Turton, C., 1999. Sustainable livelihoods in practice: Application of sustainable livelihoods concepts in rural areas. *Natural Resource Perspective No. 42*. (June) London: Overseas Development Institute.

Galpin, M., Dorward, P. and Shephered, D., 2000. *Participatory Farm Management (PFM) methods: a field manual*. London: DFID, UK.

Garforth, C, 1998. *Dissemination Pathways for RNR research. Socio-economic Methodologies. Best Practice Guidelines*. Chatham, UK: Natural Resource Institute.

Ghildyal, B. P., 1987. *Farmer evaluation of rice breeding material in rainfed lowlands of East India*, Brighton: IDS.

Gibbon, D., 1981. Rainfed Farming Systems in the Mediterranean Region. *Plant and Soil, Vol 58* pp 59 – 80.

Goode , W.J. and Hatt, P. K., 1952. *Methods in Social Research*, New York: Mcgraw Hill.

Goulet, D. 1971. *The cruel choice: A new concept on the Theory of Development*, New York: Atheneum.

Grimble, R., 1998. *Stakeholder methodologies in natural resource management. Socio-economic Methodologies. Best Practice Guidelines*, Chatham, UK: Natural Resource Institute.

GTZ, 1991. *Where there is no participation*, Eschborn: Deutsche Gessellschaft fur Technische Zusammenarbert.

Gueye, E. F., 2000a. The role of family poultry in poverty alleviation, food security and the promotion of gender equality in rural Africa. *Outlook on Agriculture. Vol 29* No 2: 129 – 136.

Gueye, E. F., 2000b. Approaches to family poultry development. Symposium of the International Network on Family Poultry Development (INFPD). *Proceedings of the XXI World's Poultry Congress. 20 – 24 August 2000*. Montreal, Canada: WPSA.

Gubbels, P., (1992a). Towards more effective 'farmer-first' research. Linking theory to practice in agricultural technology development. *Paper prepared for the IIED/IDS 'Beyond Farmer-Farmer'. Rural people's knowledge. Agriculture research studies, University of Sussex 27 – 29 Oct 1992*, Brighton: Mimeo.

Gubbels, P., 1992b. 'Farmer-First: Populist Pipedream or Practical Paradigm? A Case Study of the Project Agro-Foresterie (PAF) in Burkina Faso', *paper prepared for IIED/IDS Beyond Farmer First: Rural People's Knowledge Agricultural Research and Extension Practice Workshop, 27 – 29 October*, Institute of Development Studies: University of Sussex, UK.

Guijit, I. and Hinchcliffe, F., 1998. Participatory Valuation of Wild Resources: An Overview of Hidden Harvest Methodology. Sustainable and Rural Livelihoods Programme, IIED, London. In: : Dalal-Clayton, D. B., Dent, D and Dubois, O., 2003. *Rural planning in developing countries: supporting natural resource management and sustainable livelihoods*, London: Earthscan Publication Ltd.

Hagmann, J., Chuma, E., Murwira, K. and Connolly, M., 1999. Putting process into practice: Operationalising Participatory Extension. In: *Agricultural Research and Extension (AGREN) Network Paper No. 94*, London: ODI. www.odi.org.uk/agren/papers/agrenpaper_94.pdf or booklet.

Handwerker, N. P., 1973. Kinship, Friendship and Business failure among market sellers in Monrovia, Liberia. *Africa, Vol XLIII* (4) pp 208 – 301.

Harding, D. J. K. and Thompson, K., 1996. Soil and water conservation in Kenya: the development of the catchment approach and structured participation led by the

Soil and Water Conservation Branch of the Ministry of Agriculture, Kenya. *Paper prepared for the OECD/DAC Workshop on Capacity development in the Environment, 4-6 December*, Rome: OECD.

Harwood, R., 1984. The integration efficiencies of cropping systems. In Edens, T. C., Fridgen C. and Battenfield, S. (eds), *Sustainable Agriculture and Integrated Farming Systems: A conference proceeding*, East Lansing: Michigan State University Press, , pp 166 184.

Heinrich, G. M., 1993. Strengthening farmer participation through groups: experiences and lessons from Botswana. *OFCOR Discussion Paper No. 3*, The Hague: ISNAR.

Hoaglin, D. C., Liht R. J., McPeek, B., Mosteller, F. and Stoto, M. A., 1982. *Data for decisions: Information strategies for policy makers*. Cambridge, MA: Abt Books.

Hoeper, B., (ed) 1990. Qualitative versus Quantitative Approaches in Applied Research in Rural Development. *Proceedings of workshop at Sokoine University, Morogoro Tanzania, 21-26 May*, Bonn: German Foundation for International Development.

Howes, M. and Chambers, R., 1979. Indigenous Technical Knowledge: Analysis, Implications and Issues. In Rural Development: Whose Knowledge Counts? *IDS Bulletin, Vol 10*(2) pp 5-11.

Ibe, S. N., 1990. Increasing rural poultry production by improving the genetic endowment of rural poultry. In: *Proceedings of International workshop on Rural Poultry in Africa. Obafemi Awolowo Univ*, Ile – Ife, Nigeria: INFPD/FAO.

Imboden, P., 1979. *Setting up a monitoring and evaluation system for social programmes*, Paris: OECD.

IFAD, 2001. International Fund for Agricultural Development, *Rural Poverty Report 2001: The challenge of ending Rural Poverty*, New York: Oxford Univ press.. http://www.ifad.org/media/pack/rpr/index.htm.

Johnstone, P., 1998. *Planning and managing agricultural and ecological experiments*, Cheltenham, UK: Stanley Thornes Ltd.

Johnston, N., Lilja, N. and Ashby, J., 2000. Using Participatory Research and Gender Analysis in Natural Resource \management: A Preliminary Analysis of the PRGA Inventory, *Working Document No. 10, CGIAR Systemwide Program on Participatory Research and Gender Analysis*, Cali Colombia.

Kaimowitz, D., Snyder, M and Engel, P., 1990. A conceptual framework for studying the links between agricultural research and technology transfer in developing countries. In Kaimowitz, D. (ed), *Making the Link: Agricultural Research and Technology Transfer Services in Developing Countries*, Boulder, Colorado: Westview Press,.

Kambhampati, U. S., 2004. *Development and Developing World*, Cambridge, UK. Prity Press.

KARI, 1994. *Kenya Agricultural Research Institute's Phase II (1994-1999) of the National Agricultural Research Programme (NARP II)*, Nairobi Kenya: KARI,

KARI, 1995. *Kenya Agricultural Research Institute's National Agricultural Reseach Project II - National Poultry Research Programme Plan of Action, 1995-1999*, Nairobi Kenya: KARI.

KARI, 1999. Summary report of the research projects evaluation team. *Proceedings of 6th biennial Kenya Agricultural Research Institute scientific conference, 9 - 13 November 1998, pp 633 – 636*, Nairobi, Kenya: KARI.

Kievelitz, U., 1995. *Rapid Distric Appraisal: An Application of RRA on District Planning Level. Kurzinfo Nr 21, 8-12*. Sektoruberg Städtische und Ländliche Programme. GTZ.

Korten, D. C., 1990. *Getting to the first 21st century: Voluntary action. The global agenda*, West Hartford: Kumarian press.

Lawrence, T. L. J. and Fowler, V. R. 1997. *Growth of farm animals*, London: CAB International.

Ledesma, A. J., 1982. Participatory research for community-based agrarian reforms: The SIAY BCC experience, In: *Human Society, Manila, No 9* Feb 1982.

Lightfoot, C. and Noble, R., 1992. Sustainability and on-farm experiments: Ways to exploit participatory and systems concepts. *Paper presented at the 12th Annual Farming Systems Symposium, Association for Farming Systems Research/Extension, 13 – 18 September*, Michigan State University, USA.

Lipton, M., 1989. *New seeds and poor people*, London, Unwin Hyman Ltd.

Lipset, S. M., Trow, M. and Coleman, J., 1956. *The union democracy: The inside politics of the International Typographical Union*, New York: Free Press.

Lilja, N. and Ashby, J. 2000. *Types of Participatory Research Based on Locus of Decision-Making. PRGA Working Document No. 6*, CGIAR Systemwide Program on Participatory Research and Gender Analysis, Cali, Colombia.

Long, N., 1992. Introduction. In *Battlefields of knowledge: the interlocking of theory and practice in social research and development*, London: Routledge.

Long, N. and Long, A., 1992. *Battlefields of knowledge: the interlocking of theory and practice in social research and development*, London: Routledge.

Marilee, K. 2000. Monitoring and evaluating stakeholder participation in agriculture and rural development projects: a literature review. *FAO SD-Dimensions*. http://www.fao.org/waicent/faoinfo/sustdev/PPdirect/Ppre0074.htm.

Marsland, N., Wilson, I., Abeyasereka, S. and Kleih, U. 2001. *Combining quantitative (formal) and qualitative (informal) survey methods. Socio-economic Methodologies for Natural Resources Research. Best Practice Guidelines*, Chatham, UK: Natural Resource Institute.

Martin, A. and Sutherland, A., 2003. Whose Research, Whose Agenda. In Pound, B., Snapp, S., McDougall, C. and Braun, A. 2003 (eds), *Managing Natural Resources for Sustainable Livelihoods – Uniting Scinece and Participation*, London: Earthscan Publications Ltd, pp48 – 66.

Mayoux, L., 1995. Beyond Naivety: Women, gender inequality and participatory development. In *Development and change, 26* pp 235-258.

Mbugua, H. C. W., Owango, M. O. and Ndegwa, J. M. (eds) 1994. *Proceedings First Poultry Research Priority setting Workshop. Naivasha, 18 – 19 October*, Naivasha: Kenya Agricultural Research Institute.

Mbugua, P. N., 1990. Rural smallholder poultry production in Kenya. In: *Proceedings of A seminar on Smallholder Rural Poultry Production 9 - 10th October 1990*, Pg 113 – 115, Thessaloniki, Greece: FAO, Rome.

McDougall, C. and Braun, A, 2003. Navigating Complexity, Diversity and Dynamism: Reflections on Research for Natural Resource Management. In Pound, B., Snapp, S., McDougall, C. and Braun, A. (eds) *Managing Natural Resources for Sustainable Livelihoods – Uniting Science and Participation*, London: Earthscan Publications Ltd and Ottawa: International Development and Research Centre (IDRC), pp 20 –47.

McDougall, C., 2001. Gender and Diversity in Assessing Sustainable Forest Management and Human Well-being. In Colfer, C. J. P. and Byron, Y. (eds), *People Managing Forests: The links between Human Well-Being and Sustainability*, Washington, DC and Bogor, Indonesia: Resources for the Future and CIFOR,.

Meadows, K. and Surtherland, A., 2000. *Addressing Gender in Renewable Natural Resources Knowledge Strategies. Socio-economic Methodologies for Natural Resources Research. Best Practice Guidelines*, Chatham, UK: Natural Resources Institute.

Merril-Sands, D. and Collion, M. H., 1992. Making the Farmer's Voice Count: Issues and Opportunities for Promoting Framer-Responsive Research, *Paper presented at the 12th Annual Farming Systems Symposium, Association for Farming Systems Research/Extension, 13 – 18 September*, Michigan State University, USA.

Mead, R., Curnow, R. N. and Hasted, A. M., 2003. *Statistical Methods in Agriculture and Experimental Biology. 2rd Ed*, England: Chapman and Hall.

Miles D. W. J., 1982. Appropriate Technology for Rural Development: The ITDG Experience, *ITDG Ocassional Paper 2*, ITDG.

Milne, M. McDougal, C., Siagian, Y. and Uprety, L.,2001. '*A Participatory Gender Analysis Impact Assessment: The Local People, Devolution and Collaborative Management of Forests Research Programme'*, Bogor, Indonesia: CIFOR Report to the CGIAR System-wide Program on Participatory Research and Gender Analysis, Centre for International Forest Research.

Misturelli, F. and Herffernen, C., 2003. *Poverty and Participation: An analysis of bias in participatory methods*, Reading, UK: The livestock development group, University of Reading, UK.

MoALD&M, 1993. Ministry of Agriculuture, Livestock Development and Marketing, Kenya. *Animal Production Division, Annual Report, 1990*, Nairobi: MoALD&M.

Mohan, G. and Stokke, K., 2000. Participatory development and empowerment. The dangers of localism. *Third World Quarterly 21* (2): 247-68.

MoLD, 1989. Ministry of Livestock Development, Kenya. Animal Production Division, National Poultry Development Project (NPDP), *Local Chicken Rearing Booklets*, Nairobi: NPDP/MoLD.

MoLD, 1990. Ministry of Livestock Development, Kenya. *Animal Production Division, Annual Report, 1990*, Nairobi: MoLD.

Moore, W. E., 1963. *Social change*, Engelwood Cliffs, New Jersey: Prentice-Hall Inc.

Morton, J., Adolph, B., Ashley, S. and Romney, D., 2002. Conceptual, Methodological and Institutional issues in participatory livestock production research. *Livestock*

Research for Rural Development Vol 14 (4). http://www.cipav.org.co/lrrd/lrrd14/4/mrt144.htm.

Mosher, C., 1989. Gender Planning in the Third World: Meeting practical and strategic gender needs. *World Development, Vol 17* (11), pp 1799 – 1825.

Mulwa, F. W., 1987. *Participation of the poor in rural transformation: A Kenyan case*, Eldoret, Kenya: Gaba publication, ANECEA,.

Musharaf, N.A., Mbugua P.N. & Zubeir El, E.A. (1990). Feeding and Feed Resources, (WG3), CTA - *seminar proceedings on smallholder rural poultry production, 9-13 October, Thessaloniki Greece vol 1* p 17-19.

Mwaniki, J., 1993. *Christian Community Services Annual Report*, Machakos: C.P.K. diocese of Machakos, Kenya.

Narayan, D., 1993. Focus on Participation: Evidence from 121 Rural Water Supply Projects, UNDP-World Bank Water Supply and Sanitation Program, World Bank, Washington, DC.

Narayan, D. 1997. Voices of the poor: Poverty and Social Capital in Tanzania. *Environmentally and Socially Sustainable Development Network, Studies and Monograph Series No. 20*, Washington, DC: World Bank.

Ndegwa, J. M., 1992a. *Digestibility and Metabolic Energy determination of ground and unground sesame (Sesamum indicum) seeds in broiler diets*. Msc Thesis, 1992, Wageningen Agricultural University, Wageningen, The Netherlands.

Ndegwa, J. M. 1992b. *Use of sesame seeds (Sesamum indicum) in broiler feeds*. Proceedings, World Poultry Congress - Young professionals program. October 1992. Amsterdam, The Netherlands.

Ndegwa, J. M., Mbugua, H. C. W.,Owango, M. O. and Mburu, B. M. (eds) 1994. *Proceedings of second Poultry Research Priority setting Workshop. Naivasha, 15 – 16 November*. Kenya Agricultural Research Institute.

Ndegwa, J. M. and Kimani, C. W., 1997. Rural poultry production in Kenya: Research and development strategies. In: *Proceedings of 5th Kenya Agricultural Research Institute (KARI) scientific conference, October, 1996*. KARI, Nairobi.

Ndegwa, J. M., Tchombe, T., Kabuage, L. W., Mukkibi-Muka, G. and Kosgey, I. S., 1998a. Improvement of indigenous poultry production in Sub-Saharan Africa. *A paper presented at the International Course on Intensive Poultry Production held at the Centre for International Agricultural Development Co-operation*

(CINADCO). Kibbutz Shefayim, 4 March - 1 April 1998. P.O. Box 7011, Tel-Aviv, Israel.

Ndegwa, J. M., Kimani, C. W., Siamba, D. N., Mburu, B. M and Waweru, O. M., 1998b. Evaluation of the state of the art in poultry industry in the Rift Valley province in Kenya. *Proceedings of rural poultry production workshop. August, 1998. Kakamega*, Kenya: Kenya Agricultural Research Institute.

Ndegwa, J. M., Kimani, C. W., Siamba, D. N., 1998c. A Rural Poultry Production Manual. In: *Proceedings of rural poultry production workshop. August, 1998*. Kakamega: Kenya Agricultural Research Institute.

Ndegwa, J. M., Kimani, C. W., Siamba, D. N., Mburu, B. M., Mukisira, E. A. and de Jong, R., 1999. Characteristics of rural poultry production in different agroecological zones in Kenya. In *Proceedings of the 6th biennial Kenya Agricultural Research Institute (KARI) scientific conference 9 - 13 November 1998, pp 540 - 547. Nairobi, Kenya. KARI*.

Ndegwa, J. M, Norrish, P. Mead, R., Kimani, C. W., Wachira, A. M., 2000. A research process and methodology focusing on indigenous Kenyan chickens. Proceedings of the Symposium of the International Network for Family Poultry Development (INFPD) at the XXI World's Poultry Congress. 20 – 24 August 2000. Montreal, Canada. In: The *INFPD Newsletter Vol 11* No. 1 Jan – June 2001 http://www.fao.org/ag/againfo/subjects/en/infpd/documents/newsletters/Infpd111.pdf

Ndegwa, J. M, Norrish, P. Mead, R., Kimani, C. W., Wachira, A. M., Githinji, M.M., 2001a. Participatory Strategic Approach to Development of Improved Indigenous Poultry Systems in East Africa, *Paper presented at the International Community Development Conference In Rotorua, New Zealand, 2-6 April 2001*. Unpublished.

Ndegwa, J. M, Norrish, P. Mead, R., Kimani, C. W., Wachira, A. M., Githinji, M.M., 2001b. Role of family poultry (scavanger poultry) production in sustainable livelihoods and poverty eradication – the case of Wanjiku. *A development case study presented at the International Development Conference, Rotorua, New Zealand, 2 – 6 April 2001*, Unpublished.

Ndegwa, J. M, Norrish, P. Mead, R., Kimani, C. W., Wachira, A. M., 2001c. The growth performance of indigenous Kenyan chickens fed diets containing different levels of protein during rearing. *Tropical Animal Health and Production, 33* (5), 441-448.

Ndegwa, J. M, Norrish, P. and Shephered, D. with others, (2001d). Training and disseminations strategies for the promotion of improved management practices of indigenous chicken already developed through an on-farm participatory research project, and their impact on the livelihoods of landless women in Kenya. *A research proposal submitted to the Livestock Production Programme of DFID, 2001*. Natural Resource International, UK.

Ndegwa, J. M, Norrish, P. and Shephered, D. with others, (2001e). Evaluation of strategic approaches to information dissemination for management and control of major endemic diseases in indigenous poultry systems with poor women groups in kenya: a livelihood and poverty eradication strategy. *A research proposal submitted to the Animal Health Programme of DFID*, Centre for Tropical Veterinary Medicine Easter Bush Veterinary Centre UK August 2001.

Ndegwa, J. M, Norrish, P. and Shephered, D., Githinji, M. M., Wachira, A. M., WB-DM2001, 2002a. Strategies for harnessing indigenous poultry systems to combat poverty among Kenyan women. *A project proposal sumitted at The Word Bank Group Develoment Markeplace2001 Proposal Submission Finalist Conference:, 9 – 10 January 2002*, Washington DC, World Bank. www.worldbank.org/dm2001.htm

Ndegwa, J. M, Norrish, P. Mead, R., Kimani, C. W., Wachira, A. M., 2002b. Hatching characteristics of eggs artificially incubated from six reciprocal crosses of indigenous Kenyan chickens. *Tropical Agriculture (Trinidad), Vol. 79* No 1.

Ndegwa, J. M, Norrish, P. Mead, R., Kimani, C. W., Wachira, A. M., 2005. Growth characteristics of indigenous chickens lines and a cross with Rhode Island Red in Kenya. *Tropical Agriculture (Trinidad)) Vol 82 No 1. Included in chapter 4 this thesis*.

Ndegwa, J. M, Norrish, P. Mead, R., Kimani, C. W., Wachira, A. M., 2005b. Growth characteristics of six reciprocal crosses of Kenyan indigenous chickens *(unpubl/submitted). Included in chapter 4 this thesis*.

Nelson, N. and Wright, S. (1995). Participation and power. In: N. Nelson and S. Wright (eds) *Power and Participatory Development: Theory and Practice*, London: Intermediate technology Publication. Pp 1 – 18.

Ngunjiri, C. K., Kiptarus, J. K, and Ndegwa, J. M., 1998. *National Poultry Development Programme (NPDP) - Evaluation Report of the Cockerel Exchange Project in Laikipia District.* NPDP, MoALD, Nairobi.

Norrish, P., Lloyd Morgan, K. and Myers, M., 2001. *Improved communication strategies for renewable natural resource research outputs. Socio-economic Methodologies for Natural Resources Research. Best Practice Guidelines*. Chatham, UK: Natural Resources Institute.

Nyerere, J., 1968. *Freedom and socialism*, Dar es salaam: Oxford University Press.

Oakley, P., Marsden, D., 1984. *Approaches to participation in rural development*, Geneva: ILO.

Oakley, P., 1991. *Projects with people: The practice of participation in rural development*. Geneva, International Labour Office.

ODA (1995) *Technical Note on Enhancing Stakeholder Participation in Aid Activities (April)*. London: Social Development Department, Overseas Development Administration.

Okali, C., Sumberg, J. and Farringto, J., 1994. *Farmer participatory research. Rhetoric and reality. Intermediate Technology publications* London, UK: Overseas Development Institute.

Okong'o , Kabuage, L., Mbugua, P. N. and Ndegwa, J. M., 1998. The effect of cooking grain amaranth (Amaranthus hypochodriacus) on its utilisation by broiler and indigenous chickens. In *Proceedings of Rural Poultry Workshop. Kakamega, July 1998.* Kenya Agricultural Research Institute.

Parkin, D. J., 1972. *Palm, wine and witness: Public spirit and private gain in an African farming community*, London: Intertext.

Parr, J. F., Papendick, R. I. And Youngberg, I. G., 1983. Organic farming in United States: *Principles and perspectives, Agro-ecosystems, Vol 8*, pp 183 – 201.

Patton, M. Q., 1987. *How to use qualitative methods in evaluation*, Berverly Hills California: Sage Publications.

Pearse, A.; Stiefel, M., 1979. Inquiry to participation. Geneva, UNRISD.

Platt, J., 1992. "Case study in American methodological thought. *Current sociology*, 40, 17 – 48.

Poats, S., 1991. *The Role of Gender in Agricultural Development*, Washington DC: Consultative Group on International Agricultural Development (CGIAR.

Pound, B., Snapp, S., McDougall, C. and Braun, A. 2003 (eds). *Managing Natural Resources for Sustainable Livelihoods – Uniting Science and Participation*, London: Earthscan Publications Ltd. Pp 252.

Povertynet, 2000. *Understanding and Responding to Poverty, July 2000*, Washington DC: The World Bank Group. http://www.worldbank.org/poverty/mission/up1.htm

Pretty J. N. and Chambers, R., 1992. Turning the New Leaf: New Professionalism, Institutions and Policies for Agriculture. *Overview paper prepared for IIED/IDS Beyond Farmer First: Rural Peoples Knowledge Agricultural Research and Extension Practice Workshop, Institute of Development Studies, University of Sussex, 27 – 29 October.*

Pretty, J., 1995. *Regenerating Agriculture: Policies and Practice for Sustainability and Self-Reliance*, London: Earthscan Publication.

Pretty, J., Guijt, I., Thompson, J. and Scoones, I.,1995. Farmers guide for participatory learning and action. *IIED participatory methodology series*. Intermediate Institute for Enviroment and Development.

Pretty, J. N. and Kiara, J. K., 1995. *Agricultural regeneration in Kenya: the catchment approach to soil and water conservation. Ambio 24* (1): 7-15.

Probst, K., Hagmann, J., Becker, T. and Fernandez, M. 2000. Developing a Framework for Participatory Research Approaches in Risk Prone Diverse Environments. *Proceedings, Deutscher Tropentag 2000, University of Hohenheim.*

Probst, K. and Hagmann, J. with Fernandez, M. and Ashby, J. A., 2003. Understanding participatory research in the context of natural resource management – Paradigms, Approaches and Typologies. *Overseas Development Institute's Agricultural Research and Extension Network (AgREN) Paper No. 130*.

Quiros, C. A., Gracia, T. and Ashby, J., 1991. *Farmers evaluation of technology: Methodology for open-ended evaluation, Instructional Unit 1*, Cali, Colombia: CIAT`.

Ramm, G., Balzer, G., Eckert, M. v., Hugo, R., Massler, B., Muller, R. and Richter, J. 1984. *Animal health in East Kalimantan: Integration of animal husbandry into transmigrant farming systems in the middle Mahakam area in East Kalimantan, Indonesia*. Berlin: Fachereich Internationale Agraentwicklung, Technische Universitat Berlin, , 212p.

Rahnema, M., 1992. Participation: In Sachs W. (ed), *The development dictionary – A guide to knowledge and power*, London, New Jersey: Zed books: 24 – 32.

Ratkowsky, D. A., 1989. *Handbook of nonlinear regression models*, New York and Basel: Marcel Dekker, INC..

Rauen, H. W., De Los Santos, M. and Fabian, P. 1990. Actual situation of the small scale poultry production in rural areas in the Dominican Republic and improving perspectives for the future. *Proceedings CTA International Seminar on Smallholder Rural Poultry Production, 9-13 October 1990, Thessaloniki, Greece. Vol. 2*.

Richards, P., 1978. Community Environmental Knowledge in African Rural Development. In *proceedings Workshop on the Use of Indigenous Technical Knowledge held at the Institute of Development Studies, University of Sussex, Brighton, 13-14 April*, pp 28 – 36.

Richards, P., 1985. *Indigenous agriculture revolution – Ecology and food production in West Africa*, London: Unwin, Hyman Ltd., pp192.

Richards, P., 1986. *Coping with hunger: Hazards and Experiment in an African Rice Farming System*, London: Allen and Unwin,.

Roseberg, M., 1993. Participatory methodologies of research and survey in third world rural development*. Msc. Dissert. 1993 AERDD*, University of Reading, UK.

Salas, M. A., 1992. The cultural dimension of knowledge conflict in the Andes. *Paper prepared for IIED/IDS Beyond Farmer-First: Rural People's Knowledge, Agricultural Research and extension Practice Workshop, Institute of Development Studies, University of Sussex, 27 – 29 October*.

SAS, 1985. *SAS Users' Guide: Statistics, version 5 edition*, SAS Institute Inc. Pp 575 – 606.

Scoones, I., 1998. *Sustainable rural livelihoods: A framework for analysis. Working paper 72*, Brighton: IDS.

Scoones, I. And Thompson, J., 1992. Beyond Farmer-First: Rural people's knowledge, agricultural research and extension practice: towards a theoretical framework. *Overview paper prepared for IIED/IDS Beyond Farmer-First: Rural People's Knowledge, Agricultural Research and extension Practice Workshop, Institute of Development Studies, University of Sussex, 27 – 29 October*.

Setioko, A. R. 1997. Recent study on traditional system of duck layer flock management in Indonesia. *Proceedings 11th European Symposium on waterfowl, Nantes. France. 8 – 10 Sept* 1997.

Sharner, W. W., Phillip, P. F., Schmehl, W. R., 1982. *Farming systems research and development – Guidelines for developing countries*, Boulder, Colorado: Westview press.

Shaw, R. and Gatheru, W., 1998. eds: *Kenya, Our problems, our solutions*. Institute of Economic Analysis. IEA, Nairobi.

Siamba, D. N., Ndegwa, J. M. Kimani, C. W. and Mburu, B. M., 1998. Ethno-Veterinary practices among the Kikuyu in the Rift Valley Province in Kenya. In *Proceedings of Rural Poultry Workshop. Kakamega, July 1998*. Kenya Agricultural Research Institute (KARI).

Sieber, S. D., 1973. The integration of field work and survey methods. *American journal of sociology, 78*, 1335 – 1359.

Smith, N. L., 1990. Cautions on the use of investigative case studies in meta-evaluation. *Evaluation and Program Planning, 13* (4), 373-378.

Spicer, E. H., 1962. *Human Problems in Technological Change*, New York: Russel Sage Foundation.

Stake, R. E., 1986. Quieting reform: *Social science and social action in an urban youth program*, Urbana: University of Illinois Press.

Starkey, P., 1996. Networking for sustainable agriculture: Lessons from animal traction development. *Gatekeeper series No 58*. London, UK. International Institute for Environment and Development.

Staudt, K., 1985. *Women, Foreign assistance and Advocacy Administration*, New York: Praeger inc.

Stotz, D., 1983. Production techniques and economics of small holders livestock production systems in Kenya. In: *Farm management handbook of Kenya vol. 4*. Pp 95 – 106. Ministry of Agriculture, Nairobi.

Stoecker, R., 1991. Evaluating and rethinking case study. *The Sociological review, (39)* 88-112.

Strauss, A. and Corbin, J., 1990. *Basics of qualitative research. Grounded theory procedures and techniques*, Newbury \Park, CA: Sage.

Sumberg, J. and Okali, C., 1988. Farmers, on-farm research and the development of new technology. *Experimental Agriculture, Vol 24* (3), pp 333-342.

Sutherland, A., 1998. *Participatory research in natural resources. Socio-economic Methodologies. Best Practice Guidelines*, Chatham, UK: Natural Resource Institute.

Swift, J., 1979. Notes on Traditional Knowledge, Modern Knowledge and rural Development. In Rural Development\; Whose Knowledge Counts?, *IDS Bulletin Vol 10* (2) pp 41-43.

Thirlwall, A. P., 2002. Development as economic growth. In: Desai, V. and Potter, R. B., eds. (2002). *The companion to development studies, pg 42*, London: Arnold.

Tuitoek, J. K., Chemjor, W., Ndegwa, J. M. and Ottaro, J. M., 1999. Morphological characteristics and protein requirements of indigenous Kenyan chicken. In *Proceedings of the 6th biennial Kenya Agricultural Research Institute (KARI) scientific conference 9 - 13 November 1998, pp 1 – 9. Nairobi: KARI*.

UNDP, 1993. *United Nations Development Program, Human Development Report*, Oxford: Oxford University Press.

UNDP, 1994. *United Nations Development Program. Good governance for sustainable human development*, New York: UNDP Policy document, 1994*,*

UNDP, 1997. *United Nations Development Program, Human Development Report*, New York: Oxford University Press.

UNDP, 2003. *United Nations Development Program, Human Development Report 2003 - Millennium Development Goals: A compact among nations to end human poverty*, New York: UNDP. *www.undp.org/hdr2003*

Uphoff, N., 1986. *Local institutional development*, West Hartford: Kumari Press.

Uphoff, N., 1991. Fitting projects to people. In Cernea, M. (Eds.) *Putting People first: Sociological variables in rural development*, New York: Oxford University press.

Uquillas, J. E., 1992. Research and Extension Practice and Rural people's Agroforestry knowledge in Ecudorian Amazon. *Paper prepared for IIED/IDS Beyond Farmer-First: Rural People's Knowledge, Agricultural Research and extension Practice Workshop, Institute of Development Studies, University of Sussex, 27 – 29 October*.

Van der Bliek, J. and van Veldhuizen, L., 1993. *Developing tools together: Report of a study on the role of participation in the development of tools, equipments and techniques in appropriate technology programmes*, Eschborn/Leusden: GATE/ETC,.

Van Maanen, J. *Tales of the field: On writing ethnography*, Chicago: University of Chicago Press.

Versteeg, M. N. and Koundonkpon, V., 1993. Participative farmer testing of four low external input technologies to address soil fertility decline in Mono Province, Benin, *Agricultural Systems Vol 42* pp 265 – 276.

Warburton, H. and Martin, A. 1999*. Local people's knowledge in natural resource research. Socio-economic Methodologies for Natural Resources Research*, Chatham, UK: Natural Resources Institute.

WBDR, 2000. *World Bank Development Report 2000/2001: Attacking Poverty*, Washington, DC: World Bank, Oxford University Press. htpp://www.worldbank.org/poverty/wdrpoverty/docs.htm.

Wellard, K. and Copestake,J. K., 1993. *State-NGO interaction in the development of new agricultural technology for small farmers: Experience from Sub-Saharan Africa*, London: Routledge.

Wilson, J. H., 1974. Discussion of D. J. Finney, 'Problems, data, and inference'. *Journal of Royal Statistical Society A 137*, 20.

Wolf, E. R., 1957. Closed corporate peasant communities in Mesoamerica and Central Java. Southwestern *Journal of Anthropology 13*.

Wolfensohn, J. D. 2000. Forward by the World Bank President to the World Development Report 2000/2001: *Attacking Poverty. World Bank,* Washington, D. C: Oxford University Press. htpp://www.worldbank.org/poverty/wdrpoverty/docs.htm

Woodhouse, P., 1991, Participatory agricultural research and grassroots resource management: What role for the extension service in Africa? *Paper presented at the Conference on Sustainable Agricultural Development, University of Brandford, December 1991*.

World Bank, 1994. *The World Bank and Participation (4th draft)*, Washington DC: World Bank.

Yin, R. K., 1981a. The case study as a serious research strategy. *Knowledge: Creation, Diffusion, Utilisation, 3*, 97 – 114.

Yin, R. K., 1981b. The case study crisis: Some answers. *Administrative science Quarterly, 26*, 58 – 65.

Yin, R. K., 1983. The case study method: *An annotated bibliography (1983-1984 ed.)*, Washington, DC: Cosmos Corporation.

Yin, R. K., 1994. *Case study research. Design and Methods. 2nd ed. Applied Social Research Methods Series Vol 5*, London, UK: Sage publications Inc.

Zazueta, A. 1995. Policy Hits the Ground: Participation and Equity in Environmental Policy making. World Resources Institute, Washngton DC. In: Dalal-Clayton, D. B., Dent, D and Dubois, O., 2003. *Rural planning in developing countries: supporting natural resource management and sustainable livelihoods*, London: Earthscan Publication Ltd.

APPENDICES 3.1 - 3.10 – BOX REFERENCES FOR CHAPTER THREE

Appendix 3.1: Research reports and publications from the on-station research activities

Box 3.1: On-station research reports and publications

1. Ndegwa, J. M., 1992. Digestibility and Metabolic Energy determination of ground and unground sesame (Sesamum indicum) seeds in broiler diets. Msc thesis, Wageningen Agricultural University, Wageningen, The Netherlands

2. The effect of cooking grain amaranth (Amaranthus hypochodriacus) on its utilisation by broiler and indigenous chickens. In Proceedings of Rural Poultry Workshop. Kakamega, July. Kenya Agricultural Research Institute (Okong'o *et. al., 1998)*.

3. Morphological characteristics and protein requirements of indigenous Kenyan chicken. In Proceedings of the 6th biennial Kenya Agricultural Research Institute (KARI) scientific conference 9 - 13 November 1998, pp 1 – 9. Nairobi: KARI (Tuitoek, *et. al., 1999)*.

4. Growth performance of indigenous chickens fed diets with different protein levels. (Ndegwa et.al., 2001c – enclosed at the back of this thesis).

5. Hatching characteristics of eggs from six reciprocal crosses of Kenyan indigenous chickens artificially incubated (Ndegwa et al., 2002 – enclosed at the back of this thesis).

6. Growth characteristics of indigenous chickens lines and a cross with Rhode Island Red in Kenya (Ndegwa *et, al.* 2005a – accepted for publication - Tropical Agricultural Journal and included in chapter 4 this thesis).

7. Growth characteristics of six reciprocal crosses of Kenyan indigenous chickens (Ndegwa et al., 2005b –submitted to Outlook in Agriculture Journal and included in chapter 4 this thesis).

Appendix 3.2: Categories of organisations and institutions covered during the field and consultation process

Box 3.2 : Coverage of the field visits and consultations

1) Universities, research and technical training institutions:

- University of Nairobi, College of Agriculture and Veterinary Sciences
- Jomo Kenyatta University of Agriculture and Technology
- Egerton university
- University of Eastern Africa, Baraton
- Animal Health and Industry Training Institute - Nyahururu, Nyandarua distict
- Kenya Agricultural Research Institute Animal Health Programme

2) Extension services (Ministry headquarters, provincial, district and divisional level):

- Veterinary Laboratories Nairobi
- Agricultural extension service - Nakuru, Nyandarua, Laikipia Nyeri, West Pokot, Trans Nzoia, and Baringo districts

3) Professional organisations:

- Kenya Veterinary Association - Women branch

4) Development projects:

- National Poultry Development Project (NPDP) – Ministry Headquarters, Nairobi.
- GTZ poultry project in Nyeri.
- Arid and Semi-Arid Lands (ASALs) projects - Laikipia and West Pokot
- Laikipia Research Programme - an inter-disciplinary research entity under the then Ministry of Lands Reclamation, Regional and Water development in collaboration with the department of soil science of the University of Nairobi and University of Bern, Switzerland.

5) International organisations:

- ILRI library - Nairobi

6) Non-governmental organisations:

- Catholic Relief Services - Nairobi
- Catholic diocese of Nakuru, Agricultural and Rural development programme
- ACK church (Anglican) Nakuru diocese Agriculrural Programme
- ACK church - Ngarua, Laikipia district
- National Council of Churches of Kenya (NCCK), Sustainable Agriculture Project - Nakuru
- World Vision - Nanyuki, Laikipia district
- Farm Africa - Nanyuki, Laikipia district
- Farming Systems Kenya - Nakuru

7) Input suppliers:

- Cooper (Kenya) Ltd - Nairobi
- ABC Foods Ltd - feed manufacturer, Nakuru
- Milling Corporation of Kenya - feed manufacturer, Nakuru
- Unga Feeds Ltd - feed manufacturer, Nakuru
- Rift Valley Products - feed ingredients supplier, Eldoret, Trans-Nzoia

Appendix 3.3: Examples of collaborative projects on indigenous chickens between KARI and some Universities in Kenya

Box 3.3: Collaborative projects between KARI and Universities in Kenya

1. Morphological characteristics and protein requirements of Kenyan indigenous chicken - MSc, Egerton University (Tuitoek *et al*., 1999).

2.The effect of cooking grain amaranth (*Amaranthus hypochodriacus*) on its utilisation by broiler and indigenous chickens - MSc project, University of Nairobi (Okong'o *et al*., 1998).

3. Nutritional studies with indigenous chicken - Msc and PhD project, Egerton University

Appendix 3.4: Abstract of paper presented at the international community development conference in Rotorua, New Zealand, 2-6 April 2001.

Box 3.4: PARTICIPATORY STRATEGIC APPROACH TO DEVELOPMENT OF IMPROVED INDIGENOUS POULTRY SYSTEMS IN EAST AFRICA.

ABSTRACT

An on-farm farmer participatory research project was carried out in Kenya to improve the management of indigenous chicken and their productivity at farm level, in five different agro-ecological zones. This paper details the research methodology used and highlights some experiences and lessons learnt. The major objectives of the on-farm research were; to improve management and productivity of indigenous chicken at farm level, to change attitudes towards indigenous chicken, to improve farmers capacity and ability to carry out research (involve them in design, implementation and monitoring activities) using local resources and, to exploit the potential of indigenous chickens to contribute to poverty alleviation among rural landless people mainly women.

The research project was carried out in five different agro-ecological regions. In each region, four clusters (each cluster from a different village) were selected comprising of ten farmers each. This was followed by farmer training workshops that were held at cluster level. Implementation of a variety of improved management practices was done largely by use of local resources and farmers participation. Monitoring and evaluation were done continuously by farmers and on a regular basis by the research team.

Over five hundred farmers were trained on improved management practices for indigenous chicken production, a figure higher than 2-fold the anticipated target. An important achievement was made in the way of creation and enhancement of social capital by bringing together individual farmers and the research team to interact freely and share information, knowledge and experiences. Mutual trust, interest and enthusiasm were generated and were instrumental in the subsequent implementation of the project. Farmers were able to implement a variety of interventions from a basket of options, at their own pace and, with their own locally available resources. Formation of farmer groups (clusters) was a big boon in securing some limited external inputs such as roofing materials and vaccines through joint efforts (harambee).

This paper demonstrates and emphasises that involvement of beneficiaries in anti-poverty initiatives, is an imperative if the objectives are to be achieved.

Appendix 3.5:Email communication and conference attendance.

Box 3.7 Email messages communication on international conferences where indigenous chickens research work was presented

1. Symposium on Family Poultry at the XXI World Poultry Congress in Montreal Canada in August 2000

Dear all,

Many thanks for your valuable assistance which made a success of the Symposium on Familiy Poultry, held during the last XXI World Poultry Congress. I really appreciated it very much.

I wish you the best for the future, especially to Aini and Arsenia who, I strongly hope,are presently recovering well from their medical problems.

I would like to confirm that - as stated by Funso during our meeting - I am not yet tired, although I have retired, and that I am still interested and available to contribute to INFPD activities.

Kind regards.

René Branckaert

La Bergerie

F06450 CROS d'UTELLE France

Tél/Fax : 33 (0)493031529

E-Mail : rene.branckaert@wanadoo.fr

2. International Association For Community Development Conference in New Zealand in 2001

Dear Joseph

I am writing regarding your abstract that you presented for the International Association Community Development Conference "Investing in Community Development" to be held in New Zealand in April 2001.

Your abstract was considered by the Convenors at its meeting on 20 November 2000. I am pleased to advise that your abstract has been accepted. The Convenors were very supportive of your presentation. I will email you within the next week on what the next step will be. Thank you for your submission and congratulations.

Kind regards

Kala Ah Mu

Project Assistant

Project Assistant

Appendix 3.6:Email communication on electronic conferencing focusing on family poultry production

Box 3. 8: Email messages about the 2nd FAO/INFPD electronic conference on Family Poultry Production – July 2002

1. Dear Participants,

Time has come to close the African Hall of the Present Electronic Conference. Many thanks to all participants who have efficiently contributed to the success of this session particularly devoted to the present Family Poultry production problems encountered in the different areas of the African Continent.

I am especially grateful to Robyn Alders,Thomas Kaudia, Charles Ouadraogo, Christophe Chrysostome, Khalid Benabdeljelil and Joseph Ndegwa for their substantive contributions related to their respective regions. A special thank also to Mamadou Sangare for his dynamic participation in the discussions.

I would like to take the opportunity of the present World Food Summit for reminding you the exceptional role that Family Poultry can play for the alleviation of poverty and malnutrition throughout the developing world. I wish all the best to all of you for your present and future activities.

I will now give the floor to Manual Pampin who will moderate the Latin-American Hall.
Best regards.

René Branckaert
La Bergerie 06450 Cros d' Utelle
Tél/Fax : + 33 (0)4 93 03 15 29
E-Mail : rene.branckaert@wanadoo.fr

2. Dear Participants,

The electronic conference will end today and we thank you all for your contribution. We received a lot of interesting papers and comments, that will appear soon on the web site of the conference, as a compiled form.
http://www.fao.org/ag/aga/e-conf/poultry/default.htm

Emmanuelle Guerne Bleich
Animal Production Officer (Small Animals)
Tel:(39) 0657056660 Fax:(39) 0657055749
AGAP/FAO
Viale delle Terme di Caracalla
00100 Rome, Italy
Mon, 08 Jul 2002

3.
Dear Subscribers,

Please find here our web-site address regarding the 2nd FAO/INFPD ElectronicConference. We are trying to post all the information, some more are coming soon.

Cher participants,

Veuillez trouver ici l'adresse Internet de la Deuxième Conférence électronique de la FAO/RIDAF. Nous essayons de poster toutes les informations, plus viendront encore dès quelles seront disponibles.

Queridos participantes,

les envío el sitio de la "Secunda Conferencia Electrónica de la FAO/RIDAF. Estamos tratando de incluir toda las informaciones disponibles al momento, sin embargo otras más serán incluida una vez disponible.

http://www.fao.org/ag/aga/e-conf/poultry/default.htm

Emmanuelle Guerne Bleich
Animal Production Officer (Small Animals)
Tel:(39) 0657056660 Fax:(39) 0657055749
AGAP/FAO
Viale delle Terme di Caracalla
00100 Rome, Italy

4.
From: Joseph Ndegwa
To: Family-Poultry2-L@mailserv.fao.org
Sent: Thursday, June 13, 2002 11:44 PM
Subject: some research experiences with indigenous chicken in Kenya

I would like to share some experinces of research with indigenous chicken in Kenya. Please see the two attached files.

Regards

Joseph Ndegwa

5. Dear Joseph

I am managing the redesign of the Rural Poultry website
http://www.vsap.uq.edu.au/ruralpoultry

The project is taking longer than expected. I am currently updating the contact list to be used by the website editor.

I have also been following the INFPD website e-conference. I note your contributions to the conference and thought you may like to have your name added to our website editor's contact list. Please let me know if you are agreeable.
>
>Thank you
>
>Regards
>
>Sally Grimes
>Senior Research Technician
>John Francis Virology Laboratory
>School of Veterinary Science
>University of Queensland.
>St Lucia 4067
>AUSTRALIA
>Tel 61 7 33655740
>Fax 61 7 33655600
>Email s.grimes@mailbox.uq.edu.au

Appendix 3.7: Dissemination and communication of research output

Box 3.9: Publications and reports from the whole research process

1. Ndegwa, J. M., 1992. Digestibility and Metabolic Energy determination of ground and unground sesame (S*esamum indicum*) seeds in broiler diets. Msc thesis, Wageningen Agricultural University, Wageningen, The Netherlands.

2. Proceedings of the First KARI, Poultry Research Priority Setting Workshop (Mbugua et. al.,1994)

3. Proceedings of second Poultry Research Priority setting Workshop (Ndegwa et. al., 1994).

4. Rural poultry production in Kenya: Research and development strategies (Ndegwa et. al., 1997).

5. Improvement of indigenous poultry production in Sub-Saharan Africa (Ndegwa e. al., 1998a)

6. Evaluation of the state of the art in poultry industry in the Rift Valley province in Kenya. (Ndegwa,*et. al*., 1998b).

8. A Rural Poultry Production Manual. In: Proceedings of rural poultry production workshop. August, 1998. Kakamega: Kenya Agricultural Research Institute (Ndegwa *et. al*., 1998c).

9. The effect of cooking grain amaranth (Amaranthus hypochodriacus) on its utilisation by broiler and indigenous chickens (Okong'o *et. al*., 1998).

10. Characteristics of rural poultry production in different agroecological zones in Kenya (Ndegwa, *et. al.,* 1999)

11. Morphological characteristics and protein requirements of indigenous Kenyan chicken (Tuitoek, *et. al*., 1999).

12. A research process and methodology focusing on indigenous Kenyan chickens (Ndegwa, *et. al.,* 2000)

13. Participatory Strategic Approach to Development of Improved Indigenous Poultry Systems in East Africa (Ndegwa, *et. al.,* 2001a.

14. The growth performance of indigenous Kenyan chickens fed diets containing different levels of protein during rearing (Ndegwa, *et. al.,* 2001c)

15. Role of family poultry (scavanger poultry) production in sustainable livelihoods and poverty eradication – the case of Wanjiku (Ndegwa, *et. al.,* 2001b)

16. Training and disseminations strategies for the promotion of improved management practices of indigenous chicken already developed through an on-farm participatory research project, and their impact on the livelihoods of landless women in Kenya (Ndegwa, *et. al.,* 2001d).

17. Evaluation of strategic approaches to information dissemination for management and control of major endemic diseases in indigenous poultry systems with poor women groups in kenya: a livelihood and poverty eradication strategy (Ndegwa, *et. al.,* 2001e)

18.Strategies for harnessing indigenous poultry systems to combat poverty among Kenyan women (Ndegwa, *et. al.*, 2002a).

19. Hatching characteristics of eggs artificially incubated from six reciprocal crosses of indigenous Kenyan chickens (Ndegwa, *et. al.,* 2002b).

20. Growth characteristics of indigenous chickens lines and a cross with Rhode Island Red in Kenya (Ndegwa, *et. al.,* 2005a)

21. Growth characteristics of six reciprocal crosses of Kenyan indigenous chickens (Ndegwa, *et. al.,* 2005b)

Appendix 3.8: Box 3.10 Newsletter communication on indigenous chicken research (http://www.fao.org/ag/againfo/subjects/en/infpd/documents/newsletters/Infpd111.pdf)

● العربية ● 中文 ● español ● français

Agriculture Department
Animal Production and Health Division

home | programmes | projects | resources | subjects | commissions | SEARCH

INFPDNEWSLETTERS

Subjects

Production

International Network for Family Poultry Development (INFPD)

Newsletters

2003, Jan/Jun

Since 1997, AGA has supported the INFPD to produce two newsletters per year. The newsletter covers all aspects of rural poultry development in developing countries and the editor is responsible for collecting and analysing available information for each edition. The majority of contributions come from the members themselves.

The INFPD Newsletter is sent electronically to over 460 members from 70 countries worldwide and is also available on-line. Approximately 70 percent of the members are from Africa but more and more from Asia and the Pacific, Latin America and Europe are now involved in INFPD activities. You can easily become a member of the INFPD and regularly receive the newsletter.

Contact

E. Fallou Guúye
Editor, INFPD newsletter
Senegalese Institute of Agricultural Research (ISRA)
B.P. 2057, Dakar-Hann, Senegal
efgueye@refer.sn

Funso Sonaiya
Coordinator INFPD
Department of Animal Science, Obafemi Awolowo University
Ile-Ife, Nigeria
fsonaiya1@yahoo.com
fsonaiya@oauife.edu.ng

2002, July/Dec

■

2002, Jan/Jun

■

2001, July/Dec

■

2001, Jan/Jun

■

Archive/French Editions

■

Appendix 3.9: Requests made via email about indigenous chicken information by interested individuals from different countries

Box 3.11: Email messages requesting indigenous chicken research information

1. Isreal:

Dear Dr. Ndegwa,

I read your paper in INFPD's Newsletter with much interest and appreciation. Being a geneticist, with special interest in genetic adaptation of meat-type chickens to sub-optimal conditions, I wish to hear more from you about the genetic aspects of your project. Your paper deals mainly with the generation and dissemination of technical information. What about generation and dissemination of improved genetic stocks? It is well documented that the continuous enhancement of the efficiency of industrial poultry meat production has been mainly due to genetic breeding, i.e. the development of improved stocks. I belive that the same is true also for the low-input conditions in rural Africa, probably not by simply using industrial stocks such as Cobb or Ross, but possibly by selecting within indigenous stocks, or within populations derived from crosses between indigenous stocks and industrial stocks. I'm sure you can comment on this matter.

Best regards,

Avigdor Cahaner

2. Botswana

Ndegwa,

I am a researcher in Botswana working on indigenous poultry and when I was went through literature I came across your paper in International Network for Family Poultry Development (FAO). I was requesting that you could either e-mail me the following papers or send them to me if that is not big favour to ask.

1. Ndegwa et al., (1999). Characteristics of rural poultry production in different agroecological zones in Kenya. In: Proceedings of the 6th Biennial Kenya Agricultural Research Institute Scientific Conference, 9-13 November 1998, Nairobi, Kenya, pp. 540-547.

Thank you.

Slumber S. Badubi

Department of Agricultural Research

Private Bag 0033

Gaborone, Botswana.

3. Nigeria

Dear Ndegwa,

Greetings.
I came across your work published in INFPD Newsltter Vol II NO. Jan - Jun 2001 and I became aware that you have had a long standing experience with indigenous chicken research.

I am at the moment doing a Ph.D research on genetic and phenotypic evaluation of some Nigerian indigenous chicken ecotypes. I strongly believe that you can be of great help to me to get access to some relevant information on indigenous chicken of sub-saharan African.

I would, therefore be grateful if you can kindly supply me with website addresses, contact persons, and some of your personal publications that can help me in my work.

Thanks for your anticipated help.

I am yours sincerely
Momoh o. Michael
Dept of Animal Production
University of Agriculture
P.M.B 2373
Makurdi, Nigeria.

Dear Ndegwa,

I write to acknowledge the receipt of the two prints of your work on indigenous chickens which you mailed to me by post. I found them very interesting and helpful. Thanks a lot for sharing your knowledge with me inspite of the cost.
I am simply privileged to be linked to you as I hope to continue to draw from your wealth of knowledge and experience with indigenous chickens, an area in
which I am newly devleoping an interest as a result of my current Ph.D research.

The paper which you presented in Isreal in 1998 at CINADCO which appeared in the references of the prints may be interesting because of its broad coverage.

I also want to thank you for the contact addresses, which you provided namely those of Sally Grime and Prof. Avigdor Cahaner. Unfortunately I could not get in touch with them as their e-mails failed respectively, with the message "User unknown".

I look forward to hearing from you as it may be convenient for you.
Best wishes.

Yours sincerely,
Momoh O. Michael

5. Kenya

Dear Ndegwa,

I am a lady from Kenya . I am based in Kabete vetlabs where i am involved in village poultry research under IAEA research contract.I have come across your name in several publications with regard to village chicken production. I liked your paper on " A research process and methodology focusiing on indigenous Kenyan chicken presented at INFPD symposium during the XXI world poultry ongress in Montreal Canada ,2000. unfortunately it was the shortened version. What about the full version? I would appreciate if you sent me it. It would also be exciting to share the village chicken eperiences when you come back to Kenya.

Kind regards,

Dr. Sophycate Njue
Kabete Veterinary Research Laboratories
P.O. Kabete
00625 Kangemi,
Nairobi,
Kenya

6.Zimbabwe

Thabani Mophosa, Department of Animal Science, University of Zimbabwe,
P.O. Box MP167,Mount Pleasant, Harare,Zimbabwe./// mpaliwa@hotmail.com
Tel: 26311408374,

7. Tanzania

8. Cuba

Appendix 3.10: Email communication on research and development proposals focused on indigenous chickens submitted for possible funding

Box 3.12 Research and development proposals on indigenous chickens

1. DFID-UK, Livestock Production Programme (LPP) - 2000:
Dear Dr Norrish and Dr Shepherd
Concept Note No. LLK 00-08: 'Training and dissemination strategies for the promotion of improved management practices of indigenous chicken, already developed through an on-farm participatory research project, and their impact on the livelihoods of landless women in Kenya'

Dr Wyn Richards has asked me to let you know that at the last meeting of the Livestock Programme Advisory Committee (PAC) on 1-2 November, it was recommended that your concept note was considered suitable for progression to the project memorandum stage of LPP's competitive research scheme.

The comments of the reviewers and of the PAC will be sent to you shortly. In the meantime, please do not take any action until you have received these comments.
With kind regards
Christine Norris
Personal Assistant to Dr J I Richards
Natural Resources International Limited (NRIL)
Pembroke, Chatham Maritime, Chatham, Kent ME4 4NN
tel: (UK +44) (0) 1634 883628
fax: (UK +44) (0) 1634 883937
e-mail: c.a.norris@greenwich.ac.uk
For further information about Natural Resources International Ltd., please visit our Internet website at http://www.nrinternational.co.uk

2. World Bank's Development MarketPlace -2001:

Congratulations! Your project proposal has been selected to enter the second round of the Development Marketplace 2001 competition. Your proposal is among approximately 600 out of over 2,100 entries selected by the World Bank's Evaluation Committee. We now need you to complete a Full Proposal Form for the next round, by no later than August 1, 2001, 12 noon (US EST). Guidelines for Submitting a Full Proposal may be accessed by clicking here:
http://wbln0018.worldbank.org/srm/dm2001semifinalists.nsf/65a76107ef263c9685256a76002adf81/02ac53cc715d2abb85256a76002c5612?OpenDocument

Please write to us at dm2001@worldbank.org for any additional information or clarification about the form and/or process. Thank you for participating in the Development Marketplace. We look forward to receiving your Full Proposal
DM Team

3. DFID-UK, Animal Health Programme (AHP) – 2001

(‘Evaluation of strategic approaches to information dissemination for management and control of major endemic diseases in indigenous poultry systems with poor women groups in kenya: a livelihood and poverty eradication strategy‘):

Dear Dr Ndegwa

AHP would like to acknowledge receipt of your Research Proposal. This will be externally reviewed and then assessed by the Programmes' Advisory Committee meeting which is being held mid-October. We will contact you again when a decision has been reached.

Kind regards

Pauline McManus

Animal Health Programme Office

APPENDICES 4 – 7: APPENDICES REFERENCES IN CHAPTERS 4, 5, 6 AND 7 ARE FOUND IN THE CD ENCLOSED IN A PORCH IN THE INSIDE OF COVER PAGE OF THIS THESIS.

Appendix 4.1: Data on body weights of individual birds from three indigenous chicken lines and one cross of Rhode Island Red with Nyeri line

Appendix 4.2: Data on body weights of individual birds from six indigenous chicken reciprocal crosses.

Appendix 5.1: Names of regions and villages where the study was done.

Appendix 5.2: Treatment uptake - housing, vaccination, deworming and supplementation, in five regions in periods1 - 5.

Appendix 5.3: Treatment uptake totals for 5 periods for each farm in five regions.

Appendix 5.4: Demography characteristics – flock size and dynamics (addition, loss, sale, gift and consumption as recorded in each farm in region 1 over 5 periods.

Appendix 5.5. Demography characteristics – flock size and dynamics (addition, loss, sale, gift and consumption as recorded in each farm in region 2 over 5 periods.

Appendix 5.6. Demography characteristics – flock size and dynamics (addition, loss, sale, gift and consumption as recorded in each farm in region 3 over 5 periods.

Appendix 5.7. Demography characteristics – flock size and dynamics (addition, loss, sale, gift and consumption as recorded in each farm in region 4 over 5 periods.

Appendix 5.8: Demography characteristics – flock size and dynamics (addition, loss, sale, gift and consumption as recorded in each farm in region 5 over 5 periods.

Appendix 5.9: Flock demography dynamic factors - total addition, total reduction, controlled reduction (sales, gifts, consumption) and unplanned reduction (losses) in each farm in region 1.

Appendix 5.10: Flock demography dynamic factors - total addition, total reduction, controlled reduction (sales, gifts, consumption) and unplanned reduction (losses) in each farm in region 2

Appendix 5.11: Flock demography dynamic factors - total addition, total reduction, controlled reduction (sales, gifts, consumption) and unplanned reduction (losses) in each farm in region 3.

Appendix 5.12: Flock demography dynamic factors - total addition, total reduction, controlled reduction (sales, gifts, consumption) and unplanned reduction (losses) in each farm in region 4.

Appendix 5.13: Flock demography dynamic factors - total addition, total reduction, controlled reduction (sales, gifts, consumption) and unplanned reduction (losses) in each farm in region 5.

Appendix 5.14: Production factors – number of eggs laid, eggs set and eggs hatched over 3 hen cycles in each farm in 5 regions.

Appendix 6.1: Mean hatchability, treatment and demographic characteristics used in regression analysis for each farm in 5 regions.

Appendix 7.1: Average farm flock size data in five regions used in dissimilarity index analysis.

Appendix 7.2: Plots of flock size of village farm groups from dissimilarity index analysis in five regions.

Appendix 7.3: Average flock size of regional farm groups established from dissimilarity index analysis in 5 regions over five periods.