Report on the crop-livestock farming systems training course, Tamale, Ghana, 19-22 September 2012

International Institute of Tropical Agriculture

Produced by International Institute of Tropical Agriculture

Published by International Institute of Tropical Agriculture

25 October 2012

www.africarising.net

The Africa Research In Sustainable Intensification for the Next Generation (Africa RISING) program comprises three research-for-development projects supported by the United States Agency for International Development as part of the U.S. government's Feed the Future initiative.

Through action research and development partnerships, Africa RISING will create opportunities for smallholder farm households to move out of hunger and poverty through sustainably intensified farming systems that improve food, nutrition, and income security, particularly for women and children, and conserve or enhance the natural resource base.

The three projects are led by the International Institute of Tropical Agriculture (in West Africa and East and Southern Africa) and the International Livestock Research Institute (in the Ethiopian Highlands). The International Food Policy Research Institute leads an associated project on monitoring, evaluation and impact assessment.

Contents

Introduction

The Training Course

The Council for Scientific and Industrial Research's (CSIR) Animal Research Institute (ARI) convened a 4 –day Training Course on crop-livestock farming systems for personnel from Agricultural and Livestock research and development institutions, universities and private sector staff mostly from the three regions in Northern Ghana, namely, Northern, Upper West and Upper East Regions. The Training Course was undertaken in the context of the implementation of a wider Project *"Sustainable intensification of cereal – based farming systems in the Sudano-Sahelian zone of Ghana*" funded within the RISING initiative of the USAID's Feed the Future Project. The Training Course was delivered by four Resource Persons, each tackling a specific aspect on crop-livestock farming systems. The International Livestock Research Institute (ILRI) a key stakeholder in livestock and closely related enterprises in developing countries, especially in Africa, having been contracted by the International Institute for Tropical Agriculture (IITA), the USAID contractor for the RISING Project, contracted and partnered with CSIR-ARI to execute the eventual crop-livestock component of Project in Northern Ghana. The Training Course was one of the Activities identified under the Project. Twenty eight (28) persons participated in the training course.

Objectives

The objectives of the Training Course were:

- To equip the participants with the "state- of- the- art" knowledge on the subject of crop-livestock farming systems
- To sharpen the skills of participants in handling issues in the crop-livestock integration domain by providing them with analytical tools used in designing and implementing crop-livestock integrated projects

Expected outputs/outcomes

It was expected that at the end of the workshop, the following would have been achieved:

- An enhanced knowledge base of the course participants
- More confident personnel in matters dealing with crop-livestock farming systems obtained through lectures and group work.

Background

The U.S. Agency for International Development (USAID) is supporting multi-stakeholder agricultural research projects to sustainably intensify key African farming systems as a pathway to attain food security and to combat poverty in sub-Saharan Africa. In West Africa, this research project focuses primarily on maize- and rice-production systems in Northern Ghana but is intended to result in spill-over effects in other similar agro-ecological zones. The overall objective of the Feed the Future Initiative is to improve livelihoods through sustainable increased productivity of maize-legume and crop/tree/livestock systems in the northern Guinea and Sudan savanna zones of Ghana and Mali.

Increasing population (3.0% growth rate) and severe climate change effects are sufficient drivers calling for the need to put in place tested and proven systems for increased productivity sustainably to address the food and nutrition requirements. The three northern regions of Ghana are the most poverty stricken and hunger spots in Ghana (GLSS, 2000) because of a number reasons. Low input-outputs farming systems found in the northern regions are able to secure food for the population for only 3-5, 4-5 and 6-7 months for cereals (maize, sorghum, millet) and 5-7, 4-5 and 6-7 months (groundnut, cowpea, and soybean) in the Northern, Upper West and Upper East Regions, respectively. Limited integration between crop and livestock production systems and continuous monoculture has led to decreasing soil organic matter contents, parasitic weed infestation, reduced soil biodiversity, higher risk of erosion, and significant nutrients losses that in turn has resulted in reduced yields per unit per ha. The deterioration of the resource is exacerbated by low levels of mineral and organic fertilizers usage due to high cost and inadequate purchasing power.

In northern Ghana the livestock component assumes greater importance as major source of livelihood and income for many households as well as in food security initiatives of farm families and whole communities. Rural poultry, sheep and goat rearing and small scale dairy, particularly are known to best serve the interests of women and poor households.

Practical technological and institutional solutions are required at the smallholder farm level to pave the way for the sustainable intensification crop-livestock systems for improved livelihoods. In that regards, National R&D Organizations (CSIR-ARI, University of Development Studies and Ministry of Agriculture (MoFA)) and ILRI are combining their efforts to conduct R4D activities in Northern Ghana in order to identify and pilot test sustainable farming practices and to effectively deliver and scale out research outputs to end users.

Approaches to the conduct of Training Course

In order to achieve the outputs set, an approach of using four carefully selected resource persons to deliver focused lectures and practical work (Working Groups discussions, individual course participants' experiences narrated to the rest of the participants, etc.) to the participants over a period of four days. Questions asked and responses provided, as well as comments made by participants and resource persons were recorded to be used to enrich the conclusions and recommendations.

Resource Persons and Subject matter taught

The four resource persons and the titles of their lectures are listed below:

Dr. Augustine Naazie, 1st Resource Person: Methodologies in analyzing crop-livestock systems/modeling of systems

Dr. Pamela Pali, 2nd Resource Person: Improving crop-livestock integration system in the value chain system

Dr. Kwaku Agyemang, 3rd Resource Person: Topic: Crop-livestock Integration: Concepts, Principles and Practice

Dr. A. Opoku, 4th Resource Person**:** Integration of crop-livestock systems for improved soil management program

Results and Summaries

A total of 10 Lectures, 6 Working Group Sessions and 2 Experience Sharing Sessions were delivered during the four days. The Lectures delivered and questions and answers provided are compiled in a separate Volume "CSIR-ARI-USAID FEED THE FUTURE COURSE ON CROP-LIVESTOCK FARMING SYSTEMS" is attached to this Report as an Appendix. The current Report provides synthesis of questions, answers and discussions raised or done in the in the various Sessions of the Course.

Summary of Remarks made at the Opening Session prior to the delivery of the Lectures

Opening Session Presentations

a) Dr. Franklin Avornyo (FA) – Coordinator of Course

Topic: Introductions

The workshop commenced with an opening prayer by Kwaku Adumako at about 9:30am. FA then introduced the Director of CSIR-SARI (represented by Dr. James Kombiok) to open the ceremony and give the welcome address.

b) Dr. J. Kombiok (JK), Representative of the Director of CSIR-SARI

Topic: Welcome address

In giving the welcome address, JK stressed on the following points:

- It is a common phenomenon that most farmers pay more attention to crops than livestock
- Farmers are proud to boast about high (many bags) of crop yield but say less about their livestock
- The only time farmers think about animals is when there is a crop failure
- Interestingly, livestock play important roles in crop production to ensure a win-win situation; such as provision of draught power, provision of manure, weeding of plots in certain areas
- Researchers are doing their best to integrate and/or intensify Crops-Livestock (C-L) systems but farmers appreciation is questionable

Therefore, this workshop and the resource persons (who will be speaking) aims at building capacity of stakeholders to tackle issues related to C-L systems. JK thanked USAID for providing financial support that enabled the undertaking of this project. Finally, JK wished all participants fruitful deliberations and good time at the workshop.

c) Dr. Franklin Avornyo (FA) – Coordinator of Course

Topic: Brief presentation on the project

FA presented the rational for the project by outlining the following:

- Poverty is a common phenomenon in northern Ghana and its made worst by;
- Low Input-Low Output agricultural systems which results in hunger gaps in the zone
- Erratic rains and high post-harvest losses also contribute to the hunger gaps
- Limited integration of crop-livestock
- Poor soils, erosion and poor crop yields
- Poor purchasing power of farmers to buy fertilizers
- But farmers are now realizing the need for taking livestock rearing seriously

FA posed the question "How do we solve such problems?" FA advocated what need to be considered. He emphasized practical, technological and institutional solutions. FA stated the specific objectives of the project as:

- Identify constraints and opportunities to intensification of C-L systems
- Document best-bet knowledge about C-L systems
- Promote proven strategies on C-L systems

FA then introduced the Resource Person for the day, in the person of Dr. Augustine Naazie to take participants through the day's course.

d) Dr. Augustine Naazie (AN), 1st Resource Person

Topic: Methodologies in analyzing crop-livestock systems/modeling of systems

The full 3-part Presentation is in Appendix 1.

In his introductory remarks, AN stated that crop-Livestock systems is a concept from Mixed farming systems (MFS) - a system of managing a mix of different crops and/or animals. AN stated that MFS consists of: Mixed cropping systems – better use of soil nutrients, crop-livestock systems – integration; mixed livestock systems – better use of feed resources. AN gave the overall objective of mixed farming is to realize the optimal result from a combination of crop and livestock activities. AN explained that MFS for high yield of the combination of components, rather than high yield of one component! They consist of different parts which together act as a whole. They

therefore need to be studied in their entirety and not as separate parts in order to understand the system and the factors that drive farmers and influence their decisions.

Synthesis of questions, answers and discussion on Part 1 of Presentation

In response to the question "Where does the crop-livestock (C-L) integration start?" AN responded that there is no specific point of time for integration for C-L because farmers don't usually define specific times. One may be a crop or livestock farmer and when s/he appreciates the need for introduction of the other component (crops or livestock) s/he takes steps to implement it. In most cases the farmers will notice the C-L integration only at an advanced stage of the C-L system. The dilemma of promoting cattle production as part crop-livestock systems and their (cattle) contributions to greenhouse effects came up as a question. While AN admitted to the linkages between ruminants and emission of greenhouse gases, he went on to explain that Ghana's contribution to greenhouse gas (GHG) emission is very insignificant (about 0.05%) and even lower percentage from livestock. AN further stated that even at the global level, livestock contribution to GHG emissions is relatively small depending on the system, hence animals are not a big problem to the environment in terms of climate change in Ghana. Acknowledging good source of animal feed can reduce the emissions of GHG, AN provided information to the effect that the Savannah Agricultural Research Institute (SARI) is currently researching into and developing dual-purpose crop varieties that will produce good yields of grains and residues/fodder because such are the varieties most preferred by farmers.

Part 2 of Presentation

The Second Presentation by AN was on "Modeling of systems". AN explained that a "model" is a representation of a process, object or system which may be a physical replica on a reduced scale (iconic model), a graphical representation (visual model) or a mathematical approximation of the physical attributes of the system (symbolic or abstract model). AN stated that visual and symbolic models have no physical or biotic attributes, and gave examples of iconic models as models of cars, airplanes, humans, experimental plot etc., Visual models as drawings, graphs, diagrams, and Symbolic models as statistical or simulation models.

Group exercises

The participants were then divided into two groups and given topics to some C-L systems and tasked to model them. **GROUP 1,** tasked to model a ruminant – strip cropping system with Objectives to: Sustain soil fertility through the addition of manure from animal droppings, in order to maximize crop yields; Improve small ruminant productivity through regular supply of feed/fodder from crop residues; Ensure overall profitability of the farming enterprise. Three (3) systems were

identified in this crop-livestock integration, namely Ruminants, Crops (Legumes and Cereals) and Soil Nutrients. The components associated with each system were outlined as Ruminants (genetics, feed intake, fodder, climate, reproduction rate, manure, animals, animal products (milk, meat, etc.); Crops (varieties, climate, cultural practices, plant nutrients, organic matter, grain, fodder); Soil Nutrients (climate, organic matter, plant nutrients, harvested crops/nutrients uptake, leaching/erosion).

GROUP 2 was tasked to model integration of pigeon pea-maize-small ruminant for feed and soil fertility management with the objectives to generate biomass as feed for livestock, obtain manure for soil fertility management and to increase farm profit. the system sub components were identified as pigeon pea, maize and small ruminants. The Group identified the crops components as biomass, nitrogen, weeds, spacing/density, crop type and variety. Animal components were identified as breed/genetics, prolificacy of breed, manure and reproductive traits

Day 2

a) Dr. Franklin Avornyo (FA), Course Coordinator

Topic: Opening and Introductions

FA introduced the Resource Person in the person of Dr. Pamela Pali.

b) Dr. Pamela Pali (PP), 2nd Resource Person.

Topic: Improving crop-livestock integration system in the value chain system

The full Lectures given by PP are in Appendix 1 to this Report. In Part 1 and 2 of her 3-part Presentation PP talked about Innovations and Innovation Platforms and defined "innovation", and "knowledge" and posed the questions "What are the needs of people, in order that they can, and want to, innovate? And "What are the sources of "knowledge"?"

PP defined Innovation as a "social process involving many different actors" and continued to elaborate that the Innovation processes can be enhanced by creating more possibilities for actors to interact – on innovation platforms. An Innovation Platform (IP) was also defined as "coalitions of actors, formed to address constraints and explore opportunities to improve performance of activities through use of knowledge and mutual learning" to provide a mechanism to facilitate communication and collaboration amongst actors, to promote joint action, and to stimulate innovation. Other topics covered by PP were Effective IPs, What is needed to establish and maintain IPs, Local and higher level IPs and challenges in running IPs.

In order to bring home more forcefully the new approach of Innovation in comparison with how things were done in the past, PP organized three (3) Working Groups and tasked them to perform what is old and new about the USAID-funded Project for which some of the course participants are a part. The Groups worked on

three (3) projects namely; **Group 1**: Small ruminant, **Group 2**: Poultry (guinea fowl) and **Group 3**: Diary. The Groups were tasked with the following:

- Identifying part of the project objectives/activities that is new to you (compared to before)
- Stating Why has it not been done before
- Identifying a part of the project objectives/activities that has been tried before
- Stating What results were achieved

Synthesis of questions, answers and discussion on Parts 1 and 2 of Presentation

In response to the questions "Has the linear form of innovation transfer got a place in innovation platform or it is antagonistic?, and "How do you sustain the innovation platform?", PP explained that the linear form of innovation has its information flow from the researcher to the extension officer and then to the farmer, whiles that of the innovation platform extends to involve the NGO's and other private individuals. In this case information flow is not only one-way but can be crisscrossing. The innovation and innovation approaches are used within the Integrated Agricultural Research for Development (IAR4D) approach of agricultural research. In another Group Work exercise the initial three groups of Small ruminant, Poultry (Guinea fowl) and Diary project groups were maintained and group members were tasked to develop interventions and identify the actors that will be involved in such projects and how these interventions can be linked/interact with one another.

The Group which worked on Poultry (Guinea fowl) raised several issues or interventions in the areas of improving productivity and marketing of Guinea fowl; breed improvement; feeding; marketing and actors. Activities were defined under each of the intervention areas. A considerable amount of time was devoted to discussion on breed improvement. The role of Government of Ghana in breed improvement was particularly discussed. It was explained that in the Innovation Platform approach roles and responsibilities of each actor in each of the interventions should be pre-defined. In the case of breed improvement programs the initial policy setting out what the longer term directions for the country only an approved government Agency can initiate the process. To illustrate how interventions could be linked, an example of how market interventions and breeding interventions are linked was used. It was said that interventions in marketing that lead to increased profit can influence breeding in the form of introduction of improved breeds or procurement of better feed for the guinea fowls.

For Group 3 which worked on dairy an intervention of hygienic storage and appropriate containers to use dominated the Plenary discussions. The question of what improved storage or packaging containers meet the "standard" of the sector was discussed. It emerged from the discussion that so far as dairy (milk) is concerned there are specific technical standards to meet. For example, containers for milk

storage should have a wide mouth to avoid contamination and re-contamination, Stainless steel type of containers are recommended because complete “pour-out” is assured thus preventing re-contamination from left-overs in the container.

In order to impart further skills to course participants on creation and running of IPs, another session of Group Work was organized to discuss the following:

- What role can Innovation platform play in the project
- What do we need to establish the innovation platforms (in terms of information, initial activities)
- What key activities and resources do we need to keep the innovation platform functioning

The three Groups on Small Ruminant IP, Poultry IP and Dairy IP were maintained.

Synthesis from Group Work

In response to the question of “What role can Innovation platform play in the project”, the three Groups gave a range of answers some which overlapped. For the small ruminant Working Group IPs were understood to be able to increase knowledge and understanding of integration of small ruminants and crops, for example, the use of cowpea residue to feed sheep/Goats and manure from Sheep/Goats for crop production; IPs would help in the identification and linkage of actors, which will help achieve the objective of the project, for example, linkages of farmers to hotels, butchers, etc., to sell their animals to them. IPs would increase and sustain information flow in the value chain. For the Poultry Group IPs would contribute to building capacities of members in the area of breed improvement, marketing and feeding. For the Dairy Group IPs would help to addressing the issue of adequate and quality feed supply all year round, assisting in improving access to markets for example, identifying potential markets and good price negotiation.

Small Ruminant Value Chain Group at Work

With respect to the question -"What is needed to establish IPs?" the three Groups listed a number of approaches including Stakeholder analysis to identify actors, Participatory Rural Appraisal to select and prioritize constraints in the value chain, SWOT analysis to take advantage of the opportunities, invitation and sensitization; have a forum to ascertain the challenges and opportunities of various actors; develop a program to enable its sustainability. Identify the actors (stakeholders) eg. Farmers, researchers, processors etc. and their interest which will determine the focus; organize regular and productive meetings and appoint or elect leaders . In the area of resource and activities needed to keep the IPs, structuring and setting up governance of the IP, developing Action plans for the IP, putting up a strategy for initial source of funding, and Monthly payment of dues by members

In the Part 3 of her Presentation "Experiences: Research-based IPs" PP used her experiences on the Sub-Saharan Africa Challenge Program (SSACP) Pilot Learning Site in Kenya. In setting up the IP for the Project some questions needed to be answered. Among them; IP Formation / Methods of formation – Is the IP based on existing structures – the stakeholders may already be existent with less number of actors – Is the IP beginning from scratch – because different actors operate separately: What type of innovation platform is appropriate? – Grass roots – largest number of actors are farmers, slow decision making due to long deliberations, bottom up decisions, – Apex body IP – Decisions made at a higher level, Decisions communicated downwards, decisions are made faster, – Itinerary IP – Combination of grass roots and the apex body. What is the Life of the IP? –it depends on the nature of the issue and finances. Are the current IP actors relevant to the IP issue? Who else is a relevant actor Integrated crop livestock production?

The Dairy Value Chain Group at work

PP shared a Case Study with the Course Participants: " Established in November 2008 in District Rubavu, and territoire Mudende and found in a poor market access area the focus of the IP was to Improve productivity of Irish potato and to improve milk production. Among the characteristics of the area – 70% participation of women, met once a month, funds from researchers (100$ per month). There were "Storming" periods: For example the chairperson and executive committee of the IP stopped meetings due to various reasons – chairperson was removed from the post & others elected. Opportunity: Commercial milk production for INYANGE industries in Rwanda. Another "Storming" period: co-operatives and milk middle men (women) actors in the chain not considered so milk production for the large milk firm stopped. Farmers were not organized. Product quality: Milk was kept in plastic containers which was unhygienic. Innovation: Cost sharing access to credit to procure milk cooling system to meet the standards of Inyange Industry raise 9,000,000 Rwandese francs (15,000 USD). Outcomes: Increased prices of milk from 90RWF– 180 RWF, increased quality and quantity.

DAY 3

Opening:

a) **Dr. Kwaku Agyemang (KA)- Facilitator/ 3rd Resource Person**

Topic: Crop-livestock Integration: Concepts, Principles and Practice

KA gave a 3-Part Presentation. Part 1 was on Concepts, Principles and Practice of crop-livestock systems. Part 2 was on Situation analysis of crop-livestock Systems in Northern Ghana. Part 3 was experience sharing from Course Participants.

KA gave the Scope of his Presentation as: What are the building blocks of Agricultural-Livestock Integrated Systems (ALIS) of which crop-livestock integrated systems is a subset? What are the Contributions of these components to human wellbeing and national economies. Why integrated crop and livestock systems matter– Reciprocal benefits and efficiency considerations? How do crop-livestock systems evolve? --- What are the Drivers? What is intensification and why should it be promoted?, How far can intensification go and what happens at the end of the road?, Are there practical examples where integration has succeeded or failed, How can we recognize one if we see one--Classification Systems, What are the current issues concerning Crop-Livestock Integration, Constraints and Opportunities in Northern Ghana.

KA gave the Objectives of his Presentation as: To Share and impart knowledge on Concepts and Principles of crop – livestock integration with Course Participants and To Learn of the experiences and knowledge of course participants for documentation for future use in Project designs and implementation.

After providing the Concepts and Principles, KA posed the Question-"Why integrated crop and livestock systems matter?" KA listed the main functions of livestock in the smallholder household/economy. KA then invited Course Participants to give their knowledge on the various functions of livestock. The following responses were received from the persons indicated:

Dr. Franklin Avornyo (CSIR-ARI, Nyankpala): A UDS undergraduate student conducted a research in Bawku to determine the contribution of livestock (donkeys) to household income. A comparison was made between the use of the incomes of male-headed and female-headed households. It was realized that income obtained from female-headed households were used to support the needs of the family, and could be accounted for. Incomes earned by male-headed households were usually taken by the family heads and could not be properly accounted for.

Dr. Nicholas N. Denwar (CSIR-SARI): He keeps a few sheep at his home in Nyankpala in the Northern Region. He collects and uses the droppings (manure) to fertilize an acre of land behind the house. He tried applying the manure to some areas on the plot and as maize plants grow on the land, a clear difference in the growth of the

plants could be seen between areas where manure was applied and areas where manure was not applied. Plants grown on fertilized spots outgrew and yielded higher than their counterparts that grew on unfertilized spots.

Mr. Benjamin Alenyorege (UDS-Nyankpala): Growing up as a small boy in Bolgatanga, Mr. Benjamin Alenjorege and his siblings could not weed their farms properly. However, the family kept some livestock from which the manure obtained was often applied to the farmers. An interesting observation which was well noted by the neighbors was the fact that crops on their farms, albeit growing alongside weeds, grew and yielded better than most people's farms. People often remarked that the family of Benjamin was quite ionic as they don't weed their farms very well yet they get very good crop yields. Besides, anytime there was a need to pay school fees, an animal from the family was sold to cater for that.

Naa Y. O. D. Saaka (MOFA - UWR): A life-time observation is that houses in which livestock were reared, the children in those houses grew up with interest in rearing livestock, and could be seen rearing livestock later in life. Also, the Fulani keep people's livestock for them, and usually create mobile kraals on and around their farms, thereby fertilizing the farms with the organic manure from the dung. They also sell the milk for money, which is an additional gain.

Mr. Jakper Naandam (UDS - Nyankpala): In Tamale town, there is a woman who buys cattle to fatten them for sale. She normally rears them within the township and supply them with supplementary feeds (peels and kitchen waste) as the animals roam town scavenging. She has been able to build houses with the profits realized from the sales of the animals. However, it should be noted that such free roaming animals are nuisance to road users.

Dr. Franklin Avornyo (CSIR-ARI, Nyankpala): In Tamale, there is a former employee of ITFC who is currently undertaking guinea fowl production as full time business. He got training in guinea fowl production during his days as an employee of ITFC. While working with ITFC, he was involved in a motor accident. Immediately he recovered, he resigned from his job and started hatching and raising guinea fowls for sale. He eventually got himself incubators for hatching the eggs. Presently, he even hatches eggs for people for a fee. He also has a partner, a woman who assembles and distributes guinea fowl eggs, and both of them are working very well.

Dr. K. Adomako (KNUST, Kumasi): In Ashanti Region, some poultry birds (domestic fowls) were given to rural farmers to improve upon their local breeds and increase local breed performance. Evidence showed that there was increase in number of birds per farmer resulting in increase in income and nutritional status of the farmers, as they obtained more eggs and birds for consumption and sale.

Synthesis of Part 1 of Presentation, contributions from Participants and questions and answers during Session

Although functions and roles played by livestock in farming systems in developing countries are fairly well documented, KA wanted a confirmation from the Course Participants that in the context of Ghana, and in particular Northern Ghana, these functions in reported in the scientific literature and text books do apply. It can be gauged from the responses provided by six (6) individuals that the multiplicity of functions of livestock is also found in the production systems in Ghana. It emerged from the responses that livestock is not restricted to rural areas but also in peri-urban and urban areas. The problems that had been recorded in urban agriculture involving livestock in the area of conflicts came through some of the narratives. The need to have some regulations on livestock movements and housing in commercial and human populated areas came up for discussion. The question of Government support for market development to support crops from specialized crop-farming to the disadvantage of crop-livestock integrated systems was raised. Some of the participants agreed that in such scenario integrated systems do suffer. The decoupling of livestock and crops from integrated systems happen faster than expected.

Part 2 of Presentation

In the Part 2 of his Presentation KA focused on the development of crop-livestock systems in Northern Ghana and attempted to match observed systems against categories of crop-livestock integration as defined under land-use and input use-based classifications. The types of systems referred to were: Pastoral Systems in Arable areas (interactions) and Matured or Full Crop-Livestock Systems (Integrated) when the Land use-based classification system is used. When the Input use-based classification system was used, the systems were: Mixed systems making use of communal grazing Mixed, crop residues Mixed, cut and carry Mixed, feed from farm Mixed, external feed. After KA explained what each of these categories meant, he invited course participants to give their experiences in crop-livestock integrated systems and to associate each experience with the categories described.

Participants were then given opportunities to share their experiences in crop-livestock integrated systems. The experiences reported were as listed below:

Part 3 of Presentation

Ms. Lantana Munkaila (CSIR-ARI, Accra): ARI-Nyankpala ran a project in 3 selected communities in Tolon-Kumbungu District in which farmers were trained and encouraged to collect manure from their livestock and apply it to their farms. They were also made to gather crop residues immediately after harvesting and use it to feed their livestock. After three years of practice, the farmers' opinion on the practice was sort. Farmers reported of improvement in crop yields as a result of

manure application as well as improvement in body conditions of animals which translated into good prices at the market.

Mr. Benjamin Alenyorege (UDS, Nyankpala): Working as a staff of MOFA in Wa, Upper West Region, he fenced some area by his house and created a pig sty that was raised above the ground to be suspended, inside the fence. Then in the same yard, he created a hen-coop to house some (40) cockerels. The droppings of the pigs fell and heaped beneath the suspending pig sty. Maggots bred from the decaying droppings became feed for the cockerels as they moved about in the fence picking those maggots. Any pig feed that dropped beneath the sty was also picked by the fowls. No special feed was ever provided for the fowls but they grew very well to the admiration of all persons who visited the scene. The manure from the pig dung and poultry droppings was used to fertilize a near-by plot where vegetables and maize were cultivated. Those vegetables grew and yielded very well. The manure generated was usually in large quantity that some was often given to friends to fertilize their farms. With the use of the manure, it was very easy to raise a hedge around the house to prevent people from standing directly behind the house to converse in the evenings.

Dr. Edmond K. Sallah (UDS, Nyankpala): When he was working as District Director of MOFA in the Tolon-Kumbungu, he identified two serious and committed farmers with the help of the agricultural extension agent in the area. These two farmers were given training on how to take care of their farms and animals effectively. They were also encouraged to keep records on their farms. Having taking the advice of the agricultural officers seriously, the farmers had positive results and testimonies by the time Dr. Sallah left the district. One farmer's sheep number increased from 20 to 70 in about 3 – 4 years. He used to cultivate a small (about 1 – 2 hectares) of land, but this had increased to about 5 hectares, and the number of his cattle had increased from 2 to 7. He used to harvest 3 – 5 bags of grain but this had increased to 10 – 12 bags. The other farmer had similar results too. One of the farmers even bought a generator and television for entertaining his household, of which most of his neighbors came to him to be entertained too in the evenings. Those two farmers were nominated for district agric awards and they actually got some prices (donkeys and carts). Occasional, the farmers gave me (Dr. Sallah) a sheep or goat to show appreciation.

Dr. Franklin Avornyo (CSIR-ARI, Nyankpala): ARI-Nyankpala undertook a project to compare the health status and the nutrients content of manure from cattle housed in open kraal and enclosed and roofed kraal. At the end of the experiment, cattle in the open kraal were healthier than those housed in enclosed structures. However, the manure from the open kraal was lesser in nutrients contents even though the difference was not significant. The experiment concluded that it was better to house cattle in open kraals.

Dr. Avornyo keeps a few small ruminants in his house, and also has a small plot by the house which he cultivates every year. Last year, he asked the watchman to spread the manure obtained from the animals on the farm. The watchman did the

work lazily by spreading the manure to some areas and leaving other areas. When groundnut and maize were planted, it could be seen clearly that the plants growing in portions which had the manure yielded better than those growing in the other areas. Also, areas where the groundnut and maize were overlapped, maize plants in those spots yielded better than their counterparts in other spots.

Dr. J. Kombiok (SARI, Nyankpala): A recent research revealed that when pigeon pea (*Cajanus cajan*) is cut at certain heights (70 – 80 cm) while still growing, it gives about three benefits; i.e. the plant will still grow to produce seeds, the remaining leaves will fall and decompose to add organic matter to the soil and the tops (residues) after harvesting is used to feed livestock.

George Bessa-Simons (MoFA, N/R): In Japan, a rice farmer and pig farmer lived in the same community and were friends. The pig farmer used to collect rice bran from the rice farmer free of charge to feed his pigs. Sometime later, the rice farmer thought that since he is generating more rice bran, he could sell it to make more money so he started selling the bran to the pig farmer. After some time, the rice farmer decided that since he could generate more rice bran than his pig farmer friend could use, it would be a good idea to go into pig farming. Eventually, he started rearing pigs along, using the rice bran to feed them. He realized that he was generating manure from the pig dung which could be used to fertilize fish ponds so he introduced fish farming on his field. He noticed a problem on the fish ponds, which was the occurrence of weeds on the water surface so he started rearing ducks, so the ducks swam on the ponds and cleared the weeds and other green materials growing on it. Eventually the man became complex farmer, owning different systems on the same field. e made a presentation of a research findings on intercropping cereal-legumes for biomass production to feed livestock. The presentation is a published paper which is attached below.

Peter Tindukin Birteeb (UDS, Nyankpala): He made a presentation of research findings on intercropping cereal-legumes for biomass production to feed livestock. The effect of intercropping some forage legumes with maize on biomass yield of legumes and the grain yield of maize was determined in the savannah zone using a Completely Randomized Block Design. The legumes included *Centrosema pubescens, Lablab purpureus, Stylosanthes guianensis* and *Macroptilium lathyroides* and the maize-legume integrations were sole maize (SM), maize + *Centrosema pubescens* (MC), maize + *Lablab purpureus* (ML), maize + *Stylosanthes* (MS) and maize + *Macroptilium (MM).* The results indicted that intercropping forage legumes with maize did not significantly affect the growth and grain yield of maize. The biomass yield of the individual legumes showed that *S. guianensis and M. lathyroides* were similar but significantly higher than the rest of the other legumes Total biomass yield of MM was higher than those of other integrations but sole maize yielded the lowest biomass (4.7 t/ha). The results suggest that maize grain yield and biomass yields of intercrops can be maximized for both human and livestock feeding by integrating either *S. guianensis,* C*. pubescens* or *M. lathyroides* with maize respectively.

Synthesis of Parts 2 & 3 Presentations, contributions from Participants and questions and issues raised during Sessions.

It became apparent from the presentations made by participants that various combinations of plant and livestock integrated systems are being tried in the field. A complex system involving chicken, pigs, food crops and trees was described by one of the participants. While the participant felt that the system described was quite efficient in performance, it was agreed that a more comprehensive and objective evaluation is needed. As was the case reported by another participant, the mere observation that the crop yields appear to have increased or the animals involved looked good in appearance, was not enough a good indicator of an improved system. It was suggested that usually baseline data should be collected before the integration in order to make a more valid "before and after" comparisons. It was further suggested that farmers should be involved in field work demonstrations in order to improve the chances of adoption of technologies. It was stressed that by nature of crop-livestock systems, experiments involving livestock and crops require larger areas and complex logistics. An example was given where CSIR-Crop Research Institute in Kumasi is running a C-L integration project in selected communities. The major challenge of the project is how to cart manure obtained from livestock to the farms since the farms are located far away from the homes of the farmers. KA gave an example from The Gambia where animals are tethered on selected locations for a given period before they are moved to another section of the farm to be tethered there for a while. In this way manure need not be moved over long distance to fertilize crops. The bulky nature of manure which produces major challenges in transporting manure was illustrated from an-going project by SARI which revealed that 50kg (1 bag) of inorganic fertilizer requires about 3 tons (60 bags) of organic manure mix to achieve effective increment in crop yields. Another problem identified with use of fresh manure on farms is its introduction of weeds to the farm. In view of this, it was suggested that scientists consider researching into how to make organic manure less bulky. Presently one way to manage it is to allow time for complete decomposition and drying of the manure before use.

In response to a question raised as to what type of experimental design will be appropriate for a researcher to use to be able to experiment on intercropping cereal-legumes and use of the resultant biomass (residues) to feed livestock, KA stated that the problem of crop-livestock integration research in field is usually the availability of space. Experiments done in laboratories are easy to manipulate and monitor but they don't reflect exact field condition. So because field-based experiments, especially those on farming systems, are difficult to control, therefore the researcher will need to consider the challenges before undertaking the research. However, one way forward is to cultivate the intercrop but prepare to "cut and carry" the residue to where the livestock is kept for feeding.

Day 4

a) Dr. F. Avornyo (FA)-Course Coordinator

Topic: Opening and Introduction

FA introduced the resource person for the day in the person of Dr. Andrews Opoku (KNUST).

b) Dr. A. Opoku (AO), 4th Resource Person

Topic: Integration of crop-livestock systems for improved soil management program

AO gave a 4-part Presentation. In Part 1 AO touched on the assessment of nutrient flows and balances in Crop-livestock systems, assessment of tradeoffs in alternative uses of Crop residues, and evaluation of agricultural sustainability. In Part 2 AO gave the general Objective as to identifying hot spots for research intervention in cereal-legume-livestock (C-L-L) systems. Specifically the Presentation sought: to audit the flow of nutrient resources in small-scale C-L-L systems; to quantify the nutrient balances in these C-L-L system and, to identify alternative management scenarios to redress the nutrient imbalances.

Synthesis of presentations, questions and answers.

In response to a question on whether there is an estimated distance at which the roots of a growing plant can draw plant nutrients from the soil around the roots, AO stated that most of the nutrients required by the plant from the soil are mobile, especially nitrogen (N) so plants can easily draw them for use. Also, the annual ploughing of the land helps to mobilize and concentrate the nutrients for plants to use. As leguminous plants or crops are critical components of many crop-livestock farming systems there was some concern that some leguminous crops (plants) may not fix symbiotic nitrogen into the soil. J. Kombiok allayed the concerns by stating that all legumes have the rhizobium bacterial symbiotic association and are capable of fixing atmospheric nitrogen into the soil. He clear made point that it depends on whether nodulation has occurred on the roots of the plant, and whether the nodules formed are active or not. Usually active nodules will turn yellowish-brown in color when cut opened, while inactive nodules do not show any color change. However, the availability of the fixed nitrogen in the soil for other plants (eg. cereals) to use depends on how much of it is left in the soil as reserves. This is so because the legume fixes the nitrogen for its own use and so, that requirement must be satisfied first. Any reserve left in the soil is then used by other plants growing on the field. Those legumes that fix and eventually use all the nitrogen are said to be selfish legumes, example is groundnut. Some legumes use only a fraction thereby leaving some reserves, examples being soya bean and cowpea.

A participant sought to know which of the nutrient inflow sources contribute most to nutrient availability in the soil, to which AO responded that the sources that

contribute most are the organic manure and inorganic fertilizer applications. The contribution from the atmospheric source is very minute, even insignificant.

During the Part 2 of the Presentation and earlier lectures laid considerable emphasis on crop residues as one of the essential commodities in on-farm nutrient recycling. A Course participant who was aware of annual bush fires wondered about how could crop residues be properly managed, given the incidences of bushfires in the region.

Still on crop residues a participant recalled that from the presentation, it was suggested that quality residues should be incorporated into the soil while low quality residues should be fed to livestock and the manure from the droppings/dung is then applied to the soil and wanted to know how the quality of the crop residues could be assessed from farmers' point of view. In his response, AO stated that the quality of crop residues refers to how readily such residue could degrade to release nutrients in the soil for plant use as well as how readily it will digest when fed to livestock. It also refers to the carbon and crude protein contents. So such information can best be obtained from the laboratory analysis but by practice, farmers have gotten to know which plant species to choose when feeding to livestock or even for intercropping. A participant who was reflecting on the on-going debate as to whether crop residues should be used as soil cover or be fed to livestock posed the to the effect that since desertification is a major problem in Niger, why don't the farmers leave the crop residues on the field to help curb the situation. In response it was explained that: the best way to tackle desertification is to undertake vigorous afforestation. If the haulms/stover/residues are left on the field, they turn to attract termites which also pose threat of attack to crops that may be planted later.

In what appeared to be a contradiction a participant said he had observed that most animals turn to have better body conditions in the dry season than in the wet season even though green grasses are abundant in the wet season. Also, animals from the countries (Burkina Faso, Mali and Niger) north of Ghana have better body conditions than those in Ghana and those countries even export livestock to Ghana which is closer to the coast and sought to know the cause. AO explained the observation that in the wet season green grasses are abundant but they are very high in moisture content so when animals feed on them, they get their guts filled but less dry matter intake. It is the dry matter that the animals need for weight gain. AO stated further that in most cases in northern Ghana, animals are tethered in the wet season due to cultivation of surrounding fields so the animals may not have access to adequate feeds as they prefer. In the dry season, the animals move about and choose what they prefer hence may feed well than when they are tethered. In addition, the grazing habit of ruminants, especially small ruminants, also determines how much feed they can take. Sheep and goat prefer to browse on short grasses (as a result of the nature of their mouths and dentition) but in the wet season most grasses grow very tall and become unsuitable for browsing. In the wet season the grazing time may also be shorten due to occurrence of rains. No animal will feed when it is raining but in the dry season animals have all the day to feed.

Assessment of Course and awarding of Certificates to Participants

From the enthusiasm of the Course Participants towards the Group Work in modeling of systems as part of the assignments given on Day 1, their delivery on the assignments on Innovations and Innovation Platforms during Day 2, and the clear and articulate presentations of their knowledge and experiences with crop-livestock integrated systems after the Day 3 lectures, and the way the Questions and Answers sessions were handled in Day 4, a very positive picture of participants who had acquired knowledge and showed promise to effectively use them in the future, emerged. Based on this observation by the Course Resource Persons and the Course Coordinator, all Participants were deemed to be deserving Certificates recognizing their successful completion of the Course, the Course Coordinator, on behalf of the CSIR-ARI Management, presented Certificates to all the Participants.

Appendix 1: Course Participants List

S/N	NAME	ORGANISATION	TELEPHONE NUMBERS	EMAIL
1	Eric Owusu Danquah	CSIR-CRI, Kumasi	0266197247	ericdany@gmail.com
2	Shaibu Mohammed Tiyumtaba	CSIR-ARI, Nyankpala	0264521199	kinosa07@yahoo.com
3	Peter T. Birteeb	UDS, Nyankpala	0249815083	bpetert2000@yahoo.com
4	Kwaku Adomako	KNUST, Kumasi	0243149992	Kwadom75@yahoo.co.uk
5	Stephen Yeboah	CSIR-CRI, Kumasi	0243263385	proyeboah@yahoo.co.uk
6	Pamela Pali	ILRI	0246617418	p.pali@cgiar.org
7	Edgar Drah	MOFA-UER	0242636988	edgardrah@yahoo.com
8	Solomon P. Konlan	CSIR-ARI, Nyankpala	0243330849	kspigangsoa@yahoo.com
9	Franklin Avornyo	CSIR-ARI, Nyankpala	0242179596	favornyo@yahoo.com
10	Jakper Naandam	UDS, Nyankpala	0244895504	jaknaan@yahoo.com
11	G-Bessa Simons	MOFA-N/R	0243452481	kukubess@yahoo.co.uk
12	Nicholas N. Denwar	CSIR-SARI, Nyankpala	0209369976	nicholasdenwar@yahoo.co.uk
13	Ben Alenyorege	UDS, Nyankpala	0244433066	lenyorege@yahoo.com
14	E. K. Sallah	UDS, Nyankpala	0244728479	edksal@yahoo.com
15	Hussein A. S. Mbelayim	UDS, Nyankpala	0245957290	ha2sm@yahoo.com
16	Awini Mary	UDS, Nyankpala	0246757151	angellamisi@gmail.com
17	J. Y. Faalong	MOFA-N/R	0202026411	Joefaalong2000@yahoo.co.uk
18	Lantana Munkaila	CSIR-ARI, Accra	0244861757	osaalant@yahoo.com
19	James Kombiok	CSIR-SARI, Nyankpala	0244882731	kombiokjm@yahoo.com
20	Kwaku Agyemang	Consultant	0246476170	Kagyemang@yahoo.com
21	N. Augustine. Naazie	LIPREC, Legon	0208127205	anaazie@ug.edu.gh/hotmail.com
22	Naa Y. O. D. Saaka	MOFA-UWR	0244973226	daudisaaka@yahoo.co.uk
23	Alpha O. Kergna	ILRI	0022376356748	akergna@yahoo.fr
24	Enock Karbo	CSIR-ARI, Nyankpala	0247576801	Enock.karbo@yahoo.com
25	Andy Poku	KNUST, Kumasi	0243058711	andrewsopoku@yahoo.com
26	Joe Nchor	ACDEP, Tamale	0244068340	nchor@acdep.org