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# RAPPORT DE MISSION

# Appui au projet d'élevage bovin laitier dans la région de M'Barara (Ouganda)

## Amélioration du système d'alimentation des troupeaux laitiers

**du 08 septembre au 15 septembre 2002**

**LECOMTE Philippe**

**Rapport CIRAD-EMVT n° 2002-054**

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**CIRAD-EMVT**
**Elevage et Médecine Vétérinaire Tropicale**
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## Préambule

En droit coutumier africain, la sagesse Kongo rappelle que : *Ndòozi'a ntwãdi lòtila kumòsi, sikamèna mpe kumòsi*. Le songe commun, on le rêve ensemble, on s'en réveille ensemble aussi."

Le proverbe (Ryckmans et Mwelanzambi-Bakwa, 1992) s'applique au cas d'un élevage en commun. A l'image de ce proverbe, le projet FSP centré sur les dynamiques d'élevage laitier à Mbarara qui achève de se construire aura été et continuera certainement d'être le fruit d'une collaboration étroite et tout à fait exemplaire entre des acteurs multiples, chacun s'y reconnaîtra, et des institutions.

Au terme de cette mission particulièrement intéressante par le contexte, les personnes rencontrées et les dynamiques d'élevage observées dans la zone de Mbarara, je tiens à remercier tout particulièrement Mme M. Baherle pour l'accueil et l'enthousiasme communicatif dans la mise en œuvre du projet ainsi que M. Sserunjogi pour tout le travail d'accompagnement et de facilitation dans les rencontres avec les partenaires actuels et futurs du projet.

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## Résumé

La mission s'inscrit dans la suite des activités R&D développées depuis 1998 par le MAE et le CIRAD sur la filière laitière dans le district de Mbarara (Ouganda). La mise en oeuvre du projet FSP progresse à grands pas, centré sur les organisations de producteurs, le programme aboutira début 2003 à la mise en place d'une assistance technique continue. En appui à ce projet et à la recherche locale, le CIRAD propose d'affecter un chercheur plein temps en Ouganda. L'université de Makarere a largement témoigné de son accord pour l'accueillir. Un MOU fixant les modalités de cet accueil est en cours d'élaboration. L'ensemble des institutions locales de recherche (Makarere University, MUST, NARO), de service (DVO, DAO) les organisations de producteurs et les éleveurs témoignent d'une volonté claire de s'engager dans l'action en partenariat sur l'appui qui pourra être apporté à une filière en pleine émergence.

Au plan plus particulier de la gestion des ressources en alimentation des troupeaux laitiers, la diversité des situations agroécologiques et des systèmes de production apporte un terrain et des questions d'études particulièrement originaux. En transversal avec les problématiques qui se posent en matière de santé, de qualité, d'organisation de producteurs et l'existence d'une filière réelle, on est amené à présager que le terrain du projet FSP lait Ouganda sera un référentiel de première importance tant pour la promotion d'action de développement laitier que pour la production de connaissances actionnables dans les structures d'exploitation familiales qui se tournent vers la production laitière.

## Summary

The mission take place in the follow up of R&D activities initiated by MAE and CIRAD around the milk chain Mbarara District (Ouganda). The implementation of the FSP project is on it's way, centered on producer's organizations, the program will be strengthened by a continuous technical assistance beginning 2003. To support the project and local research CIRAD propose to commit a permanent researcher in Ouganda. The Makarere University of Kampala largely agrees to receive it, a MOU describing collaboration modalities is on it's way. All the local R&D institutions MUK, MUST, NARO, DVO, DAO, the farmer's organizations and cattle raiser's testify a clear willingness to engage in action partnerships to support the Mbarara emerging milk chain.

Concerning the milk cattle feeding resources management the agroecological and farming systems diversities, affords a particularly original research and development field. Connected to the problematics that stands in terms of health, quality, producer's organization and along the existence of a real chain lead to forecast that the FSP field will be a front referential even for the promotion of milk development actions, as for the production of actionable knowledge inside smallholder milk producing structures.

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# INTRODUCTION

La mission s'inscrit dans la suite des activités R&D, mises en oeuvre depuis 1998 par le MAE - SCAC Ouganda et auxquelles le Programme Productions animales du CIRAD-Emvt apporte son appui dans le contexte du développement de la filière laitière dans le district de M'Barara.

La mise en place d'un projet FSP progresse à grands pas. Face aux dynamiques laitières et à la diversité des systèmes que l'on rencontre dans le district de Mbarara, le projet envisage de contribuer à la professionnalisation du secteur laitier en s'attachant à renforcer la capacité à se développer des organisations de producteurs, en initiant et en facilitant l'appropriation d'innovations techniques et économiques, en renforçant les politiques et les structures de développement laitier du pays. L'action FSP verra début 2003, la mise en place d'un AT senior pour le suivi du projet et de deux volontaires civils de l'assistance technique sur le district.

En appui à ce projet et à la recherche locale, le CIRAD propose d'affecter en Ouganda un chercheur du Programme Productions animales dans le courant de l'année 2003.

Dans la suite de ces perspectives, la mission s'est attachée à rencontrer les institutions locales avec lesquelles des actions de recherche et développement pourront se mettre en place. Les visites sur le terrain ont ensuite permis de visualiser rapidement les principaux systèmes d'élevage et d'aborder les questions plus spécifiques en matière d'utilisation de ressources en alimentation du bétail laitier.

# DÉROULEMENT

**Dimanche 08/09** :
Bruxelles - Kampala

**Lundi 09/09** :
- Accueil Ambassade, SCAC, Mme Michèle Baherle
- Visite Université de Makarere, rencontre Vice Chancellor Pr Ssebuwufu
- Pr E.N. Sabiiti, dean Faculty of Agriculture, Pr E.K. Rwakishaya, dean Faculty of Veterinary Medicine

**Mardi 10/09** :
- Entebbe, Assistance UE auprès du Ministère de l'agriculture (MAAIF), rencontre Martin Fowler, rencontre direction générale de la recherche en agriculture (NARO), Dr J. Madjembe
- Rencontre MAAIF, Dr Sandra Mwebaze, assistant commisionner animal nutrition
- Kampala, déjeuner E.K. Karuhanga, avocat
- Royal Danish Embassy, DANIDA, entretien H. Carus

**Mercredi 11/09** :
- Mbarara University of Science & Technology (MUST), entretiens Vice Chancelor, Prof A. Kayanza, Prof H. Isharaza, head of Biochemistry laboratory
- Visite trois exploitations (accompagnement Léonard Mugarura)
- Mwebaze Moises (Khashari) ; Mweze G. Williams (Ibanda) ; G. Mwesigne (Ibanda)

**Jeudi 12/09** :
- District agricultural office, Mrs B. Bryarungaba
- District Veterinary office, Dr J. Dahlwa (for Dr J.L. Barigwe)
- Station expérimentale d'élevage (NARO), Dr Emily Twinamisika (en déplacement)

**Vendredi 13/09** :
- Kabale, visite de deux exploitations encadrée par Africare (USAID)
- Visite station ICRAF AgroForestry Research Network for Africa project, Dr D. Siriri
- Retour et visite élevage famille Karuhanga (zone sèche district Mbarara)

**Samedi 14/09** :
- Université de Makarere, Réunion préparation MOU on Project-CIRAD-University collaborative research. Dr D. Mutetika, Head Dpt Animal nutrition ; Dr D. Mpairwe, Pr Animal Feeding ; Pr F. Bareeba, Pr Ruminant Nutrition ; Pr G. Kiwuwa, Pr Animal Breeding ; Dr M Sserunjogi, Prof. Technologie et qualité aliments ; Mme Baherle, SCAC.
- Debriefing, Mr l'Ambassadeur J.B. Thiant ; premier conseiller, Y. Drillet ; SCAC, Mme M. Baherle

**Dimanche 15/09** :
- Dr Denis Mpairwe, suivis études systèmes d'alimentation
- Dr Cypriani Ebong (NARO), H$^{d}$ D$^{pt}$ Animal production Station Namulongwe
- Retour Bruxelles, Montpellier

## CONTEXTE INSTITUTIONNEL

Les rencontres avec les représentants des multiples institutions : d'éducation supérieure, de recherche et de développement aura été l'occasion de constater la perception très positive de chacune, tant à l'égard du démarrage imminent d'un projet FSP financé par le gouvernement français, que vis-à-vis de la proposition du CIRAD d'affecter à plein temps à Kampala, un chercheur senior du département Elevage et Médecine Vétérinaire.

L'environnement institutionnel est complexe, fortement hiérarchisé et bien étoffé, chaque institution a ses prérogatives et toutes font part de leur intérêt à participer directement ou indirectement à l'accompagnement du projet. Il importera de veiller continuellement à positionner clairement, tant le projet que l'activité CIRAD en relation avec les attentes et objectifs (recherche ou développement) de chacune, en intégrant les contributions potentielles des uns et des autres dans un cadre partenarial clairement établi et lisible.

### Université de Makarere

L'université compte parmi les plus anciennes de l'Est africain, par la voix de son Vice Chancellor, elle s'est montrée particulièrement réceptive à l'idée d'accueillir en ses locaux un chercheur du CIRAD.

Les doyens des facultés d'Agriculture d'une part, et de Médecine Vétérinaire d'autre part montrent un intérêt marqué pour cette perspective de collaboration accrue au sein même de l'institution. Dans la suite des recommandations du Vice Chancelier il faudra s'attacher à établir dès que possible un Memorandum of Understanding, fixant les objectifs et les modalités de cette collaboration en veillant à associer à l'établissement de ce document l'ensemble des Facultés de MUK qui auraient un intérêt potentiel à collaborer au projet (économie, sciences sociales, médecine...). L'ébauche d'un tel mémorandum est reprise en annexe.

Des rencontres plus particulières avec les doyens (Fac. of Agr. et Fac. of Vet. Med.) et dans la poursuite d'activités plus ou moins communes déjà réalisées au cours de la phase d'identification du projet, il ressort un large panel de collaborations et d'approfondissements des connaissances à pourvoir dans les domaines de la santé animale, de l'hygiène du lait, de l'économie de l'exploitation, de l'organisation des producteurs et au plan plus particulier des systèmes, sur la production et la gestion des ressources alimentaires pour le bétail.

Les principaux intitulés de collaboration spécifiques qui ressortaient *a priori* de discussions rapides ont trait à :

- L'amélioration des systèmes d'alimentation : analyse des systèmes et des pratiques, développement de cultures fourragères adaptées, stockage de ressources et intégration agriculture élevage ; outils de rationnement adaptés aux différents contextes, l'étude de l'impact environnemental et de la durabilité des différents systèmes locaux ;
- La mise en place de systèmes d'information et de suivi des paramètres zootechniques des troupeaux ;
- Au plan santé, la valorisation de l'importante collection de sérum récolté lors de l'enquête épidémiologique tuberculose et brucellose menée précédemment en vue du suivi d'autres pathologies ;
- En matière d'hygiène, l'analyse des risques dans le domaine de la qualité du lait, l'incidence humaine de la situation de prévalence tuberculose brucellose dans les troupeaux ;

- Dans le domaine des sciences sociales et économiques, la modélisation prospective en matière de rentabilité des systèmes laitiers existants, la modélisation territoriale des dynamiques lait à l'échelle du bassin de Mbarara, l'analyse des modes d'organisation des producteurs et le transfert d'innovation ;
- Un aspect jusqu'à présent peu abordé est celui de la génétique animale, l'accompagnement de schéma de sélection et la mise en place de politiques structurée en matière d'amélioration du potentiel laitier des races locales correspond bien à des demandes exprimées tant par la recherche que par les OP.

Un ensemble de "concept notes" pourraient être échangées dans les mois à venir en vue d'élaborer rapidement une programmation d'actions de recherche spécifiques à mener en commun et à articuler en accompagnement du projet.

**National Agricultural Research Organisation (NARO)**

Le NARO, institution nationale semi publique de recherche en agriculture dépendant du MAAF, occupe une place importante dans le milieu institutionnel de la recherche du pays. Elle compte plus de 700 personnes dont 300 chercheurs. Le NARO produit des travaux de qualité, on lui reproche parfois une attitude quelque peu supérieure et le fait qu'une très grande part des travaux soient orientés vers les productions végétales. Les collaborations avec l'université de Makarere sont nombreuses, de nombreux chercheurs occupent des fonctions de lecturer, les facultés d'Agriculture et de Médecine Vétérinaire conduisent des travaux en commun dans les stations expérimentales localisées dans le pays. Le NARO Supervisory Board compte plusieurs représentants du corps enseignant de l'université et la présidence en est assurée par le Pr Kayanga V., Chancelor de l'université de Mbarara. Au cours des dernières années le NARO s'est lancé dans une politique de décentralisation de la recherche et d'ouverture plus grande au développement en liaison étroite avec le National Agricultural Advisory Services (NAADS), en renforçant le potentiel et les actions de recherche dans les différents instituts et stations travaillant sur les productions animales (Soroti, génétique, Tororo, santé animale, Namulongwe agronomie des fourrages, production animale, station de Mbarara).

Dans ce dispositif, la station située à Mbarara dirigée depuis peu par le Dr Emiliy Twinamasika compte réorganiser ses activités en les focalisant sur la production laitière et à ce titre pourrait être un partenaire de choix pour la production de références expérimentales en appui au projet. L'absence du directeur en mission lors de notre passage à Mbarara n'a pas permis ici de préciser les pistes de collaboration particulières à promouvoir. Cela méritera très certainement d'être approfondi lors du déploiement du projet à Mbarara et au cours de missions d'appui ultérieures.

De même les contacts pris à Kampala avec le Dr Cyprian Ebong, chef du programme production animale et nutritionniste à la station de Namulongwe, font ressortir que des collaborations intéressantes pourront être poursuivies dans le domaine de la production de la gestion et de la qualification des ressources à des fins d'alimentation du bétail laitier. La station a produit de nombreux travaux en matière de conduite agronomique des cultures fourragères et pourrait contribuer à la production de références nouvelles. Elle est également pourvue d'un laboratoire capable d'effectuer des mesures de valeur alimentaire en références (composition chimique, in vitro, in sacco). Elle dispose également d'un équipement permettant la qualification des matières en technique rapide de spectrométrie dans le proche infrarouge à partir duquel des protocoles de suivis originaux pourraient être envisagés en

collaboration avec le laboratoire de nutrition du CIRAD-Emvt. Dans les activités de R&D initiées au cours des phases précédentes du projet, la collaboration entre le NARO et l'université aura par exemple été notoire dans la mesure où c'est le NARO qui a réalisé la qualification des ressources fourragères collectées par D. Mpairwe (MUK) et J. Chalimbaud (SCAC) dans le suivi qu'ils effectuaient en commun en 2000-2001. Le mémoire d'étude rédigé par Kagoda Wilfred pour son MSc, repris en annexe, décrit les principaux résultats obtenus à la suite de cette première étude commune sur la ressource.

**UE MAAF**

En matière de support à l'agriculture, un programme sectoriel important, financé par l'Union Européenne et prévu sur quatre ans, se met actuellement en place. Les grands domaines concernent le café, le thé, l'agro-foresterie et la gestion post récolte.

Une part conséquente sera toutefois également attribuée à la décentralisation de la Recherche dans l'objectif de maintenir une recherche de qualité tout en favorisant l'appropriation d'innovations en milieu rural.

Sous cet aspect, une première phase d'évaluation de un an conduira à la mise en place prospective d'un programme *Agriculture Extension Systems* sur un ensemble de zone ciblées dans le pays, le district de Mbarara sera associé à cette phase. Dans cette perspective, des propositions spécifiques liées à des actions de formation ou de support spécifique pourraient très bien être envisagées en relation avec le projet.

**Collaborations internationales**

Plutôt que de s'appuyer sur des projets spécifiques, les agences de coopération des différents pays représentés en Ouganda s'orientent de plus en plus vers une politique de mise en commun de moyens pour fournir de l'appui sectoriel, entre autre à la filière lait. Elles n'en restent pas moins attentives à la démarche qui se met en place dans le FSP et des appuis financiers ponctuels seraient envisageables en direct ou, en associant différents état de l'UE, sur des actions relevant de la stratégie générale qui se met en place dans le 6$^{e}$ PCRDT.

Par ailleurs, dans la suite de la mission, l'évocation de la mise en place du projet lait à Mbarara auprès de chercheurs de l'ILRI (International Livestock Research Institute) rencontrés au Mexique, lors de la conférence internationale organisée par le British Animal Science Society, suscitait un intérêt certain pour le développement d'actions complémentaires et synergiques qui pourraient également faire l'objet de financement particuliers.

En matière d'approche sur l'utilisation des ressources à des fins de productions laitières, le projet : *Research to examine the Efficiency of Production Under Intensification of Smallholder Dairying in Uganda* financé par DANIDA et le CGIAR a été mis en place par l'ILRI-Kenya, en partenariat avec le National Agricultural Research Organisation (NARO), Uganda, et le Danish Institute of Agricultural Sciences (DIAS), Denmark.

Le projet mis en œuvre en 2001 et dont le contenu détaillé est repris dans un rapport de première année rédigé par D. Romney (ILRI-Kenya) (cf. annexes), s'attache à décrire l'amélioration de la contribution de l'élevage laitier à la durabilité des exploitations familiales,

dans le cadre d'une vaste enquête centrée sur les bassins laitiers de Kampala - Jinja et Mbarara.

L'objectif y est de développer des méthodologies permettant la comparaison de la productivité et de la viabilité de systèmes laitiers contrastés au plan de l'utilisation des ressources en s'attachant spécifiquement à l'étude des cycles de nutriments et à l'intégration entre agriculture et élevage.

Dans le cadre de ce projet deux doctorats sont en cours auprès de l'université de Makarere. Une collaboration CIRAD au sein du MUK pour l'accompagnement de ces travaux serait sans doute bienvenue.

En relation avec les thématiques portant sur amélioration d'une part de l'utilisation de ressources alimentaires et d'autre part de l'efficience économique des exploitations, on ne peut que recommander qu'une concertation et un partenariat s'établissent entre les projets. La venue prochaine d'une mission ILRI en Ouganda pourrait être l'occasion d'une concertation préliminaire.

Dans un second domaine, les questions de transfert des produits de la recherche en milieu d'agriculture familiale sont un domaine où la marge de progrès à accomplir reste considérable. En matière d'appui aux organisations de producteurs et plus spécifiquement en ce qui concerne le transfert, la diffusion et l'appropriation effective d'innovations, les approches de type "Farmer Field schools" apportent des méthodologies innovantes. Dans des concepts de recherche action de type participatif, ces approches initiées au départ dans le Sud-Est asiatique pour promouvoir des techniques de lutte intégrée en culture de riz, sont fortement prisées et soutenues par la FAO. L'ILRI développe actuellement son application au domaine de la production animale. Dans la perspective générale du projet (soutien aux organisations de producteurs), et en concertation avec les politiques de soutien de l'UE ainsi qu'avec les stratégies du NAADS, tant dans le domaine de l'amélioration de pratiques d'alimentation du cheptel que de l'amélioration des conditions d'hygiène du lait, de telles approches trouveraient fort bien leur application.

De l'avis de son promoteur (B. Minjauw), le projet ILRI - DFID qui s'est mis en place dans les exploitations laitières du Kenya : *Adaptation of the Farmer Field School methodology to improve adoption of livestock health and production interventions* pourrait très bien trouver son correspondant sur le bassin de Mbarara et faire l'objet d'un financement auprès de DFID - AHP. Une note de présentation jointe en annexe décrit les tenants de l'approche LFFS et la démarche actuellement en cours au Kenya.

Sur ce point particulier il nous semble également que des contacts pourraient être pris en vue d'évaluer la faisabilité d'un rapprochement ou de synergies entre les projets.

**Les institutions à Mbarara**

**Mbarara University of Science and Technology (MUST)**

Tout comme Makarere, l'université de Mbarara se réjouit du démarrage du projet et confirme tout l'intérêt qu'elle porte à une poursuite des collaborations plus spécifiquement sur les thématiques santé, contrôle de qualité, implication santé humaine, sciences sociales, gender issues. Le laboratoire de microbiologie initié dans les phases précédentes du projet est

maintenant opérationnel et se dit prêt à réaliser toutes prestations de contrôle qui pourraient être sollicitées par les associations d'éleveurs ou les industries laitières locales. Dans l'accueil très favorable qu'il réserve au projet le professeur Kayanga, Vice Chancelor du MUST, insiste sur la nécessité d'une transparence et d'un esprit de collaboration à mettre en place avec les différentes institutions de la place de Mbarara. La mise en place d'un comité de concertation (liaison) locale diffusant une information régulière serait certainement une initiative à ne pas négliger dans l'objectif d'assurer la reconnaissance et la pertinence des activités du projet lait.

### District Agricultural Office – District Veterinary Office (DAO – DVO)

Les services agricoles et vétérinaires du district DAO et DVO s'appuient chacun sur un personnel important (40-50 personnes). Leur mission relève à la fois de la promotion, du conseil et du contrôle. Leurs moyens sont toutefois de plus en plus limités et l'état Ougandais envisage au travers du NAADS une restructuration importante de ces services.

Ils n'en constituent pas moins pour autant un pool de ressources humaines qui connaisse bien le milieu des éleveurs et de l'agriculture et sur lesquels le projet pourrait en partie s'appuyer. En associant un ensemble de personnes ressources ciblées, il serait envisageable de mener en partenariat des actions de diffusion, de promotion d'innovations techniques et d'amélioration des systèmes de production sur les thèmes :

- de la conduite de la ressource alimentaire pour le bétail,
- d'une intégration plus effective de l'agriculture et de l'élevage,
- du contrôle de santé animale et de promotion de pratiques d'hygiène du lait.

La DVO a déjà dans le passé contribué au vaste plan de contrôle mis en œuvre en 1999 sur la présence de brucellose/tuberculose dans les troupeaux du district (enquête > 12 000 animaux).

Tout en exprimant le regret de n'avoir pas toujours été pleinement associés dans le passé à l'exploitation des données d'enquête, ou au suivi des actions préliminaires du projet, chacun des offices témoignent de leur intérêt pour une participation aux actions en milieu paysan. Ceci n'incluant par ailleurs pas nécessairement la mise à disposition de moyens particulièrement importants, au-delà d'un support pour le fonctionnement. Ce qui importe pour les offices est de ne pas rester en marge de l'opération.

### Les éleveurs et Associations des éleveurs laitiers de Mbarara

Dans le temps limité de la mission et compte tenu de la disponibilité des personnes, il ne nous a pas été possible de rencontrer directement les associations d'éleveurs (SUMCA), mais des discussions avec les différents individus éleveurs rencontrés dans les 6 exploitations visitées sur les districts de Mbarara et Kabale, il ressort qu'elles apparaissent déjà bien implantées dans le milieu. Le choix d'un appui fort à ces organisations sera une entrée particulièrement effective pour le développement des filières lait dans les districts de Mbarara et Kabale.

Les demandes des éleveurs sont importantes tant au niveau technique qu'au niveau organisationnel. Au plan technique on est d'emblée frappé par la grande diversité de contextes agroécologiques et de systèmes d'élevage allant de l'extensif dans les zones de savanes plus sèches du nord de la zone vers des systèmes associés à des degrés divers à la pratique de l'agriculture jusqu'aux systèmes intensifiés pratiquant les rotations de pâturage et

la complémentation sur des races améliorées. Cette diversité dans les modes d'exploitation a par ailleurs déjà été largement décrite dans les études réalisées par les institutions de recherche nationale ou de façon plus spécifique dans le traitement des données d'enquêtes longitudinales effectuées dans les phases préliminaires du projet (Dabusti N., Vancauteren D., 1999 ; Alary *et al.*, 2001).

A cette diversité de systèmes de production animale correspond une toute aussi grande diversité de systèmes d'alimentation qui amène à des questions originales en matière de conception du développement à promouvoir sur le plan des améliorations alimentaires au sein de ces systèmes.

Les questionnements posés par les éleveurs sont fortement liés à leurs stratégies propres. Cela va de l'entretien à faible niveau d'intrants, d'un maximum d'animaux à faible production laitière sur de larges étendues communales jusqu'à l'optimalisation de la productivité d'un animal unique à haut potentiel entretenu en stabulation permanente à coté de l'habitation et qui s'alimente sur des ressources en forte intégration avec la partie agricole de l'exploitation de très petite taille.

On ne peut bien évidemment pas adapter et promouvoir un modèle d'alimentation unique et à chaque grand type, voire à l'intérieur de ces types en fonction de groupes ayant des stratégies communes, il s'agira de mettre en évidence des actions clefs ciblées en fonction des demandes spécifiques des éleveurs.

Un fait notoire est également la diversité des pratiques dans un même terroir. On peut observer une exploitation produisant 5-6 l par animal et à très peu de distance une seconde exploitation où le savoir-faire de l'éleveur et son aptitude à expérimenter par lui-même l'amène à maintenir des niveaux de production 2 à 3 fois supérieurs. Les échanges entre éleveurs et le transfert de savoirs n'apparaissent pas simples. Dans la circulation de l'information qui peut s'opérer entre éleveurs attentistes, éleveurs expérimentateurs isolés, leader locaux, agents de développement et chercheurs producteurs d'innovations en chambre, on comprend qu'il reste beaucoup de travail à faire. L'approche Livestock Farmer Field School trouverait là un terrain d'expérimentation, voire de développement assez idéal.

## Ressources et alimentation du cheptel laitier

### Problématique générale

La principale ressource alimentaire actuelle des élevages bovins est l'herbe. Sa disponibilité varie dans l'espace et surtout dans le temps. L'optimisation de l'utilisation de cette ressource reste soumise à différentes contraintes.

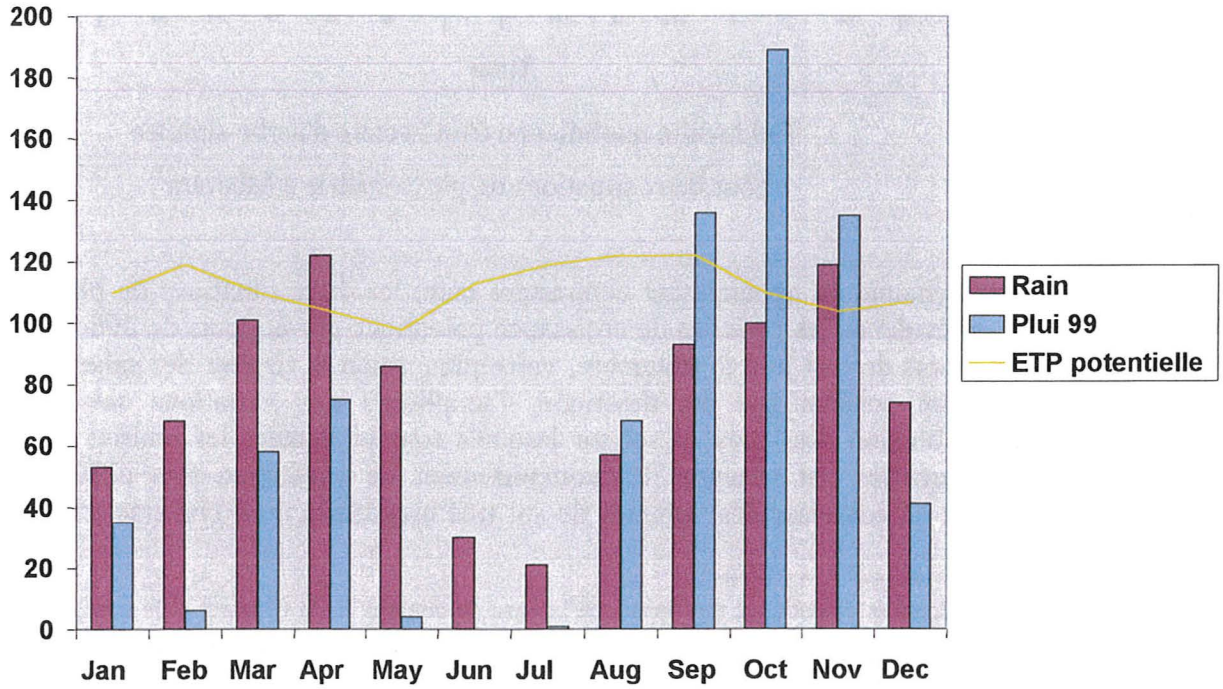
Dans la zone, la production quotidienne des espèces (graminées, légumineuses) pérennes cultivées ou naturelles évolue au rythme des saisons en fonction de l'eau disponible dans le sol et de la demande évaporative locale. Le tableau et la figure reprennent les données mensuelles générales qui caractérisent le climat de Mbarara[1]. Les températures sont constantes avec, du fait de l'altitude, des différentiels jour/nuit importants ; la pluviosité est limitée en normale annuelle à 950 mm. Elle présente classiquement un ralentissement (petite saison sèche) au cours des mois de janvier puis une saison sèche longue qui va de mai à septembre. Les variations inter annuelles de pluviométrie peuvent être importantes comme en

[1] Données extraites de la base de données FAO CLIMWAT et pluviométrie 1999 tirée du mémoire de Kagoda.

témoigne par exemple la répartition enregistrée en 1999, l'humidité relative de l'air est élevée ce qui aura une incidence sur les possibilités de récolte et conservation en sec (foins...). L'ensoleillement s'accroît au début de saison sèche ce qui rendrait la période favorable au fanage. En matière de production de ressource, cela entraîne une demande évaporative plus importante, elle ne se réalisera toutefois pas complètement du fait d'un épuisement progressif des réserves en eau du sol suite au ralentissement des pluies dont l'amplitude du ralentissement peut parfois être fort étendue tel qu'explicité à la figure 2.

Pays : Uganda — Station climatique : Mbarara (35ans)
Altitude : 1413 mètres — Coordonnées : 0.37 LS 30.39 LE

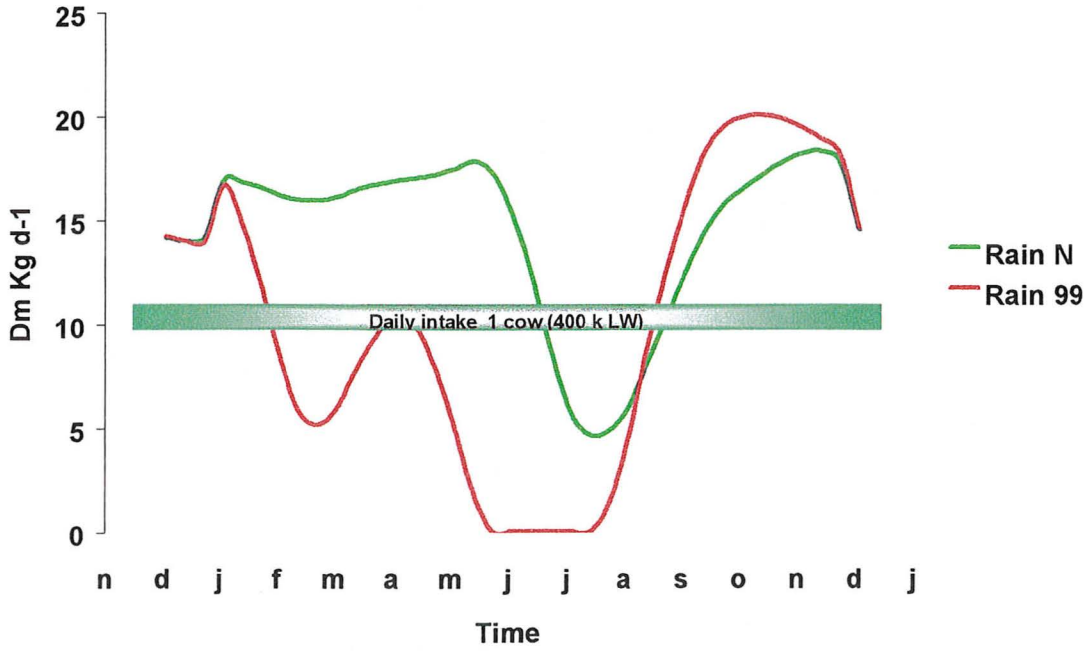
| | T° max °C | T° min °C | Humid. % | Insol. hres | ETP- mm/jour | Pluies Normales mm/mois | Pluies 1999 |
|---|---|---|---|---|---|---|---|
| Jan | 26.8 | 14.2 | 75 | 4.1 | 3.6 | 53 | 35 |
| Feb | 27.2 | 14.6 | 73 | 4.7 | 3.9 | 68 | 6 |
| Mar | 26.7 | 14.7 | 78 | 3.7 | 3.6 | 101 | 58 |
| Apr | 25.8 | 14.8 | 83 | 4.3 | 3.4 | 122 | 75 |
| May | 25.6 | 14.3 | 85 | 4.6 | 3.2 | 86 | 4 |
| Jun | 26.1 | 13.7 | 78 | 6.3 | 3.7 | 30 | 0 |
| Jul | 26.5 | 13.2 | 71 | 5.9 | 3.9 | 21 | 1 |
| Aug | 27 | 14.5 | 71 | 5.5 | 4 | 57 | 68 |
| Sep | 26.3 | 14.5 | 77 | 5.8 | 4 | 93 | 136 |
| Oct | 25.8 | 14.5 | 82 | 5 | 3.6 | 100 | 189 |
| Nov | 25.6 | 14.3 | 83 | 4.9 | 3.4 | 119 | 135 |
| Dec | 25.8 | 14 | 81 | 5.5 | 3.5 | 74 | 41 |
| Total | | | | | | **924** | **748** |




Répartition des pluies en moyenne normale et pour l'année 1999

Cela affecte bien évidemment le chargement saisonnier que l'on pourra appliquer aux surfaces en pâturage ou les disponibilités en fauche pour la constitution de réserves fourragères.

A titre d'exemple tout à fait théorique, la figure ci-après présente sur base des données d'évapotranspiration réelle issues de la base de données FAO pour la région de Mbarara, une hypothèse (simulée et empirique) de la croissance quotidienne qu'aurait la végétation d'un pâturage selon un modèle agroclimatique adapté aux végétations prairiales[2]. Cette simulation réalisée à l'échelle de l'ha pour deux situations (l'une en situation de pluviosité moyenne, la seconde selon les pluies de l'année 1999) est mise en relation avec la consommation quotidienne de fourrage d'un bovin de 400 kg.




Production quotidienne d'un hectare d'herbe simulée
pour deux situations de pluviométrie à Mbarara[3]

Les dynamiques apparaissent contrastées entre les deux situations de pluviosité, elles mettent en évidence les périodes de croissance potentielle élevée, puis de déficits d'herbe au cours des mois de mai juin à septembre, voire plus, selon la rigueur des saisons sèches. La représentation schématique est théorique, l'amplitude des variations saisonnières sera également fonction des types de sol sur lesquels sont implantées les prairies ainsi que des espèces lesquelles ont chacune des comportement de végétation très différents et sont susceptibles de coloniser des volumes de sol très importants ou à l'inverse très superficiels

[2] Les données climatiques sont issues de la base de données FAO Climwat et la simulation ETA a été réalisée sur la base du logiciel CROPWAT (prairie cultivée, sol moyen). Les productions journalières exprimées en kg de MS $ha^{-1}$ $j^{-1}$ sont ici calculées selon un modèle linéaire où x est la somme des ETA des 4 dernières décades.

[3] La représentation est issue d'une modélisation de la ressource. Bien que tout à fait théorique, elle montre l'ampleur que peuvent prendre les déficits selon les années et la nécesité pour l'éleveur d'adapter des stratégies pour gérer le risque de pénurie saisonnière. D'une année normale à l'année 1999, la production totale diminue de 30 % mais pour couvrir les besoins de l'animal il faudra stocker de 250 kg à 1 tonne de MS d'herbe.

espèces lesquelles ont chacune des comportement de végétation très différents et sont susceptibles de coloniser des volumes de sol très importants ou à l'inverse très superficiels (ex *B ruziziensis* vs Pennisetum sp). Même si l'herbe continue de croître sur une partie de la saison sèche, le ralentissement affectera le niveau de chargement que l'on peut concevoir à partir des surfaces en herbe dont dispose l'éleveur au cours des différentes périodes. Cela met en évidence la nécessité plus ou moins importante de recourir à de la complémentation fourragère ou en autres ressources selon l'importance du cheptel à alimenter en regard des surface disponibles.

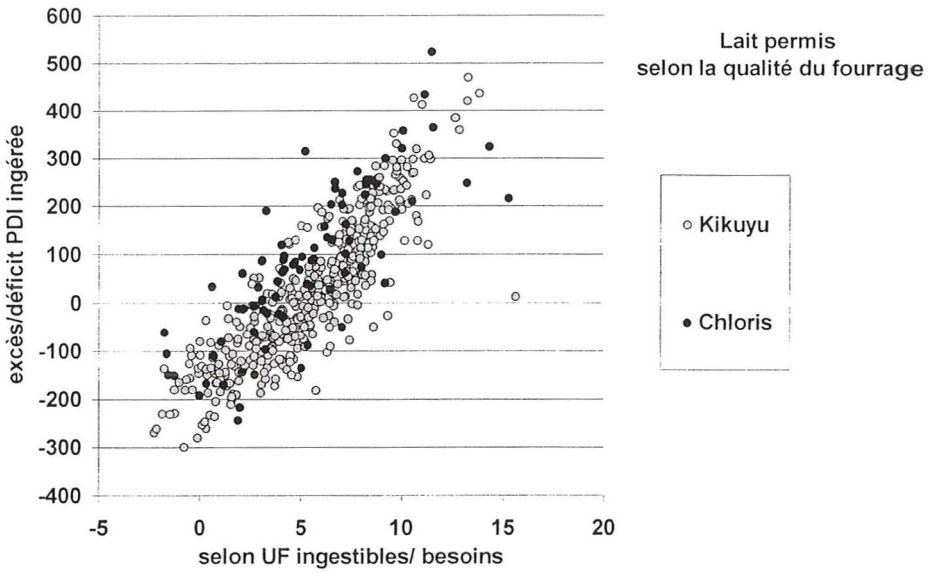
Même si dans le cadre des phases préliminaires du projet, quelques-uns ont commencé à tester à petite échelle des itinéraires de stockage d'herbe en foin, la manière de pallier les déficits alimentaires de saison sèche est la problématique majeure dans bon nombre d'exploitations.

Le fait de pouvoir continuer à alimenter correctement les vaches en production au cours de la saison sèche constitue une demande bien spécifique des éleveurs, en maintenant un niveau de production laitière élevé cela leur permettrait d'optimiser un revenu tout à fait intéressant, les prix du lait étant double ou triple à cette période de l'année.

Cela appelle au renforcement d'un schéma d'actions ciblées sur la mise au point de techniques adaptées aux différents types de systèmes pour la collecte et la conservation de ressources fourragères complémentaires.

Au-delà de la nécessité d'une mise à disposition d'herbe en quantités suffisantes, l'exploitation par ailleurs d'une herbe de haute qualité est une base essentielle de la productivité de l'animal laitier. Si l'on s'en réfère aux données de qualité d'herbe échantillonnée dans les exploitations suivies par Chalimbaud et Mpairwe (v. mémoire Kagoda en annexes) on voit qu'en valeurs moyennes, l'herbe mise à disposition des animaux est peu riche en protéines, fortement fibreuse et la digestibilité dépasse rarement les 50%.

En se référant à titre d'exemple aux bases de données disponibles au CIRAD-Emvt et en relation avec cet aspect "qualité de l'herbe", la figure ci-après décrit sur deux graminées classiques pour ce type de milieu, l'amplitude des niveaux de production laitière potentiels que l'on serait susceptible d'atteindre pour un animal de 500 kg selon que l'on exploite l'herbe à son optimum de valeur ou au contraire à des stades ou la qualité est faible. Le diagramme traduit la grande variabilité que l'on peut rencontrer et tout le parti qu'il y a à tirer d'une vulgarisation ciblée également sur cet aspect de la qualité alimentaire de la ressource. Si la recherche tant au NARO - MUK qu'au CIRAD est bien équipée pour aborder l'étude de ces questions, la construction de référentiels locaux, le transfert et la formulation de recommandations appréhendables par les éleveurs en matière de pratiques optimales restent des champs dans lesquels il y a beaucoup à faire. Cela ne peut encore une fois se réaliser efficacement que dans un partenariat étroit entre les différents acteurs.




Potentialité laitière de l'herbe[4]

Au-delà de l'exploitation d'un potentiel optimal de l'herbe, il y a ensuite toutes les stratégies de complémentation permettant soit de pallier des déficits périodiques ou dans le cas de races laitières performantes d'atteindre les niveaux permis par le potentiel génétique de la race. Cette complémentation peut provenir d'aliments acquis auprès de fabricants locaux, les coûts constituent toutefois bien souvent un frein pour les exploitations familiales ; ou comme on aura pu l'observer dans certaines exploitations, d'une utilisation très raisonnée et très efficiente[5], de sous-produits de l'agriculture locale (bananes, brisure de maïs,...).

En termes d'amélioration des systèmes d'alimentation, si les pratiques classiques d'intensification à fort niveau d'apport de concentré sont bien connues et en soi n'appellent pas vraiment de questions de recherche innovantes pour le développement, l'association plus étroite de l'animal aux systèmes agricoles locaux, la mise au point en exploitations familiales de systèmes à forte intégration, et qui dans une optique de durabilité optimisent le recours aux ressources locales et le transfert de fertilité au travers de l'animal sont des champs où il reste beaucoup de connaissance à construire et de savoirs locaux à exploiter.

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[4] Tiré de données récentes de suivi en exploitations laitières à la Réunion dans des conditions de climats assez similaires. Le diagramme illustre pour une graminée d'altitude (*Pennisetum clandestinum*), Kikuyu et pour une graminée cultivée adaptée aux conditions plus chaudes et sèches (*Chloris gayana*), la productivité laitière potentielle simulée selon l'énergie et l'azote qu'ingérerait un animal de 500 kg.

[5] Sur l'exploitation de G. Mwesigwe à Ibanda, 3 vaches maintiennent en saison de pluie un niveau de l'ordre de 20 l, avec une alimentation faite de repousses très jeunes de *P. maximum* et *P. purpureum ad libitum*, complémentées avec des produits acquis localement (4-5 kg de banana peals fermentées (1000 UG£/25 kg) et 3 kg de brisure de maïs 250 UG£/kg).

# RECOMMANDATIONS POUR LES PHASES ULTÉRIEURES DU PROJET

## Systèmes d'alimentation

Dans la suite de l'étude de Dabusti (1999), il serait intéressant de compléter l'analyse descriptive des systèmes de production par une approche ciblée sur les systèmes d'alimentation mis en place par les éleveurs dans les quatre grands types reconnus à l'époque. Une approche en analyse fonctionnelle selon les méthodologies Institut de l'Elevage (Guérin *et al.*), s'adapterait bien à un travail de mémoire ou de stage de quelques mois et aurait l'avantage de donner une description approfondie du fonctionnement annuel et de cibler dans chacun, les facteurs clés sur lesquels des interventions seraient à apporter. Une description/documentation non exhaustive sur ces approches fonctionnement fourrager peut être extraite sur les sites :

http://www.cra-mp.org/groupefou/j160697/g25_1.html

http://www.corse.inra.fr/pub95/p95lr22.htm

Dans une telle approche, il faudrait attacher une importance particulière à l'analyse des relations qui, à des degrés divers, selon les types d'élevage, peuvent s'établir avec les systèmes agricoles en place dans les différents terroirs. Dans cette optique un partenariat avec le travail conduit par Danida - ILRI serait tout à fait opportun.

## Amélioration des disponibilités fourragères

Dans la suite des travaux initiés par Rippstein (1999, 2000), Bellenger et Domergue (2000), on perçoit bien la demande faite par les éleveurs pour la poursuite de travaux sur l'introduction d'espèces (graminées – légumineuses) améliorantes en pâturage. Les connaissances en matières d'espèces adaptables existent auprès du NARO et MUK, et les services du DAO pourraient apporter un appui en terme de diffusion de techniques d'implantation, le problème majeur actuellement étant celui de l'organisation d'une mise à disposition de semences à des prix raisonnables dans le commerce local d'intrant agricole ou directement auprès des associations. Sur ce domaine particulier de l'agronomie des fourrages le CIRAD est également prêt à mobiliser toutes les compétences et références largement établies qui existent à l'intérieur du Groupe Ressources Fourragères (GREFO).

Si l'introduction d'espèces plus performantes peut en partie contribuer à améliorer la disponibilité instantanée, il n'en reste pas moins que le problème majeur réside plus dans la stratégie annuelle d'exploitation de cette ressource et dans la conception avec les éleveurs (selon les types), de schéma de chargement/rotation, mise en réserve selon des objectifs clés.

## Conservation de ressources

Dans une perspective d'amélioration des performances laitières en saison sèche (période de prix la plus favorable), il faudrait démontrer la faisabilité technico-économique d'itinéraires de conservation en foin ou en ensilage. En soi les techniques sont connues et au-delà des démonstrations à très petite échelle déjà réalisées précédemment, elles nécessiteraient toutefois pour l'éleveur un investissement en temps et en travail important qu'il serait utile d'évaluer en conditions réelles en tenant compte des effectifs d'animaux, des superficies et du temps de travail disponibles sur l'exploitation. Si le fanage apparaît plus simple à concevoir, sa réalisation n'est pas toujours adaptée aux conditions climatiques et ne conduit le plus souvent qu'à stocker des fourrages de fin de saison de pluie et donc de faible valeur. L'ensilage est plus lourd à mettre en œuvre mais permet de se dégager des aléas climat

et de façonner des stocks à partir de ressource de haute qualité. Sur les troupeaux de grande taille, compte tenu de l'absence de moyens mécaniques et de possibilité d'investissement, on ne peut que très difficilement imaginer de tels itinéraires de conservation. Par contre, dans les exploitations familiales de taille réduite à moyenne, et en se limitant à la constitution de stocks pour les animaux productifs, ce serait parfaitement envisageable même avec de faibles moyens.

Il y a donc là pour la recherche des questions intéressantes en terme de modélisation de la ressource et de mise au point d'ITK d'exploitation différenciés selon les types d'élevage, et pour le développement de conception du transfert des améliorations techniques qui soient mises à l'échelle des exploitations en milieu d'éleveurs.

## Qualité ressources

S'agissant d'élevage laitier, la productivité instantanée des animaux étant directement liée à la qualité énergétique et protéique de l'ingéré, il reste également un important travail de formalisation de référentiels à mettre en place au niveau local ; non pas que les problématiques de qualité de fourrage ne soient pas connues, les institutions MUK et NARO disposent déjà d'un ensemble d'informations non négligeable, et il en va de même au CIRAD, mais dans le but de mettre efficacement cette information à disposition du développement.

Suite aux études effectuées dans la phase précédente par Mpairwe (MUK) et Ebong (NARO), près de 140 échantillons ont déjà été analysés en laboratoire classique au plan de la composition et de la digestibilité. Au-delà d'une publication descriptive, ces premières références sur le milieu de Mbarara, pourraient être utilement valorisées dans la suite du projet compte tenu de l'existence tant au NARO MUK qu'au CIRAD d'équipements de type spectromètres dans le proche infrarouge.

A partir de tels équipements, il serait parfaitement envisageable de constituer très rapidement des référentiels larges et complets sur tous les fourrages potentiellement utilisables, en s'appuyant sur des collectes d'échantillons ciblés, sur un nombre limité d'analyses de référence classique complémentaires et sur un système de mise en réseau NTIC des laboratoires. Les lectures spectrales qui seraient effectuées à Namulongwe pourraient ensuite être échangées via Internet et agrégées aux bases de données disponibles à Montpellier de manière à constituer des modèles aptes à prédire en retour, à moindre coût et dans des délais quasi instantanés, des échantillons de fourrages inconnus. Une planification structurée de travaux de terrain, de labo et de standardisation des équipements et méthodes permettrait d'atteindre rapidement cet objectif. L'approche pourrait également prendre une dimension régionale dans la mesure où ce type d'équipements existe également en Ethiopie et au Kenya (ILRI) et où il est en passe d'être acquis par l'UAFP en partenariat avec le CIRAD à l'Ile de la Réunion. Cela contribuerait à renforcer l'image du projet au plan international et donnerait une dimension régionale permettant en particulier une valorisation commune des données sur les ressources fourragères d'altitude.

Parallèlement, il faut aussi tenir compte du fait que les informations en matière de qualité (listes, tables, ouvrages descriptifs...) ne sont le plus souvent que difficilement exploitables par les exploitants. Il importerait de travailler encore une fois en partenariat étroit entre recherche-développement et éleveurs sur les manières d'appréhender la qualité alimentaire et sur des modes de représentation qui soient les plus adaptés. Il y aura également là un travail intéressant de recherche-développement à construire dans l'objectif de produire des outils d'aide à la représentation et à la décision pour la conduite alimentaire des animaux laitiers. Les outils informatisés actuellement disponibles en métropole sont très peu adaptés

au contexte local, ils sont optimisés pour des animaux à très haute production et ne référencent pas les fourrages et autres compléments disponibles localement.

Dans une démarche de co-construction d'outils, et d'adaptation spécifique à la très grande diversité des systèmes de production sur le district de Mbarara, en partant des savoirs locaux et des demandes des éleveurs, en revisitant les formes d'expression des très larges connaissances scientifiques existantes en matière de nutrition, il y a là un travail très intéressant à conduire en partenariat étroit entre tous les interlocuteurs.

Dans ce domaine de l'aide au rationnement des animaux laitiers tropicaux, une démarche intéressante et assez exemplaire est celle qui a été adoptée dans le développement de l'outil Dairy RAtionning System for the TropIC, initiée en Tanzanie et au Kenya par le DFID et la R&D anglaise, elle est décrite sur http://www.stirlingthorne.co.uk. Les compétences mises en œuvre au CIRAD pour développer l'outil de suivi troupeau Laser pourraient être rapidement valorisées pour faire évoluer une approche similaire adaptée au contexte de Mbarara.

## Qualité du lait

Dans ce domaine particulier, sans pour autant minimiser tous les autres aspects liés au développement de la filière lait, il y a des enjeux très importants en termes d'initiations de démarche qualité adaptées au contexte des exploitations familiales. Les stratégies normatives de qualité qui se mettent en place dans les pays développés constituent un risque important pour les systèmes du Sud. On ne peut que difficilement concevoir un simple transfert de ces normes et de systèmes de contrôle et il nous semble qu'il y a là un important travail à mettre en œuvre pour à la fois identifier les points critiques et rechercher des solutions adaptées. A cet égard les compétences particulières de M Sserunjogi (MUK) en matière de technologie du lait mériteraient d'être exploitées et associées à celles qui se mettent en place dans le cadre du groupe CIRAD Laitrop sur les terrains Réunion et Vietnam. Il importera de définir des objectifs concrets et des moyens adaptés aux contextes actuels de santé (santé humaine et animale), de marchés et enfin à l'environnement socio-économique des exploitations et des filières.

# CONCLUSIONS

Au terme de cette mission, il apparaît assez clairement un ensemble de perspectives très intéressantes pour le projet FSP Mbarara. La mise en place, si elle a été longue, n'en est que d'autant plus positive dans la mesure où les points clés de l'action ont été bien identifiés par les différentes phases d'étude réalisées sur le terrain et dans la mesure où le choix d'une stratégie orientée vers les acteurs et l'appui aux organisations apparaît tout à fait opportun.

La relation étroite qui continuera de s'établir entre recherche et développement sera un facteur clé du succès du projet.

La proposition d'affecter un chercheur auprès de l'Université découle d'une volonté réelle d'investissement de la part du CIRAD. Pour être efficace cet investissement devra s'inscrire dans un schéma de partenariat fort avec les institutions locales et le projet.

Parallèlement au soutien limité qui pourra être apporté en marge du projet, il importera d'initier rapidement de nouvelles pistes de collaboration en vue de dégager des moyens de fonctionnement complémentaires.

# BIBLIOGRAPHIE

Alary V., Chalimbaud J., Faye B., 2001. Déterminants socio-économiques de la production laitière dans les systèmes d'exploitation ougandais - Caractérisation des logiques et stratégies laitières. Montpellier, République d'Ouganda/MAE/CIRAD-EMVT, 79 p. (Rapport provisoire « projet laitier Mbarara »).

Bellenger C., Domergue M., 2000. Mise en place d'une typologie et étude des innovations possibles dans les systèmes d'alimentation des élevages bovins laitiers du district de Mbarara (Ouganda). Mémoire de stage ESITPA, 58 p.+ annexes.

Boudjadi S., 2000. Suivi du volet sanitaire et hygiène alimentaire dans le bassin laitier de Mbarara (Ouganda). CIRAD-Emvt, Montpellier, France, 54 p.+ annexes. Mémoire de stage, DESS Productions animales en régions chaudes. CIRAD-Emvt, année universitaire 1999-2000.

Chalimbaud J., Faye B., Tulane J.J., Rippstein G., Alary V., 2001. Mbarara milk project workshop proceedings. *In:* Montpellier, CIRAD-Emvt / R. of Uganda, ed. Rwizi Arch Hotel, Mbarara, 75 p.+ annexes.

Dabusti N., Vancauteren D., 1999. Les systèmes d'élevage du district de Mbarara (Ouganda) et leur contribution à la filière laitière. CNEARC/ESAT, Montpellier, 276 + ann. p. (Mémoire de Master Développement agricole tropical).

Desvaux S., 2000. Contraintes hygiéniques et sanitaires de la filière lait dans le district de Mbarara, Ouganda. ENVN, Nantes (Thèse vétérinaire).

Faye B., 1999. Mission d'appui pour la mise en place d'un suivi zootechnique et sanitaire des élevages bovins laitiers dans la région de M'Barara (Ouganda). CIRAD-Emvt, Montpellier, 22 p. (Rapport de mission).

Faye B., 2000. Stratégie du dépouillement des données et préparation d'une seconde phase du projet laitier de Mbarara. Rapport de mission en Ouganda. Montpellier, CIRAD-Emvt, 17 p.+ annexes.

Faye B., 2001. Rapport de mission en Ouganda : Appui aux enquêtes sanitaire et économique. 21 p. + annexes (Rapport de mission).

Faye B., 2002. Mission en Ouganda à l'occasion du Séminaire de lancement du projet FSP "Concertation agricole et structuration des filières en Ouganda". 14 p. + annexes. (Rapport de mission).

Faye B., Letenneur L., Tulasne J.J., 1997. Mission d'étude des filières de productions animales en Ouganda du 14 au 27 juillet 1997. Montpellier, CIRAD-Emvt (Rapport).

Faye B., Lhoste P., 1999. Le conseil en élevage en milieu tropical. 6e Rencontres autour des recherches sur les ruminants. Paris, France, 63-67.

Lesnoff M., 1998. Methodological support of a survey of the productivity of cattle rearing systems in the M'Barara dairying basin, Uganda. Montpellier, CIRAD-Emvt (Rapport de mission).

NARO, 2001. Livestock and Fisheries. *In:* K. Mukiibi ed., Agriculture in Uganda, Volume IV, Fountain Publishers/CTA/NARO, 380 pp.

Rippstein G., 1999. Rapport de mission d'appui en production fourragère et en alimentation au projet d'élevage bovins laitiers dans la région de M'Barara et Kabalé (Ouganda). Montpellier, CIRAD-Emvt.

Rippstein G., 2000. Projet d'élevage bovin laitier dans la région de M'barara (Ouganda) : appui à deux stagiaires en production fourragère et en alimentation. 45 p. (Rapport de mission).

Rippstein G., 2001. La production laitière bovine dans la région de M'Barara (Ouganda). Production laitière, gestion et valeur des pâturages. Séminaire INRA-CIRAD à Montpellier les 31/01 et 1er/02/01 « Dynamique de végétation et relation herbe/pâturage ». Session I - Présentation du contexte et des problèmes tropicales et méditerranéens.

# ANNEXES

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Effect of season on dry matter production and chemical composition of pastures on selected farms in Mbarara and Kabale districts of Uganda.
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*Research to examine the Efficiency of Production Under Intensification of Smallholder Dairying in Uganda* financé par DANIDA et le CGIAR. Ce projet a été mis en place par l'ILRI-Kenya en partenariat avec le National Agricultural Research Organisation (NARO), Uganda, et le Danish Institute of Agricultural Sciences (DIAS), Denmark. **(Page 38)**

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*Adaptation of the Farmer Field School methodology to improve adoption of livestock health and production interventions.*

- ANNEXE 1 -

# EFFECT OF SEASON ON DRY MATTER PRODUCTION AND CHEMICAL COMPOSITION OF PASTURES ON SELECTED FARMS IN MBARARA AND KABALE DISTRICTS OF UGANDA

**BY:**

**KAGODA WILFRED**

**97/U/16**

**SUPERVISOR:**

**Dr. DENIS MPAIRWE.**

**A SPECIAL PROJECT REPORT SUBMITTED TO THE FACULTY OF AGRICULTURE AND FORESTRY AS PARTIAL FULFILMENT FOR THE AWARD OF A BACHELOR OF SCIENCE DEGREE IN AGRICULTURE OF MAKERERE UNIVERSITY**

**2001**

## DECLARATION

I hereby declare that this report is my own research effort and has never been submitted to any institution of higher learning for a formal document.

Signature ..... Date .....

KAGODA WILFRED

This prefect report has been submitted with my approval as the University supervisor.

Signature ..... Date .....

DR. MPAIRWE DENIS

## DEDICATION

I have dedicated this work to my parents, Eric and Racheal.

## ACKNOWLEDGEMENTS

I wish to extend my humble appreciation to my supervisor Dr. Mpairwe Denis for the assistance rendered to me to compile this report. Without him I think everything would have been not easy for me.

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## ABSTRACT

An experiment was carried out to determine the effect of season on chemical composition and dry matter of pastures collected from the Districts of Kabale and Mbarara.

Analyses of collected pasture samples were carried out using method of AOAC (1990) for percentage dry matter, ash crude protein. Neutral detergent fibre (ADF) were analysed according to gearing and Vansoest (1970). Digestibility was analyszed using in vitro rumen digestibility system according to Tilley and Terry (1963). It was observed that season had a very significant effect on total dry matter yield though location was not very significant. Season affected the chemical composition in terms of minerals, crude protein, and Neutral detergent fibre. Values were high with low Acid detergent fibre values which resulted in low digestibility of pastures with seasonal changes.

## LIST OF ABBREVIATIONS

| | | |
|---|---|---|
| AOAC | - | Association of official analytical chemists |
| CF | - | Crude Fibre |
| NDF | - | Neutral detergent fibre |
| NFE | - | Nitrogen free extract |
| NPN | - | Non Protein Nitrogen |

# CHAPTER ONE
# INTRODUCTION

## 1.1 Background

Uganda lies astride the equator, between latitudes 4o 12'N and $1^{o}$ 29' and longitudes $29^{o}$ 34' W and $35^{o}$ O' E. Temperatures are in the range of $15^{o}$ - $13^{o}$C. More than two-thirds of the country is plateau lying at 1.000 - 2500 meters above sea level. The rainfall is fairly reliable varying from 750mm in the North East to 1.500mm in the high-rainfall areas on the shores of Lake Victoria, around the highlands of Mt. Elgon in the East, the Rwenzori ranges, in the South West and some parts of Masindi and Gulu. Uganda has an area of 241,034sq km of which 81% is suitable for agriculture, 16% under water and swamps and 3% under forests (Jameson 1970)

Agriculture is the main stay of the country's economy. It accounts for about 45% of the National Gross Domestic Product (GDP), and offers employment to over 80% of the population in rural areas. Livestock accounts for 17 % of the Agricultural GDP and 9% of the National GDP (MFED, 2000). Eighty nine per cent of Uganda's population is rural and agricultural output comes exclusively from about 2.5 million small holders, 80% of whom have less than 2 hectares each. With Uganda's human population increase of 7% per annum and with undebated growth, the present population of about 21million will be approximately 32.5 million by the year 2015 (MFEP, 2000). This means that there will be more pressure on land, for crop-production to feed the increasing population leaving the land for livestock farming to be minimal. This calls for high-levels of positive management, in order to maintain pasture productivity and nutritional quality in order to match with the changing weather conditions. And manipulation of animal numbers during the different seasons of the year for a sustainable animal production.

## 1.2 Scope of Study area

The study covered twenty-two (22) farms selected from districts of Kabale and Mbarara districts.

At independence Kabale was part of Kigezi district. In 1974 Kigezi district was divided into North and South Kigezi, with the former becoming Kabale district. (Appendix 1). It borders the districts of Kisoro in the west, Rukungiri in the north, Bushenyi in the northeast and the Republic of Rwanda in the south, covering an area of 1,827sq. km. With Kabale as the administrative headquarters has got four counties mainly Ndorwa, Rubanda, Rukiga and Kabale Municipality with 22 sub-counties. This gives Kabale a population of 417,218 people who comprise mainly Bakiga and Banyarwanda.

Kabale lies at an approximate altitude of between 1,219m - 2,347m above sea level. It has an average temperature of 17.5 °C, which sometimes drops to 10 °C at night. Rainfall averages 1,000mm-1,480mm per annum and vegetation includes bamboo forests and afro-alpine shrubs. Man's intense activity in the district is however steadily changing this type of vegetation. Economic activities include growing food crops: e.g. Beans, sorghum, finger,

millet, maize, cassava, sweet-potatoes, irish potatoes, ground-nuts, bananas, and field peas. Cash crops: Coffee, fruits and vegetables: Passion fruits, tomatoes, onions and cabbages, and dairy farming.

Mbarara District (Appendix 2), borders the districts of Rakai in the east, Bushenyi in the west, Masaka in the northeast, Kabarole in the north, Ntungamo and the Republic of Tanzania in the south. It was the eastern part of the old Ankole district. It covers an area of about 10 square meters. It comprises of eight counties with 34 sub-counties with Mbarara and Ibanda as the administrative headquarters. Mbarara district has a population of 930,772 thousand people, mainly Banyankore. Main counties include Bukanga, Ibanda, Isingiro, Kashari, Kazo, Nyabushozi, Rwampara and Mbarara Municipality.

It lies at an altitude of between 129m - 1,524m above sea level with temperatures averaging 25-27 °C and rainfall reaching up to 1,200mm per annum in some areas. Vegetation is a combination of bush and short grass, which is good for animal rearing. Main economic activity include growing of food crops: Beans, sorghum, finger millet, maize, cassava, sweet potatoes, Irish potatoes, groundnuts, bananas and field peas, cash crop: Coffee, fruits and vegetables: Passion fruit, tomatoes, onions and cabbages, ranching and dairy farming.

### 1.3 Statement of the problem

In Uganda, the main feed resources for livestock are natural pastures consisting of grasses, legumes and natural pastures whose productivity and nutritive value decline sharply during the dry season. At that stage, pastures are deficient in energy, protein and minerals (Mpairwe, 1998). This leads to their fast deterioration leading to low productivity of animals in terms of milk and meat which are highly demanded by the increasing population of Uganda. It is with that back-ground that farmers should be informed about the changes in forage quality and dry matter yield with the changing weather conditions. This is most applicable to farmers in southwestern Uganda who practice dairy farming, and those who carry out dual-purpose livestock farming i.e. rear animals for purposes of milk and beef production.

It is important to note that to some extent some farms in Mbarara District still practice pastoralism whose movement for pasture is dictated by weather trends (Kart Zow *et al.*, 1995) and hence seasonality of pasture availability greatly affects these farmers during the course of movement, due to herd mixing from various localities, there are chances of animals spreading diseases due to long distances moved. During the dry seasons, animals get emaciated and they easily succumb to infection. There is a problem of malnutrition because during draught, pastoralists spend most of the time looking for green pastures with no surety of getting it. This problem is aggravated by large population of livestock whereby in most cases farms are overstocked. With proper stocking rates, pastures will be properly utilized sward productivity will be increased and herd performance will be improved. Therefore determining the dry matter yield and chemical composition of pastures both on fenced farms and natural pastures at different seasons could help maintain the pasture sward in a productive state by keeping animal numbers in relation to pasture availability in a particular season and determining the chemical composition will help to access the forage quality in a particular season and therefore establish whether it requires supplementation of the animals or which pasture species should be planted in a particular season. With this background the study was conducted to address the following objectives.

## 1.4 Objectives of the study

1. To determine the effect of season on productivity of pastures in terms of dry matter yield.

2. To determine the effect of season on chemical composition of pastures in terms of Crude Protein (CP), Neutral detergent fibre (NDF), Acid detergent fibre (ADF) and Invitro-Dry Matter Digestibility (IVDMD).

# CHAPTER TWO

## (1) LITERATURE REVIEW

### 2.1 Importance of Livestock

Uganda's Livestock Sector is relatively small contributing about 17% to agriculture GDP and 9% to National GDP (MPED, 2000). However, the Livestock Sector is an important component of the agricultural systems in many parts of the country. It is estimated that smallholder mixed farms and pastoralists own over 90% of the cattle national herd, 100% of small ruminants, pigs and poultry (MPMPS, 1998). Present livestock production is low and there is urgent need to improve it so as to provide the much needed animal protein in terms of milk and meat. Cattle plays a major role in providing draught power and is a source of manure under zero-grazing practice and is a source of income. Annual per capita availability stands at about 22 litres of milk, 6kgs of beef as compared to FAO recommendations of about 200 litres of milk and 50 kgs of meat respectively per person annually. It therefore means that the Nutritional Standard's of Uganda's population is still low in terms of animal protein, which means that efforts must be made to increase livestock production. This can be achieved by proper utilization of pastures during periods of draught and to minimize wastage during plentiful supply (rainy season) and avoid under feeding of animals during scarcity in order to have a continued supply of nutrients throughout the year. This calls for the knowledge about the changes in the chemical composition at different seasons of the year and the dry matter availability.

### 2.2 Pastures as feed for livestock

Pasture is abroad term that entails species of grass (es) multi-purpose trees, shrubs and legumes type of vegetation that is not under frequent arable farming but is mainly used to rear livestock with shade trees dotted here and there for some reasons e.g. shade (Walgambi, 1993). It is the cheapest most economical and important source of feed to livestock in Uganda, on both pastoral and dairy farms. It falls under two categories, natural and planted pastures. Planted pastures in Uganda, occupy a small total area, which is mainly confined to enclosed fields on government farms, mission stations and occasionally on private and co-operative farms (Jameson 1970). However, developments in the dairy industry have greatly stimulated interest in the establishment of sown pastures and there has been an increase in acreage.

Pastures in Uganda are a considerable national asset, which support a grazing population of 5.1 million cattle, 0.9 million sheep, 5.5 million goats (MPMPS, 1998). Additional role of pastures include, protecting the soil from erosion, improves the structure of the soil by soil-particle aggregation by roots, water infiltration in the soil is improved and also the fertility of the soil is maintained especially with legumes which re-cycle nitrogen in the soil with the help of Rhizobia.

### Major pasture species in Uganda

**Grasses:** This forms the largest group of pastures fed to livestock. The palatability of grasses and nutritive value are influenced by the chemical composition which changes with age, changing weather conditions, soil fertility and level of management i.e. fertilizer application

will influence the level of minerals composition as compared to natural grasses where fertilizers are not applied. (Whiteman, 1980) stated that leaves, contains more protein and more dry matter than stems. Stem quality declines more rapidly as the plant matures due to increase in cell wall contents and decrease in soluble contents. The major grass species common in Uganda pastures include: C*ynodon dactylon, Panicum maximum, Pennisetum purpureum, Brachiaria spps, Hyperrhenia spps, Chloris gayana* (Jameson,1970)

**Legumes:** Regardless of their nutritive value legumes account for only 10% in natural pasture in Uganda (Jameson, 1970). They are rich in proteins, which make them to be of great value of animal nutrition (White man, 1980). Legumes are highly digestible because of high-levels of cell-solubles. Common legume species in Ugandan pastures include: *Centrosema pubescens, Stylosanthes gracilis, Desmodium Intortum, Glycinl wightii)* (Sebatta, 1991). Legumes have a higher concentration of cellular protein as a result of the different biochemical path-ways of carbon fixation during photosynthesis and therefore have got a higher crude protein level compared to grasses.

## 2.3 Chemical Composition of Pastures

A variety of elements are concerned with the physiological functions of plants and animals. Chemical composition of pastures can be characterized by studying the nutritive value of plants whereby the crude-fibre fraction which is comprises of the indigestible part of forages and the nitrogen free extracts which is comprised of soluble sugars (carbohydrates) is the digestible portion. When pastures are low in crude-fibre they are considered to be with high nutritive value, which varies between species and within species at different levels of growth and plant part i.e. when you compare leaves and stem and also varies with season. (Van Soest, 1994). It has a major influence on the time the forage stays in the rumen and therefore will influence the level of intake of pastures and the overall effect will be on animal production.

## 2.4 Factors affecting Chemical Composition of pastures

The chemical composition of pastures depends on the growth characteristics. Any changes in the physiology during growth will lead to changes in the chemical composition. And a number of factors are associated with plant growth and these include, the type of soil the pastures are grown, pH and fertility and the management practices which may include fertilization, this will influence the nitrogen level of the soil and amount that will be taken by the plants (Stobbs, 1969). These factors can be categorized as Agro-climatic, plant, harvesting or grazing schedule.

### 2.4.1 Plant factors

Chemical composition variation when other factors are held constant is due to the genetic difference or variability between species and cultivator for example at the same stage of maturity legumes contains more proteins and minerals compared to grasses, temperate grasses have a bigger tiller density, higher moisture, crude protein, minerals than tropical grasses and this is a difference due to genotype. (Norton, 1990).

### 2.4.2 Agro climatic factors

Differences in agro climatic conditions have an influence on the growth performance of forages, which will in turn influence the chemical composition. Such factors of soil type, atmospheric temperatures, humidity and day length will also contribute to the chemical composition in forages. Under optimum conditions, pastures will grow and obtain nutrients in a balanced form and utilize them for normal growth and other physiological processes. Changes in these factors will affect chemical composition e.g. under high levels of soil management with high organic material in the soil pastures will have high levels of crude protein and low fibre content. High ambient temperatures will lead to 10% more NDF in tropical pastures as compared to 4% NDF in temperate pastures (Van Soest, 1994) Light intensity is known to affect non-structural carbohydrates in grasses and legumes. (Pratt and Gawyn, 1977).

### 2.4.3 Agronomic practices

Soil-management practices will affect performance of forages seed rate, seed treatment, time and methods of sowing, fertilisation together with weed management apart from the their effects on growth and dry matter yield but will also influence chemical composition. Nitrogen fertilisation, improves on the crude protein content of forages, and reduces on the fibre fraction of forages though adverse effects were observed with high levels of nitrogen application. For example hydrocyanide antiquality factor increases and increase in lignin content was also noted with an increase in nitrogen fertilization of star grass. (Mihreteab, 2000).

### 2.4.4 Harvesting by Grazing Animals

The chemical composition in forages and other plant species is significantly influenced by the harvesting schedule and grazing practices followed on the farms. Factors like stage of harvesting, intensity and grazing schedule contribute towards significant changes in chemical composition, with advancing maturity water and crude protein levels are reduced while structural carbohydrates are increased. This means that the harvesting interval should be as short as possible.

## 2.5 Nutritional Quality of Pastures

Nutritional value is essentially a function of the availability of energy and required nutrients. The nutritional quality of animal feeds may be affected by the form of the feed and method of preparation. This means that the animal response to a particular feed is dependent upon a complex interaction of the diet composition, method of preparation and its nutritive value (Van Soet, 1994). Also the quality of forages and fibrous feedstuffs vary greatly due to age. When plants mature they tend to decline in their nutritive value due to altered chemical composition and an increase in lignification and a decrease in the proportion of leaves to stems (Van Soet, 1994). Other factors include, genotype of the pasture species, plant part, pests and folial disease. Pastures are usually rated on their productive energy and protein content, while other differences like minerals and vitamins are satisfied by supplementation.

This is determined by the efficiency of forage to support the different biological processes of the body e.g. maintenance production and reproduction. Animal health and level of production are the best indices of nutritive value of forage over a given period of time, which will also be influenced by availability and intake, together with their digestibility and the efficient utilization. However, certain factors influence feed intake like, level of rumen fill, animal preference due to taste, palatability as may be affected by physical characteristics of the feed. Nutritive value determination is quite hard because all factors that affect nutritive value are not conclusive; e.g. chemical composition is variable in many forages, due to differences between species and seasonal weather changes that may affect forage performance and chemical composition.

## 2.6 Nutritive value of grasses and legumes

The nutritive value of plant species is largely determined by the anatomy, biochemical composition and morphology. While tropical grasses have developed a specialised leaf anatomy associated with a $C_4$ pathway of carbon fixation, temperate species ($C_3$) have a unique radial cells around the vascular bundles. Tropical grasses have got high proportions of lignified and suberized cells, which are resistant to digestion. This anatomical difference makes tropical grasses to progress rapidly to maturity which has a direct relationship with digestibility and reduced intake of tropical grasses. As grasses approach maturity (flowering, the proportion of leaf decreases and that of stem increases, resulting in an overall decrease in nutritive value. (Skerman and Riveros, 1990). However, legumes have (C3) pathway of carbon-fixation and leaves have lower cell contents, and contain lower proportions of vascular tissue and higher proportions of the more readily digestible thin walled non-lignified mesophyll tissue than tropical grasses. Legumes have a higher concentration of cellular protein than the ($C_4$) grasses because of the different biochemical pathways of carbon-fixation during photosynthesis (Whiteman 1980).

Changes in leaf: Stem ratios are less marked in legumes during maturation and nutritive value declines at a slower rate than grasses over a similar period. Nutritive value for legumes depends on the proportions of leaf and steam consumed, which in turn is related to the selectivity of grazing animals. (Norton *et al.,* 1990).

## 2.7 Effect of Nutritive Value of Grasses on live weight gain

Under tropical grassland, the live weight of cattle grazing on pastures increases with age in a step-like direction. But cattle lose weight in the dry season in the tropics, and in the wet season in the tropics, animals gain weight due to compensatory growth. The extent of loss is greatest in the dry season. (Skerman and Riveros, 1990). There is usually a small weight loss immediately after the break of the season, when cattle seek the young shoots of the rejuvenated grass on burnt country, it is because intake is low and cattle scour. While the old fibrous material is less digestible with low nutritive value and unattractive. As the rains progress with time, there is rapid weight increase corresponding to seasonal growth of the dominant pastures, and finally a decline after the pasture begin to mature. Live weight gain reflect not only the availability of pastures but also grass-quality. This was illustrated by **(Norman *et al.*, 1970)** who reported that animals fed native *Themeda australic* began to gain weight at the start of the main flush of the wet season. Pastures growth continued to do so until shortly after the wet-season. He observed maximum rates of gain in January when

pastures were high in nitrogen and phosphorous and peak live weight occurred in March where it coincided with maximum dry-matter. The maximum live weight loss occurred at the end of the dry season.

### 2.7.1 Effects of Nutrient Value on Animal Production

Nutritive value of grasses is associated with high intake and digestibility by the animal resulting in good meat, milk and wool production. Stages of maturity, species and variety are all factors involved. Frost in the sub-tropics is an important reason for the decline in nutritional value of grasses. Maturity and desiccation cause nutritive value of pastures to decline late in the season and therefore cannot maintain a sustainable animal production throughout the year. However, pastures with high soluble carbohydrate content, and palatability are readily utilized by the animals and this will be reflected in the overall performance of the animals in terms of production and reproduction.

### 2.7.2 Effects of Nutrient Value on Digestibility

The Nutritive value of pastures is determined by the chemical composition, and forage characteristics. The digestibility of pastures is closely related to the chemical composition of herbage. The chemical entities that affect digestibility are lignin and fibre. Protein, soluble carbohydrates, lipids soluble ash, cellulose and hemi-cellulose are digestible by the animal due to low resistance of breakdown by microbes. However, the digestibility of these constituents is further influenced by weather conditions, maturity of the crop, maturation and rate of plant growth.

The chemical composition of the forage may account for 25-45 per cent of total variation in digestibility of forages. Crude protein may affect digestibility of other nutrients, when in low concentrations. Presence of low levels of nitrogenous compounds in the ruminant ration depresses microbial growth in the rumen. Rumen micro flora will be very low and therefore more feed retention time in the rumen due to low digestibility of the forage.

## 2.8 Grazing Systems

Grassland management is an integrated system within the soil plant animal complex, with emphasis on management of the plant and soil on one-hand and herd management on the other. Pasture management is the provision of rest or recovery periods between grazing cycles, during which the plants builds up reserves that will ensure continued vigor. Under good management, palatable species are catered for while the unpalatable species e.g. shrubs, which compete for light and nutrients, are controlled. If the pasture is grazed until half the forage is grazed, more palatable species will have been seriously over used. Heavy defoliation of the preferred species weakens the plants' competitive ability in relation to less palatable and nutritious species, causing them to disappear. Therefore to prevent deterioration grazing systems have been devised that in-corporate rest periods on a rotational basis though the systems don't comply e.g. continuous grazing. The aim is to promote plant vigour, allow for seed production, reduce differences in vigour between the preferred and less preferred and therefore allow for large quantities of herbage, (Skerman and Riveros, 1990).

### 2.8.1 Continuous Grazing

It is grazing system whereby there is only a perimeter fence and not sub-divided into paddocks. Animals are kept on the same land throughout the year. It could lead to under utilisation of pastures under low stocking rates giving chance to undesirable species to thrive. Under high-stocking rates, with high grazing pressure and decreased herbage allowance, there could be malnutrition of the animals leading to poor performance. And could also become an environmental hazard. Especially with high stocking rate which may lead to range degradation and eventually soil erosion.

### 2.8.2 Rotational Grazing

Involves a good deal of subdivision and usually costly fencing. It maintains sward productivity in terms of nutritive value and dry matter yield. It eases management of the herd because of keeping different age groups in different paddocks. It is important in disease control especially endo-parasites. However it is a very expensive venture in terms of initial capital.

### 2.8.3 Lead and follower system

Calves as well as lactating animals require a high plane of nutrition and therefore the quality of forage is important. When animals enter a new pasture they select the leafy and more digestible and nitritious parts of the plants first, and if grazing is prolonged the quality declines. The lead and follower system is a practice of letting the calves and milkers (leaders) graze the pastures first (Top-grazing) and non lactating or mature animals (follower) use the pasture remaining (bottom grazing).

### 2.8.4 Strip-grazing

An electric fence a head of the herd mainly cows rations the grazing, and one behind them prevents grazing low-quality material. This allows follower to graze the stubble (Skerman and Riveros, 1990).

## 2.9 Effects of Livestock Activity on Pasture Productivity

Pasture species need a rest period between grazing cycles to produce new tillers and new leaves. The response to defoliation varies with species; the more vigorous species and those with high regeneration rate will stand closer grazing than the weak creeping type. Stobbs (1969) found out that in the dry season the heavier defoliation gave a much inferior performance, as recovery was slower whereas during the wet season there was no difference.

## 2.10 Effect of climate on productivity and chemical composition of pastures

Climate is the ultimate driving force for all the biological activity in plants. There are important distinctions between plants in their response to climatic variability for example; there are differences between annuals, which through their time of germination largely escape unfavourable influences and perennials which have to survive these effects. The climatic differences which exist between regions result in a very significant difference in the water demands of pastures in different regions, thus limiting pastures growth due to lack of water (Davies and Skidmore, 1989). It is further stated that in most of the tropics the annual rainfall

is less than the potential transpiration from pasture if it is adequately supplied with water throughout the year. Thus a characteristic feature of many tropical pastures is that their annual transpiration is limited by the annual rainfall and the plants composing the pasture must either be able to withstand draught sometimes for considerable periods of time or else be rapid growing and rapid seeding annuals (Davies and Skidmore, 1989).

### 2.10.1 Effects of Temperature on pasture productivity

The radiation regime is a basic determinant of plant growth through the direct input of energy into the photosynthesis system and transpiration process. The amount of light received on the leaf surface has a major effect on growth and reproduction of pasture species due to its influence on the rate of photosynthesis, (Whiteman, 1980). The rate of growth of pasture plants, expressed, as the rate of increase in dry matter is primarily a function of the rate of net photosynthesis and the rate of increase in leaf area. In many grasses increase in leaf area is related to the rate of tiller development, though in legumes it is related to shoot development and rate of appearance of new leaves. Higher temperatures will lead to leaves peeling off from forages which are highly nutritious and with high protein and mineral content due to wilting, (Ludlow *et al.* 1995). Stems left behind with low biomass and high fibre and Lignin content will affect intake and nutritional quality.

### 2.10.2 Effects of Rainfall

It is a main climatic factor controlling tropical vegetation and it is not the total amount but the length and intensity of the dry seasons. It affects herbage yield, botanical composition and sward characteristics towards defoliation by grazing animals. Throughout the large areas of the tropics, moisture deficits are the major limitations to pasture production. As available soil moisture declines, internal water deficits develop in the plant leading to loss of turgor, until the plant reaches a state of permanent wilting when sufficient moisture cannot be extracted from the soil to maintain turgor, (Whiteman, 1980). Therefore during periods of water stress, growth processes appear to be suspended (Ludlow *et al.*, 1995), but in the humid or moderately dry tropics certain selected grasses and to a lesser extent legumes if managed properly can maintain their quality for a long period.

### 2.10.3 Effects of Solar Radiation

At the equator the amount of radiation received at the outer atmosphere varies only about 13% throughout the year. Seasonal variation in the radiation receipt increases greatly with increasing latitude, this means that the total energy to the outer atmosphere will decline with increasing latitude. Therefore, the amount of radiation received at the earth's surface depends upon the degree of atmospheric filtration. During periods of prolonged cloud cover, low radiation received can limit plant growth. In terms of pasture productivity in the tropics, the relationship between photosynthesis and radiation is of particular importance (Whiteman, 1980). The amount of solar radiation will determine the level of starch in plant tissues. Another important feature of the effects of latitude and radiation regime is mediated through the seasonal changes in day length or photoperiod. In a wide range of pastures plants the change from vegetative growth to reproductive development is induced by changing day length which is perceived in the leaves of the plant which transmit a floral stimulus to the vegetative meristem to cause a change to reproductive development (William and Skidmore, 1966).

### 2.10.4 Role of Bush-Fires

Fire may be a beneficial function in the ecology of grasslands since it clears off undesirable vegetation, removes insects such as ticks and tsetse flies which affect animals, forage and people, hastens the growth of desirable grasses or shrubs and enriches the soil (Pratt and Gawyn, 1977). However, it may not bring about any positive effects, unless the burning occurs in the appropriate vegetation, season and interval (Pratt and Gawyn, 1977). If mis-used can remove desirable forage, leaving fire resistant and less desirable species of woody plants. It contributes to reduced soil quality and even results in denudation, which can be followed by soil erosion and/or reduced infiltration of essential water. Summarized fire effects on pastures as:

- Destroyer of tree seedlings, younger trees and annual grasses.
- Consumer of litter and accumulated old grasses which hinder new growth.

Other effects include:

1. Removes large quantities of unutilized grass.
2. Probably has an encouraging effect on the spread of *Afronodus cymboprogon.*
3. May contribute indirectly to the thickening of the stand of Acacia bush in many areas.
4. Increases the proportion of *Themeda triandra* in the society.

## 2.11 Effect of season on pasture productivity

### 2.11.1 Effect of season on chemical composition

Chemical composition of pastures is influenced by the fertility of the soil, species composition and environmental factors like temperature and soil moisture. It is a valuable indicator of the quality of the pasture in terms of protein, mineral composition. It determines the rate at which feed is broken down in the rumen especially acid detergent fibre (ADF), which will eventually have an affect on animal production; because low digestibility of pastures means long time spent by animals ruminating and this will affect rumen-fill. NDF (Neutral detergent fibre) determines intake of pasture because it is related with fibre contents that occupy space in the rumen and slowly digested. Chemical composition is a means of explaining animal production over the various seasons of the year, (Show and Bryan, 1976). During the rain season where there is limited moisture, pastures tend to increase leaf to stem ratio due to delayed stem development and aging of young leaves. During the dry season where light is available the protein content increases due to increased photosynthesis rate. However, extreme draught tends to increase lignification (fibre content) of pasture leading to low nutritive value of pastures (Whiteman, 1980).

Therefore the large fluctuations in chemical composition of pasture in areas with pronounced wet and dry seasons makes it necessary for regular sampling through the season in order to come out with meaning results to assess nutritional quality of pastures (Shaw and Bryan,

1976). In order to access the Nutritive Value of the pastures at different seasons of the year for proper stocking rates and better animal production.

Season influences the amount of solar radiation cloudy cover and intensity of rainfall, has an effect on the concentration of sugars e.g. Fructan (Whiteman, 1980). On a dull cloudy cover the soluble carbohydrate content of grass will be lower than on a fine day. Precipitation affects the mineral composition of pasture herbage. Calcium content tends to accumulate in plants during periods of draught but tend to be present in small concentrations when the soil moisture is high. Phosphorous appears to be present in higher concentrations when rainfall is high (Whiteman, 1980). Overgrazing especially during the dry spell will tend to eliminate or weaken many of the best grasses by depriving them of the opportunity for building up and storing reserve nutrients. (Whiteman, 1980) noted that there is a striking difference between temperature and tropical pastures. At similar stages of growth tropical grasses have a considerable lower crude protein percentages than temperate species. It is particularly evident in many tropical swards (McDonald *et al.* 1987). This is due to difference in physiology and physical characteristics, which plays a major role in carbon dioxide fixation, which lead to high proportions of lignified tissues in tropical pastures, which is resistant to breakdown during digestion by micro-flora. Also the rapid maturity of tropical grasses, which is associated with the law digestibility and intake of tropical pastures.

### 2.11.2 Effects of season on dry matter yield

Pastures suffer loss in yield during dry weather but are more particularly vulnerable when under severe water stress is conditions of high temperatures. In such areas, there is high transpiration rates and low soil moisture due to low rainfall leading to wilting of pastures aggravated by frequent defoliation by grazing animals and yet there is poor regeneration because of low photosynthesis or tiller development (William and Skidmore 1989; William and Payne, 1959). It is also a major limiting factor of pasture growth, because of its effects on tiller development and density and therefore the amount of dry matter yield in the pasture sward. The availability of soil nutrients is also dependent on the total annual rainfall, the availability of organic material in a particular soil, will influence the amount of water in a particular soil which will eventually support vigorous pasture growth leading to a high-dry matter yield.

In areas having reasonably uniform distribution of rainfall, grasses grow and mature relatively slowly and can thus be utilized at an early stage. It is at this stage when there is a high leaf to Stem ratio. In warmer or dry conditions grasses have a soil moisture deficit, which leads to loss of leaves leaving behind only fibrous material (stem) with a high fibre content and low-digestibility. This leads to a low output of dry matter yield (McDonald *et al.* 1987).

## 2.12 Forage quality (indicators)

The proportion of plant cell wall and degree of lignification and the amount of cellular contents in the dry matter determines the proportion of the completely available nutrients present in the feed (Van Soest, 1994). Invitro Dry matter digestibility (IVDMD) determines the nutritive value of pastures and feeds, (Whiteman, 1980) defines digestibility as a measure

of the proportions of the feed consumed which is digested and metabolized by the animal. It is also associated with high crude fibre content of tropical pastures (William and Skidmore, 1966). Minson *et al.*, (1976) looks at digestibility as a fraction of feed which is digestible minus the sum of the fraction of the feed, which escapes digestion and metabolic excretions, which appear in faeces. It is an indicator of forage of quality in terms of Nutritive value since it is associated with lignin and fibre that escape digestion due to lignification. High levels of this portion will indicate low nutritive value of the forage.

### 2.12.1 Neutral detergent fibre (NDF)

Fibre is a biological unit and not a chemical entity. It constitutes the complexity of the cell wall and mainly composed of lignin, cellulose hemicellulose, and pectin. The higher the proportions of cell wall, which is resistant to enzymes the lower the nutritional value of that feed (Vansoest, 1994). It is a measure of the total fibre in pastures. It comprises the less digestible portion of the feed, it is a measure of food intake because it determines the retention time of forages in the rumen. It is a measure of the total part of the plant cell wall that is insoluble in water (Van Soest and Robertson, 1965).

### 2.12.2 Acid Detergent Fibre (ADF)

It comprises of more soluble and extractable pectin's, waxes and proteins. Susceptible to enzymatic proliferation by the mammalian gastro-intestinal tract. It varies with the type of cell wall (Van Soest, 1994) it is the best indicator of digestibility. Higher values will indicate the ease with which pasture are readily digestive. And this will influence dry matter intake and ingesta flow in the gastro-intestinal tract and this will have an effect on animal performance.

### 2.12.3 Crude Protein

It is involved in all the important physiological functions of living things. It is made up of nitrogenous chemical constituents e.g. proteins, free amino-aids, peptides, nitrates and nitrites. Apart from the true proteins another group known as the non-nitrogenous nitrogen exists (NPN) which can be utilized by some ruminants and other herbivores for their protein needs. In order to maximize production in terms of milk and meet an optimal standard must be attained. Knowledge about protein and crude protein in animal feed ration to farmers is an important tool to selection of pastures as forage (Mihreteab, 2000).

Crude protein of mature grasses is often low ranging between 6 -8 percent for considerable periods of the year. Pastures when still young especially tropical grasses usually contain sufficient protein to meet the requirements of most classes of livestock, however, it falls rapidly as the plant matures and after growing rapidly for two months, marked differences between crude-protein levels of grasses are apparent (William and Skidmore, 1966).

## 2.13 Anti-Nutritional factors in Forages

These affect the utilization of forages e.g. Lignin but other compounds have been also described as a self defense mechanism in plants and again limit the nutritive value of plants.

They are a wide variety and have got bad effects. They interfere with animal body metabolism through the inhibition of rumen bacteria. They include phenypropanoids e.g. lignin and flavones. Tannins (phenolic polymes) of relatively high molecular weight and form complex with proteins to make it unavailable.

### 2.14 Stocking rate

In any area being grazed, whether improved pastures, natural pasture or range land, the output of animal products per unit area is a function of the production per animal and number of animals per unit area. (Whiteman, 1980) defines stocking rate as the number of livestock units per a given piece of land for a specified period of time (Sebatta, 1991) Categories stocking rate into two types: **1**. Set stocking**:** where heads of cattle are put on a given area of land and remain there for a long period say half a year without the changing the number. This practice is most applicable on ranches and could lead to disastrous effect. **2**. The other category is variable stocking rate, where animals can be added or taken away from the pasture area in order to achieve optimum stocking rate.

This could be applicable on dairy farms in Kashari (Kabale districts) where there is fluctuations of pasture during the dry and wet seasons if farmers can achieve maximum benefit from their animals throughout the year. (Mott, 1961) observed that stocking rate has the most important influence on production per acre.

# CHAPTER THREE

## 3.0 Methodology and study area

The study was conducted from the Districts of Mbarara where dairy farms and ranching is the most livestock farming activity and Kabale where mainly dairy farming is carried out. Mbarara and Kabale have got a mean annual rainfall of 40-60" as shown from the map with three seasons. The long dry-spell from July to September (Appendix 3), the early rainy season from February to March and the late rains from May-July. The soils in Mbarara District (Appendix 4) originate from Phyllites and quartz its rocks while those of Kabale originate from Quartziter, Slates, Phllites and Schists (Jameson, 1970).

## 3.1 Farm selection

Farm selection, farms were selected randomly in area of Kabale and Mbarara districts. On arrival at a particular farm, farm lay out was observed for physical features, e.g. anthills, valleys, rivers and prominent vegetation like trees. The type of fencing was also observed whether there was any type of puddocking or only perimeter fence was used. Based on the status of the farm i.e. layout, it was divided in plots equivalent to a paddock ranging from 1 - 10 hectares depending on the size of the farm. A farm was divided into plots, a plot ranged from 1ha - 10ha where there was no actual measurement of plots, it was mainly visual estimation. Physical features like trees aligned in the same position were used to mark off a particular plot. 3 farms were selected from Kabale in the county of Rubanda, 19 farms from Mbarara, % farms from Nyabushozi County, 8 farms from Kashari, and 6 farms from the county of Ibanda.

## 3.2 Collection of pasture samples

In a plot, small areas (quadrate) measuring $1m^2$ were used for sampling. And the number of quadrates depended on the size of the plot. Samples were obtained from these quadrates and immediately packed in polythene bags to avoid continued respiration, which would lead to loss of organic material. In the laboratory pasture samples in the polythene bags were oven dried over night at 60°C and weighed to determine the laboratory dry matter yield per plot which was obtained by getting the mean dry-matter of the quadrates. Then different quadrates in the different plots were combined after sub-sampling from each quadrate to come up with a sample for laboratory analysis in a particular season. 1mm Sieve was used to come up with a fine sample. After grinding of each sample, a fresh empty clean bag was used to collect the new ground sample.

## 3.3 Crude Protein Determination

The Kjeldah method (AoAC, 1990) of analysis was used to determine the total nitrogen. Basically this method is based on the conversion of organic nitrogen into ammonium ions by digestion with concentrated sulphuric acid in the presence of a catalyst (a mixture of potassium sulphate with selenium or copper sulphate.

### 3.4 Invitro Dry matter digestibility

Digestibility was estimated by invitro rumen systems that stimulate the digestion process (Tilley and Terry, 1963), using prepared medium rumen liquor, carbon dioxide, water bath and pepsin solution to create an environment similar to that of the rumen.

### 3.5 Determination of NDF

Van Soest and Robertson method, 1985, was used. The NDF represents the insoluble matrix of the plant cell wall. It was extracted using neutral detergent solution (NDS).

### 3.6 ADF Determination

Van Soest and Robertson method, 1985, was used to extract the soluble matrix of the plant cell wall using acid detergent fibre solution.

### 3.7 Field forage dry matter yield determination.

Information used to determine dry matter yield included, the following:

Acreage per plot in hectares, Dry matter yield in Kg/ha (Laboratory dry matter), per cent pasture coverage.

### 3.8 Statistical analysis.

Da5ta analysis was done using Randomized complete block design for factor A (location) with B (season) a split on factor A using MSTATIC programme

# CHAPTER FOUR
# RESULTS AND DISCUSSIONS

## 4.0 Effect of season and location on any matter yield

The results of the effect of season and location on total dry matter yield from the two districts are presented in Table 1and Fig 4. It was observed that season had a significant (P<0.001) effect on total dry matter yield. The greatest effect of season was experienced in the June - August 1999 long dry season which resulted into low dry matter yield of 1407kg/ha when compared to the two rainy seasons i.e Feb – April 2000 long rains with dry matter yield of 3045 Kg/ha and a relatively fair production with the short rains June – July 2000 with dry matter yield of 2423 kg/ha. The differences in yield were attributed to variation in the amount of rainfall received in a particular season and the effects of high temperatures which affected growth of pastures. Location had a significant (P<0.05) effect on dry matter yield. With Kabale having the highest dry matter yield 2899kg/ha followed by Kashari with 2494Kg/ha, Ibanda 2270Kg and Nyabushozi with 1503Kg/ha. Looking at the four locations, Kabale had the highest dry matter yield compared to the other locations due to the fact hat it is favoured by cool climate due to its hilly nature. This favours pasture growth and development. Also the pasture sward had a mixture of legumes (Clovers) which improved on production because of Nitrogen fixation which improves on fertility of the soil. This indicates that, the amount of rainfall at a particular time will influence pasture growth, its ability to regenerate after grazing, tiller production and therefore the amount of dry matter yield. High temperatures as was experienced in the areas of Kashari, Ibanda and Nyabushozi affected dry matter production due to increased water loss through transpiration, leaf loss due to wilting, as a result of soil moisture deficit.

**Table 1: Effect of Season and location on total dry matter yield of Pastures in Kg/ha from Kabale and Mbarara Districts**

| | Location | | | | |
|---|---|---|---|---|---|
| Season | Kabale | Ibanda | Kashari | Nyabushozi | Mean |
| June-August 1999 Long dry season | 2131 | 1172 | 1331 | 993 | 1407 |
| Feb – April 2000 long rains | 4182 | 2928 | 3227 | 1842 | 3045 |
| June – July 2000 Short rains | 2384 | 2710 | 2925 | 1674 | 2423 |
| Mean | 2899 | 2270 | 2494 | 1503 | 2292 |

Table 2 shows the results for the effect of season and location on available pasture in (Kg/ha) from the two Districts.

The amount of pastures available to animals was also greatly affected by seasonal changes. Season determined the amount of forage available for grazing animals. Effect of season on available pasture was very significant (P<0.001) effect. Seasonal changes determined the available pasture during the three seasons lowest being in the long dry season 1157Kg/ha, highest in the long rains 2588kg/ha and average yield towards the end of rains (short-rains) 1980kg/ha.

Locational results show that Kabale still had the greatest pasture availability 2657kg/ha, Kashari 2176kg/ha, Ibanda 1828kg/ha and Nyabushozi 972kg/ha. The other three locations due to their location were greatly affected by environmental factors especially high temperatures and lack of good pasture management. The highest level of pastures available in Kabale was due to its favourable climatic endowment and better pasture management that improved yield. Many farms in Kabale are dairy farms and their level of management was better than those in Mbarara especially Nyabushozi where the farms were beef ranches. Bush encroachment therefore reduced the amount of available pastures for animals to graze in Nyabushozi. Termite activity was greatly evident in Mbarara especially Nyabushozi as compared to Kabale. As such the lower total dry matter yield and available pastures reported for Nyabushozi than Kabale farm was also attributed to termite activity which destroy pastures especially in the dry season. The cool temperatures for Kabale also do not favour termite activity.

**Table 2: Effect of Season and Location on available pasture Kg/ha from Kabale and Mbarara Districts.**

| Season | Location | | | | |
|---|---|---|---|---|---|
| | Kabale | Ibanda | Kashari | Nyabushozi | Mean |
| June-August 1999 Long dry season | 1934 | 937 | 1175 | 583 | 1157 |
| Feb-April 2000 Long rains | 3822 | 2417 | 2928 | 1185 | 2588 |
| June-July 2000 Short rains | 2216 | 2130 | 2424 | 1149 | 1980 |
| Mean | 2657 | 1828 | 2176 | 972 | 1908 |

### 4.2 Effect of Season and location on chemical composition

The results of the effect of season and location on the percentage Ash in pastures from the two Districts are presented in Table 3. Season had a major role to play on the amount of Ash% in pastures. During the long rains when there is a lot of plant biomass, Ash percent was 9.9%, 8.6 in the short rains and 6% in the long dry season. This was attributed to variation in the amount of rainfall which determines vegetative growth of plants and vigour which increases the mineral content of plants during the vegetative growth phase. This is why the amount of ash was greatest within the period of Feb-April with heavy rains, decreasing with decreasing rains and lowest in the dry – season.

Location had no significant (P>0.05) effect on Ash. Ibanda 8%, Kashari 8.5% and Nyabushozi 8.5% with slightly lower value in Kabale 7.7%. Although there are some differences in the values, these are so small as to have a significant effect. The amount of organic material depended on environmental factors i.e rainfall, and temperature. This indicated that mineral content of pastures was similar for all the farms and seemed not be affected by location of the farms.

**Table 3: Effect of Season and Location on Ash % in pastures from Kabale and Mbarara Districts**

| | Location | | | | |
|---|---|---|---|---|---|
| Season | Kabale | Ibanda | Kashari | Nyabushozi | Mean |
| June – August 1999<br>Long dry season | 6.6 | 5 | 7 | 5 | 6 |
| Feb – April 2000<br>Long rains | 8.2 | 9.7 | 9.8 | 11.9 | 9.9 |
| June – July 2000<br>Short rains | 8.3 | 9.4 | 8.6 | 8.4 | 8.6 |
| Mean | 7.7 | 8 | 8.5 | 8.5 | 8.2 |

Table 4 shows the results of the effect of season and location on crude protein percent in pastures from the two Districts.

There was a significant (P<0.001) effect of season on crude protein, 10.8% in the long dry season, 9.4% in long rains and 8.7% in the short rains. Location was also significant (P= 0.05) on crude protein indicating that all the four places had differences in the amount of crude protein in pastures. 13.6% in Kabale 10% in Ibanda 6.5% in Kashari and 8.3 in Nyabushozi.

The seasonal differences in the crude protein content in the dry-season and the wet season was attributed to Nitrogen flush effect which is experienced after along dry spell. It is believed that there is a drastic increase in soil Nitrogen immediately after the onset of rains following along dry spell. This effect reduces with increasing rainfall and the amount of Nitrogen decreases due to leaching with increasing rainfall.

Location showed a great variation in the amount of crude-protein in pastures. Kabale having the highest percentage followed by Ibanda, Nyabushozi and Kashari respectively. High value in Kabale is due to better pasture mixture with legumes especially clovers which not only improve yield but also the crude-protein, which could not be the case with Kashari with a higher total dry matter yield, available pasture but then with low crude protein value. Ibanda county also had a significant amount of legumes mainly Desmodium spp and many indigenous ones like Glycine. That's why the pastures in these areas had higher crude protein than those from Nyabushozi and Kashari where legumes were scanty during the period when the samples were collected.

**Table 4: Effect of season and location on crude protein percent in pastures from Kabale and Mbarara Districts**

| | Location | | | | |
|---|---|---|---|---|---|
| Season | Kabale | Ibanda | Kashari | Nyabushozi | Mean |
| June – August 1999<br>Long dry season | 14.8 | 12.5 | 6.8 | 9.3 | 10.8 |
| Feb – April 2000<br>Long rains | 13 | 8.8 | 7 | 8.7 | 9.4 |
| June – July 2000<br>Short rains | 3.4 | 8.6 | 5.7 | 7 | 8.7 |
| Mean | 13.7 | 10 | 6.5 | 8.3 | 9.6 |

The results of the effect of season and location on Neutral Detergent fibre (NDF) in pastures from the two districts are presented in Table 5. According to results season had a significant ($P<0.05$) effect on NDF in pastures. 65.1% in the long dry season, 73.8% in the long rains and 69.5% in the short rains. Location has no significant ($P>0.05$) effect on NDF. It is the proportion of the plant cell wall that is slowly digestible and therefore affects intake of pastures because of its composition. i.e lignin, cellulose and hemi cellulose which is not easily attacked by the rumen micro flora, High temperatures and low rainfall increases the ratio of stem to leaves and therefore the other probable reason for the high fibre content (NDF) in the dry season as compared to the rainy season, could be that botanical composition of the pasture stand and the stage at which pastures were sampled could have affected this fraction.

During the dry season, the highest proportion (more than 90%) of the pastures sampled were dominant by mature and coarse grass species and thus high NDF. During the rains, it was a mixture of both young and mature grasses and therefore fibre content increases.

**Table 5: Effect of season and location on NDF % in pastures from Kabale and Mbarara Districts**

| | Location | | | | |
|---|---|---|---|---|---|
| Season | Kabale | Ibanda | Kashari | Nyabushozi | Mean |
| June – August 1999<br>Long dry season | 64.1 | 63.4 | 67.4 | 66.6 | 65.1 |
| Feb – April 2000<br>Short rains | 74.5 | 73.2 | 77 | 70.5 | 73.8 |
| June – July 2000<br>Short rains | 72.8 | 67.8 | 71.9 | 65.7 | 69.5 |
| Mean | 70.4 | 68.1 | 72.1 | 67.3 | 69.5 |

Table 6 shows the results of the effect of season and location on Acid Detergent fibre percent in pastures from the two Districts. Season was very significant (P<0.001) on ADF. Seasonal ADF values had a similar trend like the NDF values, 36.4% in the long dry season, 39.7% in the short rains and 42.8% in the long rains. Location was also significant (P<0.005) on ADF. Kabale had 38.3%, Ibanda 40%, Kashari 49.1% and Nyabushozi 38.1. ADF represents the non-structural carbohydrates of and therefore determines digestibility. This means that as plants become more succulent, this proportion increases and therefore pastures become easily digestible. High temperatures and low rainfall as indicated in Figure 3 tend to increase the indigestible proportion (NDF) and ADF fraction decreases. ADF also varied with location as a result of the type of pasture management employed and the amount of solar radiation received by plants which later influences the amount of leaves on the plant which are easily digestible and the fibrous content which is indigestible. It therefore means that as season changes the amount of rainfall determines the characteristics of the pasture stand, long dry season means NDF, more mature fibrous plants hence high and low ADF therefore, low digestibility. With location, because of differences in management the ADF fraction varies with the particular areas i.e. pure stand compared with pasture mixtures in different areas.

**Table 6: Effect of season and location on ADF% in pastures from Kabale and Mbarara Districts**

| | Location | | | | |
|---|---|---|---|---|---|
| Season | Kabale | Ibanda | Kashari | Nyabushozi | Mean |
| June – August 1999<br>Long dry season | 35.2 | 36.1 | 38.2 | 36.1 | 36.4 |
| Feb – April 2000<br>Long rains | 41.7 | 44.4 | 45.4 | 39.8 | 42.8 |
| June – July 2000<br>Short rains | 38 | 39.7 | 42.6 | 38.5 | 39.7 |
| Mean | 38.3 | 40 | 49.1 | 38.1 | 39.6 |

### 4.3 Effect of season and location on dry matter digestibility

The results of the effect of season and location on in vitro dry matter digestibility (IVDMD)from the two Districts are presented in Table 7.Season had a significant (P<0.001) effect on dry matter digestibility. Most of plants loose their leaves the plant cell wall increases (fibre) especially with low rainfall. High rainfall after the dry season encourages new plants to sprout which are easily digested, more tillers develop with low plant cell wall.

Invitro dry matter digestibility was low in the long dry season (44.9%) and high with high rainfall 49.9% as was the case with long rains, and almost the same percentage with short rains 50.7% There was not significant (P>0.05) effect of location on IVDMD, although there differences in values i.e 48.7% Kabale 50.7 Ibanda 43.3 Kashari and 51.3 Nyabushozi. IVDMD indicates the rate which micro-organsims attack and digest plant tissues. High values

indicate that pastures are easily digested well as low values indicate low digestibility. Low rainfall and high temperatures as shown in Fig. 3 increase lignification and reduce digestibility because of high ADF fraction and low ADF fraction.

Location does not influence digestibility of pastures. It is not a factor that comes into play in order for rumen micro-organisms to attack plant tissues. Therefore the relationship between NDF, ADF and IVDMD is that during the dry season because of the influence of high temperatures. The plant fraction decreases, hence the IVDMD become low. As the rains start pastures sprout, they develop more fillers become succulent and therefore NDF decreases, as ADF increases and again IVDMD becomes high as was observed in the three seasons.

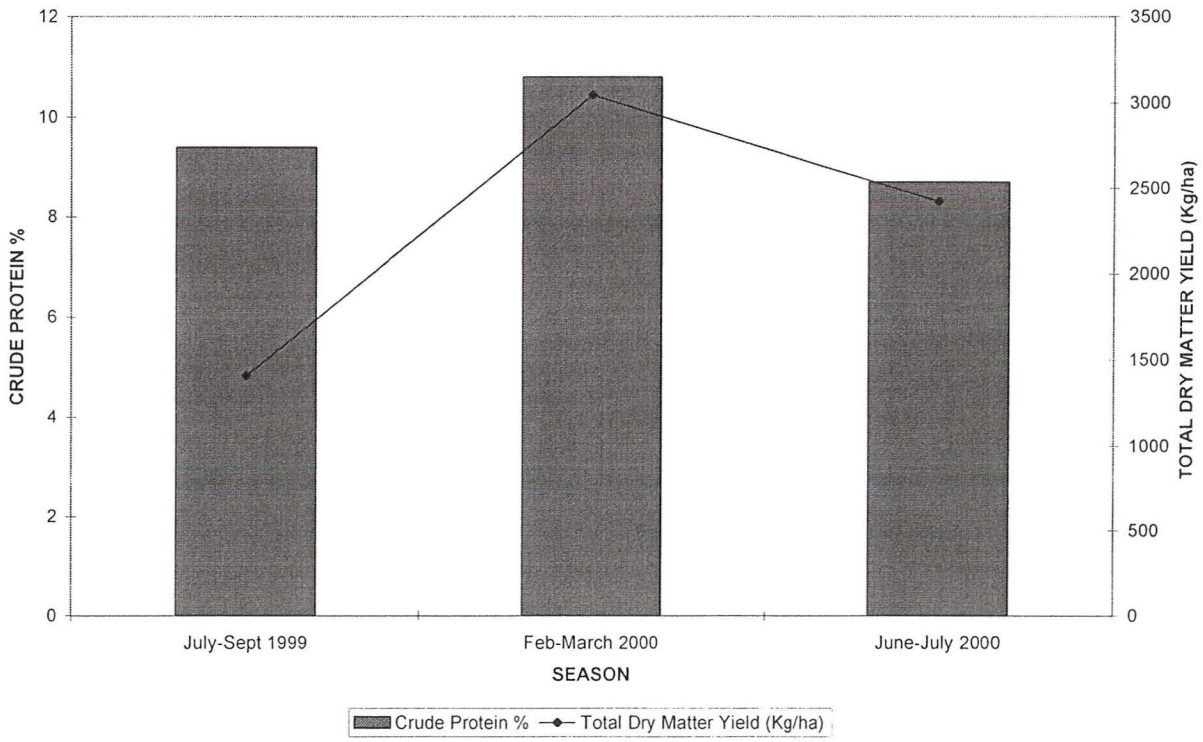
**Table 7: Effect of season and location on Invitro dry matter digestibility of pastures from Kabale and Mbarara Districts**

| | Location | | | | |
|---|---|---|---|---|---|
| Season | Kabale | Ibanda | Kashari | Nyabushozi | Mean |
| June – August 1999<br>Long dry season | 43.7 | 46.9 | 39.4 | 49.7 | 44.9 |
| Feb – April 2000<br>Long rains | 50.7 | 53.9 | 44.4 | 50.5 | 49.9 |
| June – July 2000<br>Short rains | 51.8 | 51.3 | 46.3 | 53.4 | 50.7 |
| Mean | 48.7 | 50.7 | 43.3 | 51.3 | 48.5 |

BAR GRAPH SHOWING TOTAL DRY MATTER YIELD IN KG/HA IN VARIOUS LOCATIONS

## GRAPH SHOWING RELATIONSHIP BETWEEN SEASON DRY MATTER YIELD IN KG/HA AND CRUDE PROTEIN PERCENT

**FIG 1 A GRAPH SHOWING RELATIONSHIP BETWEEN SEASONAL TOTAL DRY MATTER YIELD (Kg/ha) and CRUDE PROTEIN %**



# CHAPTER FIVE

## 5.1 Summary, Conclusions and Recommendations

This work was carried out to determine the effect of season on dry matter yield and chemical composition of pastures in terms of crude-protein Neutral detergent fibre, Acid detergent fibre and Invitro dry matter digestibility. In the Districts of Kabale and Mbarara in the seasons of June – August 1999 when there was a very long dry spell, February – April 2000 when there was short rains. The analyses showed that season has an effect on Ash%, CP%, available pasture%, dry mater digestibility, NDF% and ADF%. Seasonal changes influence the rate of growth of pastures, due to fluctuations in the amount of rainfall, dry periods, favours termite activity and therefore this reduces on the available pastures. Rainfall improves on the growth of pastures due to improved mineral content in the soil. It also influences the NDF cell wall fraction especially during the dry season where it becomes higher and digestibility is reduced.

## 5.2 Recommendations

Because of the effects of season on forage availability and nutritive value, the following measures, have been put forward to counter balance such effects for sustainable productivity of animals.

Farmers should develop early warning measures before the on set of the dry season i.e. reduce livestock numbers to match with the available pasture by selling off non-productive stock like steers and aged females (stocking rate).

Develop fodder banks to be used during the dry season.

Partition livestock into productive and non-productive stock. Productive including mainly lactating cows so these should be given special attention (Dairy animals especially in Kabale).

Develop water resource for animals in grazing fields (for beef farmers in Mbarara Dairy farmers).

Supplementation of animals with crop residues and mineral licks (Dairy farmers).

Introduce legumes in the sward to increase palatability mineral content, digestibility and protein content of the sward, to improve on digestibility in the dry season.

## REFERENCES

FAO: 1995. Production year book, Food and Agricultural Organisation of the United Nation.

Kartzow A de, Gunder M. Saki MA, 1995. Workshop on livestock, Mbarara Uganda Pp. 75.

Ludlow, M.M. Wilson, G.L., 1995. Studies on the productivity of tropical pasture plants Pg. 183-194.

Mahedean and Parsons D.J 1970. Livestock Agriculture in Uganda.

McDonald P. Edwards R.A., Greenhalgh J.F.D., 1987 Animal Nutrition 3rd Edition.

Medhanie M.Y. 2000. Special project report on chemical composition and in vitro organic matter Digestibility of selected grasses, legumes and fodders submitted to the Faculty of Agriculture.

MFEP: National house hold budget survey, vol 1 statistics Department, Ministry of Finance and Economic Planning, Entebbe.

Minson, J.J. and Milford, R. 1967. The voluntary intake and digestibility of diets containing different proportions of legume and mature grass. Aust. J. Exp. Agricultural Animal Industry. Pg. 190-200.

Mott, 1965. The relationship between the rate of stocking and per acre performance on pasture agronomy Pg. 28 – 30.

Mpairwe, D. (1998). Effect of dried *Gliricidia sepiem* leaf supplement on feed intakes digestibility and nitrogen retention in sheep fed dried $KW_4$ elephant grass (*Pennisurum purpurenin*) libitum. Agroforestry System, 41:139-150.

MPMPS, 1998. Meat Production Master Plan Study. Ministry of Agriculture, Animal Industry and Fisheries (MAAIF).

Norman, M.J.T. and Phillips, L.J. 1970. Wet Season Grazing on Tovensville Stylo-pasture at Katherine, N.T. Aust. J. Expt. Agric. Animal Husbandry Pp. 710.

Norton B.W., 1990. Differences between species in forage quality. In T.B. (ed) Nutritional Limits to Animal Production from pastures. Common wealth Agricultural Bureaux, Farnham Royal, U.K. Pg. 89 – 1000.

Payne, W.J.A. 1959. An Introduction to Animal Husbandry in the Tropics 4th Edition

Pratt and Gawyn, 1977. Rangeland Management and Ecology in East Africa, Hodder and Stonghton Limited England.

Sebatta, R. 1991. Special project report on pasture management and utilisation on specified dairy farms. Tongolo estates, Livestock experimental centre Entebbe, Kawanda research station. Submitted to the Faculty of Agriculture and Forestry.

Shaw, M.H. and Bryan W.W. 1976. Tropical pasture research principles and methods CSIRO Division of tropical Agronomy Cunnington Laboratory Pp. 454.

Skerman P.J. Riveros F. 1990. Tropical grasses (FAO Plant production and Protection Serial No. 23) Pp. 832.

Stobbs, T.H. 1969. Effect on organic fertilizer upon adaptation, persistence and production of grass, grass legume swards in East Africa, Pg. 38-80.

Vansoest and Robertson, Journal of Animal Science 1965.

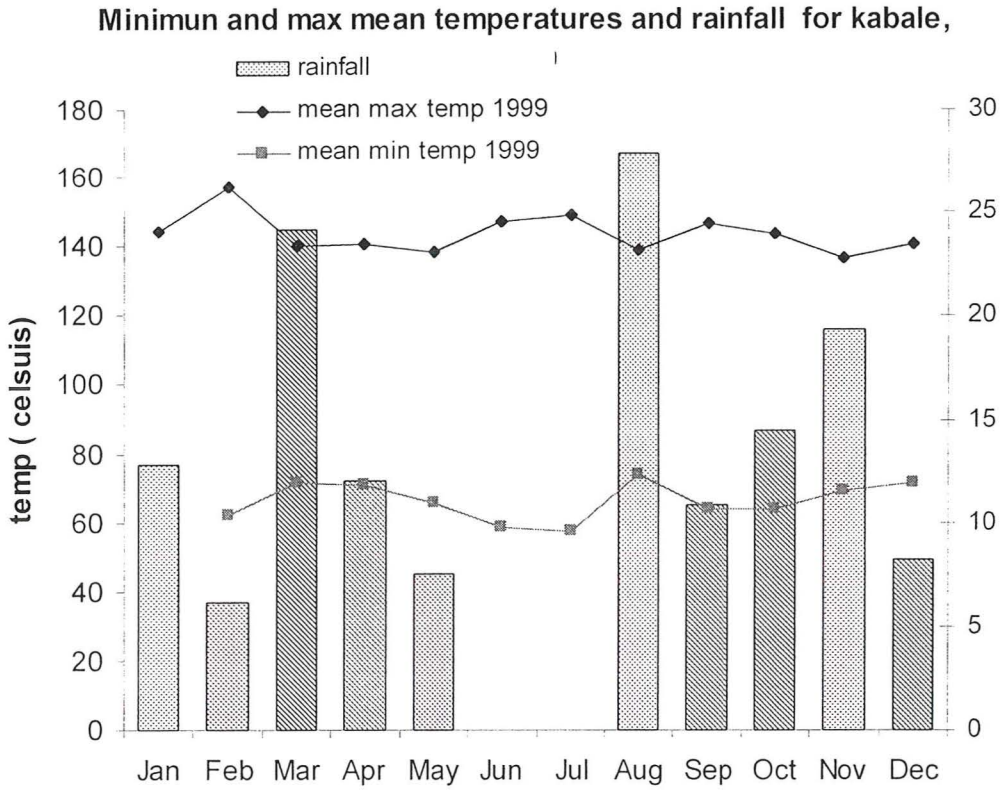
Vansoest P.J., 1944. Nutrition ecology of ruminants 2nd edition.

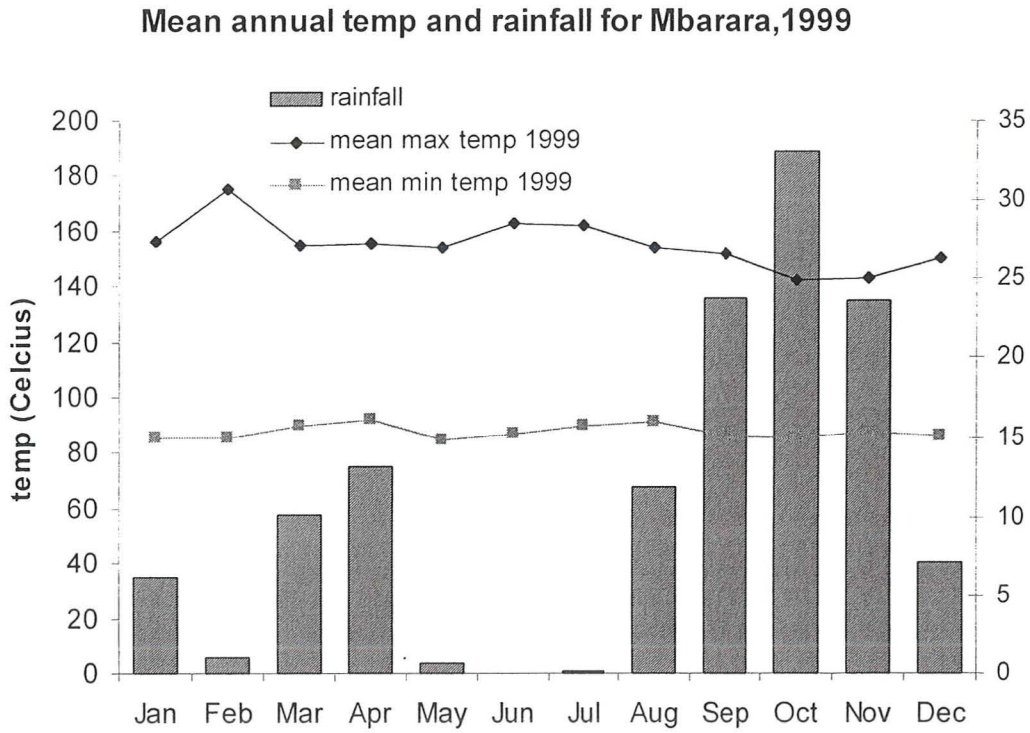
Waigambi M. M. 1993. Special Project Report on Pasture Management and Utilisation on selected Farms in Pallisa District.

William D. Skidmare C.L., 1966. Tropical pasture science Pp. 391.

# APPENDIX 3

## MINIMUM AND MAXIMUM MEAN TEMPERATURES AND RAINFALL OF KABALE AND MBARARA DISTRICT



## APPENDIX 4

## CLIMATIC DATA FOR MBARARA DISTRICT FROM 1999 – 2000

## APPENDIX 5

## FORMULARS USED TO CALCULATE

Crude Protein

$$\% N = \frac{14.01 \times (V-B) \times N}{w \times 10 \times Dm\%} = \frac{1.401(V-B)N}{W \times DM\%}$$

% Protein = % N x factor specific for different products

Where V = Volume of HCI

B = Blank titration

N = Normality of HCI

W = Weight of sample taken

Dm% = Dry matter basis

$$ASH = \frac{(W_3 + C_2) - (W_2 + C_1) \times 100}{W_1 + Dm\%}$$

Where $W_1$ = Weight of air dry Sample

$W_2$ = Weight of empty Crucible

NDF (Neutral detergent fibre)

$$NDF\% = (W_2 + C_1) - (W_3 + C_2) \times 100$$

Where $W_1$ = Weight of Sample

$W_2$ = Weight of Crucible + fibre

$W_3$ = Weight of Crucible + Ash

$C_1$ = Correlation for $W_2$ read from the balance (due to hot weighing)

$C_2$ = Correlation for $W_3$ read from the balance (due to weighing)

ADF = (Acid detergent fibre)

$$ADF\% = \frac{(W_3 + C_2) - (W_5 + C_4) \times 100}{W_1 + Dm\%}$$

Where

$W_1$ = Weight of air dried sample

$W_2$ = Weight of air Crucible + ADF

$W_3$ = Weight of Crucible + ASH

$C_2$ = Correlation for $W_3$ read from the balance

$C_4$ = Correlation for $W_5$ read from the balance

Digestibility

$$\% \text{ in vitro dry matter digestibility} = \frac{Wd - (Wrd - Wbd) \times 100}{Wd}$$

Where WD = Weight of sample dry matter

Wrd = Weight of residue dry matter

Wbd = Weight of dry matter obtained from blank

## APPENDIX 6

## ANALYSIS OF VARIANCE TABLES FOR PASTURE COVERAGE %

| | Source | Degrees of Freedom | Sum of Squares | Mean Square | F Value | Prob |
|---|---|---|---|---|---|---|
| 1 | Replication | 2 | 424.847 | 212.424 | 3.1075 | 0.1185 |
| 2 | Factor A (Location) | 3 | 5719.472 | 1906.491 | 27.8895 | 0.0006 |
| 3 | Error | 6 | 410.153 | 68.359 | | |
| 4 | Factor B (Season) | 2 | 201.764 | 100.882 | 1.1340 | 0.3463 |
| 6 | AB | 6 | 622.569 | 103.762 | 1.1664 | 0.3714 |

C.V. 11.76%

**FOR Tdmy/kgha**

| | Source | Degrees of Freedom | Sum of Squares | Mean Square | F Value | Prob |
|---|---|---|---|---|---|---|
| 1 | Replication | 2 | 1357492.722 | 678746.361 | 2.4531 | 0.1665 |
| 2 | Factor A (Location) | 3 | 9289099.417 | 3096366.472 | 11.1905 | 0.0072 |
| -3 | Error | 6 | 1660168.838 | 276694..806 | | |
| 4 | Factor B (Season) | 2 | 16407301.556 | 8203650.778 | 50.8989 | 0.0000 |
| 6 | AB | 6 | 4029152.667 | 671525.444 | 4.1664 | 0.0104 |
| -7 | Error | 16 | 2578805.778 | 161175.361 | | |
| | Total | 35 | 35322020.972 | | | |

C.V. 17.52%

## APPENDIX 7

**For Available Pasture kg/hc**

| | Source | Degrees of Freedom | Sum of Squares | Mean Square | F Value | Prob |
|---|---|---|---|---|---|---|
| 1 | Replication | 2 | 8660095.167 | 433047.583 | 1.2859 | 0.3430 |
| 2 | Factor A (Location) | 3 | 13633199.556 | 1511199.852 | 13.1912 | 0.0015 |
| -3 | Error | 6 | 2020639.278 | 336773.213 | | |
| 6 | Factor B (Season) | 2 | 12372434.667 | 618621.333 | 45.7561 | 0.0000 |
| 7 | AB | 6 | 3115320.444 | 519220.074 | 3.8404 | 0.0145 |
| -7 | Error | 16 | 2163198.889 | 135199.931 | | |
| | Total | 35 | 34171188.000 | | | |

C.V. 19.27%

For Ash %

| | Source | Degrees of Freedom | Sum of Squares | Mean Square | F Value | Prob |
|---|---|---|---|---|---|---|
| 1 | Replication | 2 | 0.869 | 0.435 | 0.1871 | |
| 2 | Factor A (Location) | 3 | 4.344 | 1.448 | 0.6235 | |
| -3 | Error | 6 | 13.936 | 2.323 | | |
| 4 | Factor B (Season) | 2 | 93.980 | 46.990 | 17.5766 | 0.0001 |
| 6 | AB | 6 | 28.824 | 4.804 | 1.7970 | 0.1632 |
| -7 | Error | 16 | 42.775 | 2.673 | | |
| | Total | 35 | 184.730 | | | |

C.V. 19.97%

## APPENDIX 8

**For CP%**

| | Source | Degrees of Freedom | Sum of Squares | Mean Square | F Value | Prob |
|---|---|---|---|---|---|---|
| 1 | Replication | 2 | 48.736 | 24.368 | 1.3021 | 0.3391 |
| 2 | Factor A (Location) | 3 | 256.510 | 85.503 | 4.5687 | 0.0542 |
| -3 | Error | 6 | 112.290 | 18.715 | | |
| 4 | Factor B (Season) | 2 | 29.542 | 14.771 | 7.6085 | 0.0048 |
| 6 | AB | 6 | 16.006 | 2.668 | 1.3741 | 0.2836 |
| -7 | Error | 16 | 31.062 | 1.941 | | |
| | Total | 35 | 494.145 | | | |

C.V. 14.47%

For NDF %

| | Source | Degrees of Freedom | Sum of Squares | Mean Square | F Value | Prob |
|---|---|---|---|---|---|---|
| 1 | Replication | 2 | 38.345 | 19.173 | 0.4945 | |
| 2 | Factor A (Location) | 3 | 129.979 | 13.326 | 1.1171 | 0.1133 |
| -3 | Error | 6 | 232.636 | 38.773 | | |
| 4 | Factor B (Season) | 2 | 452.520 | 226.260 | 5.2462 | 0.0177 |
| 6 | AB | 6 | 63.778 | 10.630 | 0.2465 | |
| -7 | Error | 16 | 690.050 | 43.128 | | |
| | Total | 35 | 1607.308 | | | |

C.V. 9.4%

## APPENDIX 9

**For ADF %**

| | Source | Degrees of Freedom | Sum of Squares | Mean Square | F Value | Prob |
|---|---|---|---|---|---|---|
| 1 | Replication | 2 | 57.812 | 28.656 | 6.6530 | 0.0300 |
| 2 | Factor A (Location) | 3 | 92.158 | 30.719 | 7.1321 | 0.0210 |
| -3 | Error | 6 | 25.843 | 4.307 | | |
| 4 | Factor B (Season) | 2 | 245.099 | 122.550 | 9.5431 | 0.0019 |
| 6 | AB | 6 | 20.243 | 3.874 | 0.2627 | |
| -7 | Error | 16 | 205.167 | 12.812 | | |
| | Total | 35 | 646.122 | | | |

C.V. 9.04%

For IVDMD%

| | Source | Degrees of Freedom | Sum of Squares | Mean Square | F Value | Prob |
|---|---|---|---|---|---|---|
| 1 | Replication | 2 | 165.725 | 82.863 | 1.3404 | 0.3302 |
| 2 | Factor A (Location) | 3 | 353.086 | 117.695 | 1.9038 | 0.2301 |
| -3 | Error | 6 | 370.920 | 61.820 | | |
| 4 | Factor B (Season) | 2 | 236.340 | 118.170 | 8.9971 | 0.0024 |
| 6 | AB | 6 | 55.260 | 9.210 | 0.7012 | |
| -7 | Error | 16 | 210.118 | 13.131 | | |
| | Total | 35 | 1391.480 | | | |

**C.V. 7.47%**

- ANNEXE 2 -

# Research to examine the Efficiency of Production Under Intensification of Smallholder Dairying in Uganda

**Annual Report Year 1**

DANIDA CGIAR FUNDED PROJECT

**Implemented by**

International Livestock Research Institute (ILRI), Kenya

In collaboration with

National Agricultural Research Organisation (NARO), Uganda

Danish Institute of Agricultural Sciences (DIAS), Denmark

June 2002

**Project location**: Uganda/Kenya/Denmark

**Project manager** Dr Dannie Romney – ILRI/Kenya d.romney@cgiar.org

**Other project staff**

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**Project duration** 4 years: 1st May 2001 – 30th April 2005

# 1 - INTRODUCTION AND BACKGROUND

## 1.1 Introduction

Smallholder African farmers are being compelled by policy and markets to diversify from traditional African export crops, whose outlook for growth remains uncertain. Alternative agricultural activities are needed which offer higher returns to land and labour, offer the expectation of future growth; and which are suitable for adoption by the resource and technology-poor smallholder farmers who continue to dominate African production. Market-oriented dairy production may fill this need for some smallholder producers. In Uganda and in East Africa in general, smallholders have begun to realise this opportunity and are taking up market-oriented dairying. Yet constraints to further development remain in the form of differential market access, low productivity, seasonal feed/fodder shortages, and high input/low output prices. Targeted research can yield information that can be used in formulation of policies to assist the alleviation of these constraints.

With growing human populations and consequent decreases in agricultural land holding sizes, crop/livestock farming systems are intensifying in East Africa, particularly when proximate to urban areas. As this occurs and labour becomes relatively less constraining than land, dairy producers in high potential and high density areas are turning to cut and carry production systems which depend on labour to more intensively harvest fodder from available land. Some 70% of dairy producers in Kiambu, Kenya, for example, now grow napier grass to provide the primary basal feed for their cattle (Staal *et al.*, 1998). A considerable variety of production strategies can be observed, however, even under relatively homogeneous high potential environments, suggesting a role for socioeconomic and resource factors in these producer decisions.

Soil fertility status has been observed to be in decline in Sub-Saharan Africa, presenting a serious threat to food security (Smaling, 1993; Shepherd and Soule 1998; Wortman and Kaizzi, 1998). For poor, smallholder farms where use of purchased inorganic fertiliser is often limited, manure becomes an important source of soil nutrients. Not only do livestock make an important contribution to income generation, but they may also contribute to the nutrient status of the land, not only by accelerating the rate of nutrient turnover, but also through importation of nutrients as purchased concentrates or fodder (Lekasi *et al.* 1998).

Preliminary analysis from the rapid appraisal in South West Uganda (ILRI/NARO/MAAIF (1996) suggest there is little evidence of strong incentives for adoption of more intensive dairy production technologies such as zero-grazing, in spite of an emphasis on such technology by some dairy projects (including USAID (US Agency for International Development) and Land 0 Lakes). Returns to land and labour from the different production systems are similar, with some indication that the highest returns are available in fenced grazing systems. Thus, land availability and labour constraints appear to favour semi-intensive or extensive systems with improved or natural pastures, even when higher transport costs are included. Relatively high opportunity costs to labour may occur in the intensive peri-urban milk-shed, while variable costs of milk production may be low in the more extensive rural areas. Further, in the semi-intensive Southwest, substantial upgrading of the

local cattle with dairy genes is observed, leading to greater production potential and the possibility for even higher levels of competitiveness. In the intensive milk-shed, continued development and high agricultural potential may raise the value of alternative agriculture activities and thus the opportunity costs of domestic resources, including land and labour. Further, if milk market supply becomes saturated, as is occurring increasingly during flush seasons when rainfall is high and feed resources abundant (ILRI/NARO/MAAIF 1996) leading to lower real farm gate prices for milk, low cash-input systems may be more viable. The same may be true if opportunity costs for labour increase with general national economic growth, current in the 5% annual range.

**1.2 Justification**

The comparative economic advantages of different levels of dairying intensity under various resource, market and policy regimes is not well understood. It may not even be understood which economic factors describing the systems that are key characteristics for farmers decision making, i.e. their choices of systems- In Uganda, two milk-sheds with different levels of production intensity supply the Kampala urban market. Semi-intensive systems based on partial grazing and with low external inputs contrast with more intensive systems based on exotic animals in cut and carry, high input systems. Preliminary analysis of their relative competitiveness suggests results contradictory to those promoted by current dairy development efforts, potentially undermining the long-term viability of those efforts (ILRJ/NARO/MAAIF 1996). Contrary to some currently held dairy development views that farmers should move towards more intensive cut and carry systems, semi-intensive dairying may have a role in dairy market supply. This may be fundamentally linked to opportunity costs, since while in high-potential areas a variety of crops may be grown, in lower potential areas semi-intensive dairying may provide a relatively valuable output given the resource base. Research is needed to better understand the relative competitiveness of different levels of dairying intensity under various resource constraints and market and policy regimes.

Better understanding is also needed of the risk exposure as land use systems evolve, and markets develop, of the nature of the trade-offs between food and fodder production and of the long term sustainability of the system in terms of nutrient status. The relative competitiveness of different production systems supplying the Kampala milk market are not well known, and the manner in which further evolution of the systems will affect that competitiveness is not well understood. There is disagreement evident among stakeholders in the dairy sub-sector as to which milk-shed should receive donor and policy attention. Research to examine underlying dairy production competitiveness in these alternative milk-sheds would strengthen prioritisation of future dairy development efforts. With growing donor interest in promoting market-oriented smallholder dairying outside of its current highland base, it is critical that this understanding of the competitiveness of varying intensities of dairying is pursued.

At the same time, to ensure that involvement in dairy marketing contributes to the sustainable livelihood of the smallholder farmer, its role in the farming system as a whole must be considered. There is also a need to further develop the indicators used to describe and compare different farming systems in order to accommodate both farmer and extentionist

needs for information. These indicators should include the characteristics that reflect farmers' objectives and criteria used when making choices in management of the farming system.

Understanding of actual nutrient management in the different smallholder dairy systems would allow identification of possible problems and the potential for interventions to improve nutrient utilisation. In more extensive systems where common grazing land is available, animals may import nutrients from a wide area (Giller *et al.* 1997). In a comparison of farm level nutrient balances in different farming systems of Uganda, Wortman and Kaizzi (1995) found that the nitrogen balance of livestock farms was not better than the balances in other fanning systems (though located in different regions) and that improved management of farmyard manure was needed. Understanding of the role of livestock and its contribution to nutrient balance under increasing intensification should allow identification of key constraints and potential interventions to improve nutrient management.

### 1.3 Goal

To improve the contribution of smallholder dairying to the sustainable livelihoods of resource poor farmers in Uganda

### 1.4 Purpose

The purpose of the present project is to develop and test methodologies that will allow comparison of the productivity and economic viability of contrasting dairy systems with a view to developing a greater understanding of these systems in order to;

- Provide information that decision makers can use to inform policy development
- Identify potential interventions that will improve nutrient management and
- Identify key characteristics of a farm that can be used to target extension messages

### 1.5 Planned activities

1. Carry out a review of secondary sources of information describing the systems where the project aims to work and of appropriate methodologies.

2. Carry out a structured characterisation survey of randomly-selected dairy households in the research sites, using a pre-tested questionnaire.

3. Carry out a longitudinal survey (regular visits over a period of at least 1 year) of a smaller sample of representative households, selected from the larger random sample.

## 2 - RESEARCH APPROACH

The project is primarily being implemented through two PhD studies described briefly in the following section

### 2.1 Completed activities

1. The reviews were completed by the 2 doctorate students registered at Makerere University under the supervision of the other members of the research team. The reviews are reported in the form of their PhD proposals which are attached in Appendix 1 and summarized in sections 2.2 and 2.3 below.

2. The characterisation survey was completed in May 2002, and data entry commenced. The survey was carried out in three districts where dairy production is a key activity and included 303 households 70% of which owned cattle and 30% did not. Data collected during this survey will be used to develop categories of dairy production systems. Details are given in section 3.0 below.

3. The longitudinal survey will be planned based on analysis of the characterization data.

### 2.2 Incentives to intensification of dairy production in Uganda (William Nanyeenya)

#### 2.2.1 Objectives of the Study

The major objective of the study is to examine the short–term and long term economic viability, crop-livestock synergism in dairy based farming systems in Mbarara and Kampala-Jinja dairy sheds

#### 2.2.2 Specific Objectives

(i) To examine the economic incentives for intensification of dairy production,

(ii) To assess crop-livestock synergistic interactions and their role on reducing milk and crop yield losses in the zero-grazed, perimeter and paddock fenced grazing systems,

(iii) To determine the appropriate level of intensification, farm enterprise sizes and combinations for each of the two major dairy sheds

#### 2.2.3 Conceptual Framework

Dairy producers in Uganda are exposed to income instability due to seasonal weather and milk price changes. Farm milk yields and prices fall to as low as 45 and 30 per cent of their corresponding figures during dry and wet seasons, respectively. Ugandan farmers are also constrained by land, labour, and feed resources yet farm production ought to offer subsistence, social and income obligations. This state of affairs can be structured in a gross income maximisation linear programming model constrained with farmer's subsistence and social needs.

### 2.2.4 Methods of Data Analysis

Economic incentives for farm production in different dairy sheds will be based on unit milk production costs vis – a – vis farm gate prices. Enterprise budgets will be drawn to work out gross margins, net farm incomes and cost of production per litre/acre for zero grazing, paddock fenced and perimeter fenced systems of in each milk shed.

Crop-livestock synergism will be examined by comparing means and variances of milk yields for farmers with dry season feeding of crop residues and/or fodder with those who do not have dry season feed buffer. Crop yields where manure is applied on food, commercial and fodder crops as opposed to farms where such interactions do not exist will also be compared using t-tests.

A Generalised Arithmetic Model Systems (GAMS) Mixed Integer Target MOTAD linear programming technique will be used to determine the risk-adjusted optimum crop and livestock enterprise combinations for each dairy management system. Extensions on GAM by sensitivity analysis will assess the effect of potential adverse milk prices and labour costs on the long-term competitiveness of dairy management intensification in each of the dairy sheds

## 2.3 Nutrient balances and options for their improvement under different levels of intensification of dairy production in Uganda (Sarah Mubiru)

### 2.3.1 Objectives

To estimate nutrient balances at various levels of intensification of dairy production

To identify options for improving nutrient balances at various levels of intensification of dairy production

To develop indicators of nutrient management useful for decision making

### 2.3.2 Background to the study

Livestock are an integral part of most farming systems in Uganda whose structure has evolved over time to suit the agro ecological zones and the socioeconomic setting. There has been increasing intensification of dairy production systems in Uganda mainly resulting from increasing population pressure, growing market for milk and governments, NGOs and donor promotion. Promotions of these systems has been with the anticipation that they are economically and ecologically sustainable. These anticipations require qualification and the research proposed here is to study the ecological competitiveness of dairy production at varying levels of intensification.

### 2.3.3 Methods of data analysis

This will be done through estimation of "nutrient balances" which are the differences between the nutrients into and out of production systems and emphasis here will be on Nitrogen (N), Phosphorus (P) and Potassium (K). A "nutrient balance" is an indicative measure for ecological sustainability. Nutrient flows within farm units will also be identified and estimated. In addition, means for improving the less competitive systems will be identified and nutrient management indicators for assessment of dairy production systems will be developed. A spreadsheet model with various parameters required for estimation of "nutrient balances" will be developed. This model could be put to future use for similar purposes for environments that match those of the research area.

## 3 - CHARACTERISATION SURVEY

### 3.1 Site familiarisation visit

Visits were made in August 2001 to the three proposed districts for the project activities by the project team members from NARO Uganda (S Mubiru and W Nanyeenya), ILRI Nairobi (D Romney and S Staal) and DIAS Denmark (J Hermansen). During the visits, the team had discussions with extension staff and visited a number of farms to familiarise themselves with the proposed sites. Following these visits and subsequent team discussions, it was agreed to include the three districts of Mbarara, Masaka and Jinja in the characterisation survey with contrasting cattle and human population densities (table 1).

**Table 1: Human and cattle population densities in the three districts selected for the characterization survey from Mugisha (1997/98)**

| | Sub counties | Area $km^2$ | Sub county size $km^2$ | Cattle pop | Cattle/ $km^2$ | Pop. | Pop/$km^2$ |
|---|---|---|---|---|---|---|---|
| Mbarara | 34 | 10154 | 299 | 607396 | 60 | 930772 | 92 |
| Masaka | 16 | 10611 | 663 | 528017 | 50 | 838736 | 79 |
| Jinja | 8 | 734 | 92 | 14031 | 19 | 289476 | 394 |

Mbarara was distinctive with more extensive cattle production systems and larger numbers of cattle dominated by long horned Ankole cattle. Masaka and Jinja had similar cattle management systems but with slightly better market opportunities observed in Jinja compared to Masaka. The possibility of reducing the area of coverage and farms for whole farm modeling were considered but this will be effected after characterisation of the livestock production systems, at the on set of the longitudinal survey.

### 3.2 Pre-testing of characterisation survey questionnaire

A first draft of the characterisation survey questionnaire was completed in the month of October 2001, it was then pre-tested in the three proposed districts for the survey. Three questionnaires were administered in each of the 3 districts and thereafter appropriate adjustments were made to respond to unforeseen features and issues encountered during the pre-testing exercise. During this period information was also obtained from each district regarding the diversity of dairy production systems and their distribution. This information together with that obtained from ILRI on clusters was used in selection of sub-counties for the survey in each of the districts.

### 3.3 Selection of study areas

In order to assist selection of sub-counties and ensure that farmers were selected from a broad range of market, climate and population density conditions, cluster analysis was carried out on GIS spatial layers of human population density, climate (using ppe) and market access (distance to nearest urban center). The output from this analysis is shown in Appendix 2. Five clusters were identified across the three districts with characteristics shown in table 2. Nine sub-counties, 3 from each district, were selected to give a broad spread across clusters. Cattle production systems observed across the districts included zero-grazing (mainly in the highly populated SCs in Jinja; paddock grazed in all districts and extensive communal grazing (mainly Mbarara).

**Table 2: Characteristics of the 5 GIS clusters and Sub-counties (SCs) selected in each district**

| Cluster | No. of SCs in cluster | Mean population density | Mean annual ppe | Mean market distance | District where cluster selected | SCs selected |
|---|---|---|---|---|---|---|
| 1 | 5 | 483 | 0.80 | 22 | Jinja | Budondo; Mafubira |
| 2 | 2 | 304 | 0.81 | 17 | Jinja | Butagaya |
| 3 | 6 | 91 | 0.64 | 34 | Mbarara | Buremba |
| 4 | 9 | 154 | 0.76 | 23 | Masaka | Kalungu; Kisekka; Kyanamukaka |
| 5 | 21 | 102 | 0.68 | 17 | | Bisheshe; Rwanyamahembe |

Two villages were then selected randomly from each of the sub-counties using lists of parishes and villages, in some cases referred to as cells, obtained from sub-county headquarters. Within the selected sub-counties, cells that were small in size and population (particularly considering number of cattle owning households) were merged to create what were termed as 'villages' for the purpose of the survey, however, where cells were big enough

they were considered villages in themselves. Using statistics obtained from the village Local Council leaders for human populations and number of households or tax payers in these villages, numbers of cattle and non-cattle households to be interviewed in each of the villages were apportioned. It was planned to have 34 respondent-households per sub-county of which 70% would be cattle keepers.

In each village 2 transects were used for sampling. Village maps were developed together with resource people from the sub-counties, key sites were marked and 2 pairs of key sites were selected at random. A sample of one of the maps drawn is shown in Appendix 3. All households along the most direct route between the paired sites were marked. Each of these households was visited and a record of their family name and whether they had cattle or not was taken. This information was later used in selecting the households for interview ensuring that the sample sizes required were obtained with the required numbers of cattle and non-cattle households. Selection of farms along either side of the route was alternated at specific intervals to ensure that much of the 'route' is covered and with more less equal number of farms on either side of the route. The sampling interval along the routes depended on household density along the route. Two and four households were being skipped on either side of the transect in low household and high household concentration areas respectively. Each of the selected households was visited to make an appointment for when the interview would be held.

In some sub-counties the required sample size, particularly the total number of cattle households could not be realised from the village selected. In such cases, two or three neighbouring villages were combined before transects were redrawn. This was particularly common in Rwanyamahembe, Bisheshe and Kyanamukaaka.

### 3.4 Sample selection

i. In order to obtain 100 households from the district, each sub-county would have a sample size of 34 households (100/3 = 34 approx.)

ii. The proportion of sample allocation of the sample to per village (Pv) was obtained using the formula:

$$Pv = \frac{\textit{Household/Village Population of Village (a or b)}}{\textit{Pop. Village (a)} + \textit{Pop. Village (b)}} \; X\,34$$

iii. Sample selection per village was based the total human or household population per village. In each village the ratio of cattle to non-cattle households was 7:3 the following calculation was used

$$C_{hh} = 0.7 \times P_V$$

$$NC_{hh} = 0.3 \times P_V$$

*Where:* $C_{hh}$ = *Number of cattle households to be sampled from the village*

$NC_{hh}$ = *Number of non-cattle households to be sampled from the village*

The sub-counties, villages and enumerators were coded for systematic recording of data. Details of the selected sites ie sub-counties and villages, statistics used in sampling, sample sizes, enumerators and their given codes are shown in Appendix 4.

### 3.5 Enumerator training

Enumerator training was carried out separately in each of the 3 districts and included: an overview of the project; survey techniques; detailed discussion of the questionnaire; and discussion of the sampling techniques to be used. A practical session was also carried out for the enumerators to practice carrying out the interview using the questionnaire. Dr D Romney from ILRI participated in the first exercise in Mbarara district together with the Ugandan team and modifications identified during these sessions incorporated into the questionnaire. The programme used during the training sessions is shown in Appendix 6.

### 3.6 Monitoring of the survey process

The questionnaires were collected regularly from the enumerators, reviewed for any missing data, incorrect or inconsistent records and returned to the enumerator for correction if necessary. Some of the irregularities could only be corrected by visiting the interviewed household again. The questionnaires were reviewed for a second time after the corrections to ensure that the areas with irregularities were clarified. In some instances questionnaires had to be returned as many as four times. A total of 303 Questionnaires were reviewed by Sarah Mubiru and William Nanyeenya, sent back and corrected by the enumerators in all the districts

### 3.7 GPS data collection

Each of the households that were included in the characterisation survey were visited to take a GPS reading so that the households could be mapped and so that at a later stage GIS layers can be used as parameters in the analysis. This was done on separate visits to the households after completing the questionnaires. The waypoints recorded during this process have been plotted in "Map Source".

### 3.8 Data entry

A 'data base manager' from ILRI, Patrick Wanjohi, joined the Ugandan team in the third week of May 2002 to train two 'data entry assistants' and the Ugandan scientists in data entry into the ACCESS database developed for the characterisation survey data. Two desktop computers were purchased particularly for this purpose. Data entry began immediately after the training, which lasted for one week. The data entry is expected to be completed in the month of July after which it will be cleaned and analysed.

## 4 - SITE DIFFERENCES

During implementation of the survey the students spent a great deal of time in the field and gained a lot of qualitative information on the systems present, the marketing conditions and the constraints that farmers were facing. A summary of their observations are given below.

### 4.1 Mbarara district

#### 4.1.1 Resource endowment and farm enterprise mix

Farmers in Mbarara district are endowed with relatively large land sizes per household that may be as large as 100 hectares. The land is not always on one site, with additional pieces of land sometimes being located at some distance from the household. Land is acquired as farmers obtain savings. The practice of using accumulated savings to buy pieces of land occurs at different times. Land expansion on consolidated blocks may be impossible leading to multiple plots instead. Human population density is much lower compared to other districts. However because of the presence of migrant workers, mainly of Rwandese origin, permanent resident farm labourers are common. These labourers are employed to work specifically for either banana and other crop management and livestock rearing and at relatively lower rates of pay. In Mbarara district a herdsman is commonly paid about shillings 30,000/= with meals and accomodation provided irrespective of the herdsize. In Masaka and Jinja herders of communally grazed cattle charge 2000/= per animal per month plus 0.5litres of milk per day from each household with milking animals. In zero grazed systems up to shillings 50,000/= are paid to the labourer together with a litre of milk per day.

Soils are less fertile than those found in Masaka and Jinja, distances to watering sources are much bigger and rainfall intensity is lower with bimodal rainfall pattern coupled with shorter wet seasons. Mbarara district is located in the short grassland sub-humid savannah whereas Jinja and Masaka districts are in the tall grassland humid savannah. Natural unimproved grazing lands form the bulk of livestock feed resources. Mixed farming with fewer crops compared to other districts is practiced with bananas being the major food and commercial crop that competes with cattle for available land, labour and operating capital resources. Apart from bananas other crops are grown on a very low - scale as intercrops to bananas or as sole crops in separate fields, including beans, millets and maize.

Local Ankole long horned cattle are the dominant breeds, raised principally for subsistence requirements. In addition other livelihood concerns like dowry and household income generation through selling milk, young and destocked animals are obtained from the livestock kept. Animals may be grazed by individual households on their own grazing lands, by larger extended families combining herds and grazing them across land owned by the different households or communally, with cattle collected from various nearby households every morning by one herdsman. Land improvements are mainly focused on improving perimeter fences using live fences of "Rukoni" and thorny *Acacia hockii.* In the more intensive production zones, barbed wire perimeter and paddock fencing features with mixtures of local Ankole and Friesian – with milk from the Ankole crosses making milk production a more important production objective. It is not uncommon to meet households with at least 20 heads of cattle. Large individual and multiple household (composite) herds - of up to 300 heads of cattle -were observed for some households. Goats that are managed on open grazing systems are the next most important livestock species after cattle. Free range chickens are considered a very minor and demeaning form of livestock – to raise and even consume - especially in the rural areas.

Livestock watering is largely done by driving animals to communal dams or individual valley tanks that some farmers have sunk in their grazing areas. Milk is extracted from both local and improved cattle breeds. A local cow yields only about two litres a day compared to a low grade crossbred which can produce at least five litres a day. The yield per animal is much lower for local cattle but because of the great numbers involved the cummulative effect leads to a larger proportion (up to 70 %) of milk sold coming from local cattle. Farmers keeping local and crossbreds are both interested in selling milk. They, however, face different resource and infrastructural conditions. Farmers with crossbreds are often richer, more enlightened, closer to urban areas and/or have better access to markets and may also have own means of transport like pick ups. They often have direct contacts with operators of collection centres and may also be cooperative members. They may also have markets beyond collection centres linking with intermediaries who look for milk from the farm gate for mark-ups at the next stage in the marketing chain. In situations where farming is the major source of livelihood with both husband and wife actively involved in farm production, the husband is in charge of all the fresh milk for sale. However it is argued that discussions are made with the wife on family priorities before income from milk is spent. Surplus and unsold milk are handled by wives who process it into locally made 'yoghurt' for home consumption and ghee for sale. The proceeds of ghee are kept and used exclusively by the wives. In situations where the husband is formally employed outside the farm the wives often take charge of farm management including handling milk sales.

### 4.1.2 Market conditions

The road density is low in Mbarara compared to other districts and distances covered from one homestead to another are much bigger because of large average size of land holdings and perimeter fencing forcing roads to circumvent grazing areas. Marketing of milk is largely done through market intermediaries who buy and peddle milk on bicycles from farmers and hawk milk to urban consumers or sell to collecting centres. Initially all collecting centres used to belong to dairy marketing cooperatives that used to supply milk to a government milk marketing monopoly – The Dairy Corporation. After liberalization of domestic marketing of raw milk in the early 1990s private processing plants set up milk buying (collecting) centres

close to production areas in order to buy at low prices and made direct contact with farmers for assured supplies. Milk collecting centres are rough milk bulking units where milk is tested, measured, mixed and in some cases cooled before it is delivered to processing plants, coolers, and/or informal market distribution points in Kampala. Some farmers have workers who deliver milk on bicycles or private motor vehicle transport to collecting centers, but this is less common. There is almost no local demand for milk because almost all households keep cattle and those without cattle are too poor to afford milk. Although one would imagine that most households in Mbarara have cattle it was discovered – to the surprise of even local extension workers – that in Bisheshe and Rwanyamahembe even more that 50 per cent of the households did not have cattle. In the wet seasons the milk prices tend to drop to as low as 100/= per litre but increase up to 300/= per litre in the dry season. When the demand for milk is low farmers process unsold milk into ghee. Mbarara district is endowed with three processing plants Country taste, Western Highlands and G.B.K. Large volumes of milk are ferried in a raw form to processing plants outside the district particularly the Dairy Corporation which still handles more than 50% of processed milk marketed in Uganda and consumed in Kampala.

### 4.1.3 Risk exposure

There are wide weather induced fluctuations in milk prices (100 to 300/=) between wet and dry seasons. In addition actual selling of milk becomes difficult during the peak of wet season, partly because production exceeds demand but also because some farms become inaccessible due to bad roads. This situation is expected to worsen as more milk is produced closer to Kampala. Labour prices are rather low and stable. Excessive milk supply as a result of over production at farm level in Mbarara district would be unlikely because many farmers who had upgraded cattle are reverting back to crosses with a lower percentages of exotic genes. The reason for down grading appears to be because of the low milk prices in general and higher input demands of exotic cattle. The fluctuations in milk price are a result of optimum milk yields during wet seasons when feeds are abundant. When yields crash during the dry seasons due to poor feeding milk prices go up as supply no longer meets demand which remains constant.

### 4.1.4 Crop-livestock interactions and nutrient flows at farm level

In Mbarara, there are limited interactions between crop and livestock enterprises. Banana stems remaining after harvesting are used for mulching within the banana plantation. This practice is mainly done to preserve soil moisture, however it also contributes to return of nutrients to the plantation. Banana peels are not fed to cattle despite the large production and consumption of bananas in the district, although they are a common feed for goats. Banana peels may also be recycled back to banana fields as mulch. The practice of feeding standing crop residues or even chopping them for cattle is uncommon. Crop areas are separated from grazing areas by exclusion for fear of damage to crops by animals. Crop residues from such fields after harvest are left standing and ploughed into the soil during land preparation for the next crop or collected and burnt.

Cattle are often grazed in the pastures and kept in night bomas at night. Dung is therefore deposited directly on the pastures during the day. Even where night kraals are used, accumulated manure is rarely applied to the crop fields. Banana growing is not a very old

practice and its husbandry largely emphasizes pruning, desuckering, digging of bunds and mulching. Even without additional inputs, yields in form of bunch sizes are good, so farmers do not appear to consider the extra effort and money required for manure application as justified. Among external sources of nutrients are rock salt kept in wooden containers curved out of logs and fed ad lib, which is used by many farmers in the district. Nutrients from external grazing lands may also be imported into the system where animals are communally grazing on neighbouring land particularly in the dry season when farmers search for pastures out of their own grazing lands, although this is likely to be deposited in the kraal where it remains as described above. Nutrients leave the farms through bananas, which are a major commercial crop, marketed milk, animals sold or consumed and dung deposited in communal grazing areas. The practice of grazing cattle in fields external to the farm causes both loss and gain in nutrients with the direction of the net flow depending on the circumstances. Purchase of herbage feed is very rare as the cattle management systems are mainly extensive. Commercial feeds are also only purchased by a few farmers in the urban and peri urban areas with small largely improved herds or zero grazing units.

## 4.2 Masaka and Jinja Districts

### 4.2.1 Resource endowment and enterprise mix

These districts have a lot in common with respect to resource endowments and dairy management. Major differences are apparent in terms of marketing opportunities and dairy feeding regimes.

The population densities in Masaka and Jinja are higher compared to Mbarara with Jinja being smaller more urban and with a higher density compared to Masaka. Land sizes per household are hence much lower – in the region of 4 acres. Evidence of scarcity of land in Jinja was indicated by the practice of cultivation in gazetted forests. The practice is highly organized and trees are not chopped down. Farmers form groups of about 30 households and their leader allocates a piece of the forest to each household where they mainly plant maize, sweet potatoes, groundnuts and beans beneath the trees. The road networks and densities are much higher compared to Mbarara. Mixed farming is practiced with a multitude of crops including bananas, maize, sweet potatoes, beans, cassava, vegetables, fruits, sugar cane and fodder. Napier and lablab were common fodders in Jinja district. Most crops are grown as intercrops in Bananas although tomatoes and leafy vegetables occupied large acreages particularly in Budondo sub county where they are grown in pure stand for commercial purposes. Cattle, goats and chicken are the common livestock species. Cattle are most important livestock enterprise raised mainly by wealthier households. Statistics of cattle numbers obtained in 1999 showed that Jinja had 21,620 heads of cattle of which 3,840 are exotic/grade breeds and the rest indigenous (Jinja district, 1999). In 1991, there were 356 zero grazing units, 59 fenced farms and a total of 1350km square of improved pasture (Anon 1991). Masaka district in 1999 reported presence of 10,030 heads of dairy exotic cattle and 92,456 heads of beef/dual purpose cattle. In comparison, in the same year Mbarara reported 57,262 heads of exotic/grade cattle and 507,907 heads of indigenous cattle (Mbarara district, 1999).

The rainfall is higher than for Mbarara – with bimodal rainfall pattern in a tall - grass savanna vegetation zone. Pasture improvements are practiced by many dairy keepers including removal of pasture weeds and planting better species. This may be attributed to more sedentarised form of livestock management as opposed to a typical pastoral system that most of the rural farmers had been used to. Furthermore, trespassing by grazing cattle onto another persons' land is seriously discouraged and heavily punished. Farmers are therefore under pressure to have adequate feed resources on their own farms as well as responding to external influences of donor funded projects promoting fodder growing.

Dairy production is more intensive with dairy breeds commonly kept in paddock fenced farms or Zero grazing management systems. There is also communal grazing of dual purpose largely local breeds. Commonly planted fodder crops where management is more intensive are calliandra, (*Calliandra calythorthus*), lablab (*Lablab purpureus*), sesbania (*Sesbania sesban*) legumes with elephant grass (*Pennesetum purpureum*) as the main basal feed source, particularly for zero grazing systems. In Jinja feeding of agro-industrial products like brewers waste bought from Nile breweries beer factory and sugar cane tops is common. Watering points are close to homesteads and animals are often taken to watering points in the communal grazing systems. Head portage and bicycle loads are common water delivery systems in zero grazing systems. In addition roof harvested rain - water and piped water sources supplement household water needs.

### 4.2.2 Market conditions

Fresh milk is the main product supplied from these districts. The high population in Jinja and its suburbs, presence of two processing plants within Jinja, proximity to demand centers in Kampala and absence of large volumes of cheaper milk from other districts maintain a stable farm gate milk price at 400 to 500/= per liter almost throughout the year. The high urban population and presence of a number of dairy processing plants and market outlets in Kampala present effective demand for milk outside the distict. There is also less trouble to find market for fresh milk within the district. In Masaka the price range is similar but getting a steady market for milk is difficult because there are many zero-grazing units within the peri-urban areas. The actual number of zero grazing units could not be accurately estimated but privately funded individual household zero grazing units and many institutions promoting zero grazing (NGOs and CBOs such as Send – A- Cow, YMCA, Red cross, Heifer project International) have been providing zero grazing cattle for income generation and soil fertility improvement in Masaka (HASP - Masaka Technical baseline survey, December 2000). Such activities promoting zero-grazing are thought to be a factor compromising the market opportunities for Masaka. It is also argued that cheaper milk from Mbarara and Bushenyi districts competes with that produced locally within Masaka The low prices paid for milk from Mbarara which could be 200/= per litre can still be sold at 400/= with a margin that covers transportation costs, yet considering the production costs farmers in Masaka are more comfortable with a price of 500/= per litre. Some farmers complained about having steady outlets for disposing off their milk. In some cases farmers in Masaka argued that it is pointless improving dairy nutrition given the intricacies of getting extra income from increased yields due to poor markets and/or low prices offered.

### 4.2.3 Risk exposure

Due to relatively higher demand for milk the prices are higher and relatively more stable compared to Mbarara. Excessive supply could affect the prices in future because of the sustained trend in upgrading. Dairying offers more regular revenues compared to other farm crop and livestock enterprises. In addition people making new investments in the sector often prefer crosses with higher yields. Urbanisation and growth in the service and industrial sector could present alternative opportunities for farm labour hence elevating the opportunity cost of labour and as a result farm wage bills could also go up.

### 4.2.4 Crop-livestock interactions and nutrient flows at farm level

Enterprise interactions on farms in Jinja and Masaka are greater than those in Mbarara. In these sites most of the crop residues including banana peels, banana stems, banana flowers, sweet potato vines, maize stover and bean and groundnut haulms are offered to cattle as feed. Fodder plants are often planted in crop gardens for soil conservation, to stabilize bunds and fix nitrogen while they are also regularly cut and fed to cattle. Fodder species used for these purposes include *Calliandra calythorsus* (Calliandra), *Sesbania sesban* (Sesbania), *Gliricidia sepium* (Gliricidia), *Crotalaria sp*, *Lablab purpureus* (Lablab), *Setaria sphacelata* (Setaria) and *Pennisetum purpureum* (elephant grass). A few of the farmers with paddocks have planted improved pasture species particularly *Desmodium intortum* (Silver leaf desmodium) and in some instances *Macroptilum atropurpureum* (Siratro) and *Centrosema pubesecens* (Centro). These species were introduced to the farmers by government and non-government projects promoting dairy production and improved natural resource management. Farmers who may not have obtained the species directly from projects, did so through neighbours and relatives. The improved species have been in use for about 15 years.

Maize particularly in Jinja is a major subsistence and commercial crop and bran from milling of on-farm maize is also used to feed the cattle. The maize produced when milled may be sold, consumed by the household or stored for periods of food scarcity. Maize is also sometimes sold in large quantities even before milling. The maize therefore is a source of food, income and feed. In Jinja sugar cane tops and thinnings of maize are also used for feed.

Farmers in these districts were using manure in the crop and fodder fields. Some farmers were also using the manure to make compost, adding kitchen wastes, crop residues and compound wastes. Urine is also collected and applied to certain fields by farmers with well constructed zero grazing units with facilities for separate collection of urine and dung. Farmers with night kraals also collect the manure and heap it in one location and is later put in the crop fields. These farmers cannot utilize the urine due to lack of collection structures. Nutrients are also imported onto the farms through crop residues, which on some farms are obtained from off the farm on a daily basis. Banana peels for instance may be obtained from neighbours who have no cattle or goats or from nearby restaurants, either purchased or at no cost. In the dry season farmers purchase fodder to feed their cattle which is another way in which nutrients are introduced into the farm. Elephant grass is often purchased as well as sweet potato vines in a few instances . Elephant grass purchases may be in loads or planted fields. In the latter case, the farmer bargains for elephant grass from a particular field with price depending on the acreage.

Once paid for the purchaser harvests the fodder using their own labour. Such purchases may be from fields as far as a 1 km away from the farm homestead. They also purchase mineral salts on a regular basis and some purchase dairy meal and maize bran. In Jinja a number of farmers use inorganic fertilizers for production of horticultural produce for the market, particularly tomatoes. Nutrients are exported off the farms mainly through milk and crop sales. Manure is purchased by a few crop farmers, however this is very rare.

## 5 - CONCLUSIONS

The characterization survey has now been completed successfully and it is expected that data entry, cleaning and preliminary analysis should be completed by the end of the year, meaning a small delay of 3 months according to the original work-plan. Delays occurred since, although completion of the survey was according to schedule, data entry was not able to run concurrently as planned because of the time taken to source additional computers and train data entry personnel. The longitudinal survey questionnaire will be developed at the same time as data analysis is carried out and pilot testing planned for the start of 2003, so no further delays are expected.

## 6 - REFERENCES

Buresh, P.A. Sanchez and F. Calhoun) pp 151-192. Soil Science Society of America, Madison, Wisconsin, USA

Gillcr, K.E., Cadisch, G, Ehaliotis, C., Adams, E, Sakala, W.D. and Mafongoya, P.L. 1997 Building soil nitrogen capital in Africa In "Replenishing Soil FertilUy in Africa"' (Eds. R.J.

Household Agricultural Support Programme (HASP).2000. Masaka Technical Baseline Survey, December 2000

ILRI/NARO/MAAIF (International Livestock Research Institute/Ugandan National Agricultural
Research Organisation /Ministry of Agriculture, Animal Industries and Fisheries) 1996. A Rapid Appraisal of the Ugandan Dairy Sub-Sector. Collaborative Research report, ILRI, Nairobi

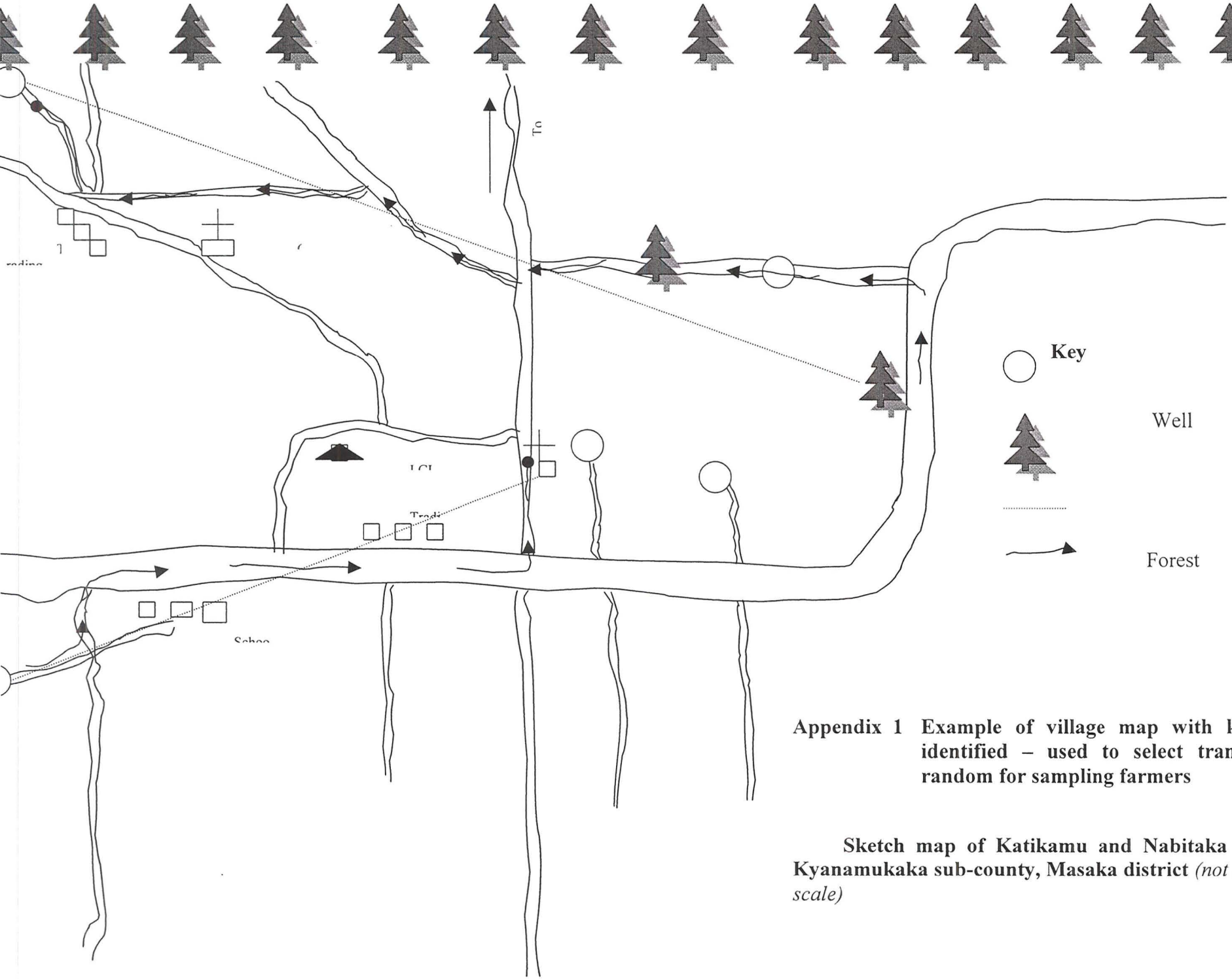
Lekasi, J.K., Tanner, J.C., Kimani, S.K. and Harris, P.J.C. 1998. Manure Management in the Kenya Highlands: Practices and potential. HDRA Publications, Emmerson Press, Kenilworth, UK

Mugisha Odrek Rwabwoogo, 1997/98. UGANDA DISTRICTS Information Handbook , Fountain Publishers

Shepherd, K.D. and Soule, M.J. 1998. Soil fertility management in west Kenya. *Agriculture, Ecosystems and Environment*. 71: 133-147
Smaling, E.M.A., 1993. Soil nutrient depletion in sub-Saharan Africa. In *"The role of plant nutrients for sustainable food crop production in SSA"* (Eds: H. Van Reuler and W. Prins), VKP, Leidschendam, The Netherlands

Staal, S. J., Chege, L., Kenyanjui, M., Kimari, A., Lukuyu, B., Njubi, D., Owango, M., Tanner, J., Thorpe, W., and Wambugu, M., 1998 "Characterisation of Dairy Systems Supplying the Nairobi Milk Market: A cross-Sectional Survey in kiambu District for the Identification of target Groups of producers" KARI/ILRI (Kenya Agricultural Research Institute/International Livestock Research Institute) Collaborative Research Report, May, 1997

Wortman, C.S. and Kaizzi, C.K. 1998: Nutrient balances and expected effects of alternative practices in farming systems of Uganda. In: *Agriculture, Ecosystems and Environment* 71: 115-129.




**Appendix 1 Example of village map with key sites identified – used to select transects at random for sampling farmers**

**Sketch map of Katikamu and Nabitaka villages, Kyanamukaka sub-county, Masaka district** *(not drawn to scale)*

## Appendix 2 Selected sites, populations used in sampling, sample sizes and enumerators and the given codes (in brackets)

| District & code | Sub-county & code | Village & code | Household Number | Human Population | Sample size | Enumerator & code |
|---|---|---|---|---|---|---|
| Masaka [2] | Kalungu [4] | Mirembe [7] | 49 | | 17 | Namanda Proscovia [11] |
| | | Byaana [8] | 73 | | 17 | Lujja Edward [10] |
| | Kisekka [5] | Kyanangaazi [10] | 130 | 650 | 17 | Sunday Ssenoga Martin [13] |
| | | Bunyere [9] | 120 | 700 | 17 | Ssetimba Edward [12] |
| | Kyanamukaka [6] | Bukunda [11] | 180 | | 17 | |
| | | Katikamu & Nabitaka [12] | 200 | | 16 | |
| Mbarara [1] | Buremba [2] | Kakoni [3] | 100 | | 17 | Kamugasha Benon [2] |
| | | Mushambya [4] | 96 | | 17 | Mugume Seragio [5] |
| | Bisheshe [1] | Kakatsi [1] | 250 | | 26 | Katungye Patience [7] |
| | | Rwebikoona [2] | 80 | | 9 | Akandwanaho Caleb [6]<br>Twinamasiko John [1]<br>Kyaterekera Umaru [8]<br>Muhanguzi John [9] |
| | Rwanyamahembe [3] | Nyakayojo A & B, Kakyerere &Rweishaka [5] | | 1288 | 17 | Babi Moses [3] |
| | | Rutooma I & V, Owengoma, Bugatsi [6] | | 1156 | 14 | Bagyenyi Grace [4] |
| Jinja [3] | Budondo [7] | Buwairama [14] | 154 | 774 | 10 | Kakaire Hassan [17] |
| | | Ibungu –West [13] | 210 | 1903 | 24 | Isiko Samuel [16] |
| | Mafubira [9] | Musima [17] | 150 | 2800 | 18 | Sunday Ssenoga Martin [13] |
| | | Kayunga [18] | 624 | 2532 | 16 | Ssetimba Edward [12] |
| | Butagaya [8] | Kiwagama North & South [15] | 177 | 1153 | 20 | Muzanyhi Billy [18] |
| | | Mpumwire Nawaguma B [16] | 91 | 859 | 14 | Musabi Nanyumba Charles [19] |
| Totals | 9 | 18 | | | 303 | 17 |

**Appendix 3 Calculations of sample size for villages** (human population and numbers of household figures were used)

**Masaka District**

Kalungu Sub-county

Figures obtained for Kalungu were unreliable and using information gathered from diverse sources in the 2 villages we concluded that population of Mirembe and Byaana were quite similar. The same sample size was therefore used for the 2 villages

Kisekka Sub-county

Kyananganzi village: 650/(650 +700) x 34 = 16.37

Bunyere village: 700/(650 + 700) x 34 = 17.62

The samples for the 2 villages were approximately the same so samples of 17 were taken from each village

Kyanamukaka Sub-county

Bukunda village: 180/(180 + 200) x 34 = 16.11

Katikamu & Nabitaka villages: 200/(180 + 200) x 34 = 17.89

The samples for the 2 villages were approximately the same so samples of 17 were taken from each village

**Mbarara District**

Buremba Sub-county

Kakoni village: 100/(100 + 96) x 34 = 17.35

Mushambya village: 96/(100 + 96) x 34 = 16.65

The samples for the 2 villages were approximately the same so samples of 17 were taken from each village

Bisheshe Sub-county

Kakatsi village: 250/(250 + 80) x 34 = 25.75 households

Rwebikoona village: 80/(250 + 80) x 34 = 8.24 households

A sample of 26 was taken for Kakatsi and 8 for Rwebikoona

Rwanyamahembe Sub-county

Nyakayojo, Kakyerere & Rweishaka (Kakyerere group):

1288/(1288 + 1156) x 34 = 17.92 households

Rutooma, Ogwengoma & Bugatsi (Rutooma group):

1156/(1288 + 1156) x 34 = 16.08 households

The samples for the 2 villages were approximately the same so samples of 17 were taken from each village

Jinja district

Budondo Sub-county

Buwairama village: 774/(774 + 1903) x 34 = 9.83 households

Ibungu west village: 1903/(774 + 1903) x 34 = 24.17 households

A sample of 10 was taken for Buwairama and 24 for Ibungu west.

Mafubira Sub-county

Musima village: 2800/(2800 + 2532) x 34 = 17.85 households

Kayunga village: 2532/(2800 + 2532) x 34 = 16.15 households

A sample of 18 was taken for Musima and 16 for Kayunga

Butagaya Sub-county

Kiwagama North & South villages: 1153/(1153 + 859) x 34 = 19.48 households

Mpumwire Nawaguma B village: 859/(1153 + 859) x 34 = 14.52 households

A sample of 20 was taken for Kiwagama and 14 for Mpumwire Nawaguma.

**Appendix 4 Programme for enumerator training for the characterisation survey in, Mbarara**

| Day | Topic |
|---|---|
| 1 | • Welcome, opening & Introduction to the training<br>• Background to the project<br>*Problem*<br>*Objectives*<br>*Brief on methodology*<br>**Expected outputs**<br>• Surveys<br>Techniques of conducting formal surveys<br>• Questionnaire<br>Session A: *Household issues*<br>Session B: *Farm activities & resources* |
| 2 | Cont. Questionnaire<br>Session C: *Inventory*<br>Session D: *Feeding*<br>Session E: *Milk production & marketing*<br>Session F: *Health*<br>Session G & H: *Income*<br>• Discussions & arrangements for the practical session for Day 3 |
| 3 | • Practical: Visit households & interview<br>• Supervisors study completed questionnaires |
| 4 | • Reconvene & share experiences & study completed questionnaires<br>• Study the village maps & using random number draw the transects<br>• Agree on coding of districts, sub-counties, Parishes, villages and enumerators |
| 5 | • Plan survey with enumerators, organise & sort out logistics |

# Nutrient balances and options for their improvement under different levels of intensification of dairy production in Uganda

**PhD Research Project Proposal**

**by**

**Sarah Lubanga Mubiru**

| | | |
|---|---|---|
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## List of Acronyms

| | |
|---|---|
| a.s.l | Above Sea Level |
| AGDP | Agricultural Gross Domestic Product |
| DENIVA | Development Network of Indigenous Voluntary Associations |
| EDF | European Development Fund |
| FAO | Food and Agricultural Organisation |
| GDP | Gross Domestic Product |
| ILRI | International Livestock Research Programme |
| INM | Integrated Nutrient Management |
| RDP | Rehabilitation and Development Plan |
| LSRP | Livestock Systems Research Programme |
| SDP | Smallholder Dairy Project |
| UN | United Nations |
| USLE | Universal Soil Loss Equation |
| ICRA | International Centre for Development Oriented Research in Agriculture |
| NARO | National Agricultural Research Institute |
| NGO | Non Governmental Organisation |
| WFP | World Food Programme |
| YWCA | Young Women's Christian Association |
| MFP & ED | Ministry of Finance, Planning and Economic Development |

## Abstract

## 1. Background

### 1.1 Agricultural production systems in Uganda

The economy of Uganda is largely dependent on Agriculture and 95% of the population is involved in agricultural activities. Agriculture contributes over 40% towards the GDP and over 90% towards the country's foreign exchange earnings. It also contributes over 60% of total government revenue and employs more than 80% of the total labour force (MFP & ED., 1996). Livestock are an integral part of most farming systems in Uganda whose structure has evolved over time to suit the agroecological zones and the socioeconomic setting. Major livestock species are cattle, goats, pigs, sheep, poultry and rabbits. Livestock production contributes about 7.5% to the total GDP and 17% to the AGDP. In most instances livestock production systems include crop production for both subsistence and commercial purposes. It is estimated that these mixed farming smallholder systems and the pastoralists own over 90% of the national cattle herd as well as all the small ruminant and non-ruminant stock. These systems also produce the bulk of the domestic milk and slaughter animals. Eighty percent of the national cattle herd is in the south and western parts of the country where average number of cattle per household is 2.11 compared to the northern part where it is 0.67 and the national average is 1.37 (FAO., 2000). Dairy production is increasingly gaining importance with current national annual milk production at 511,000 tonnes from 457,000 tonnes in 1995 (FAO., 2001).

Major dairy production systems in Uganda are zero grazing, semi-intensive, fenced dairy farms, tethering and communal, agro-pastoral and pastoral grazing. Zero grazing systems are prevalent within vicinity of urban areas where land is scarce and the milk market is good (UN/WFP.,1993). Semi-intensive systems are commonly found in peri-urban areas mainly in South Western, Central and South Eastern parts of Uganda. The fenced dairy farms are also common in the same areas, however, they are not necessarily close to urban centres. Communal and pastoral systems are found in the South West, Central, North and North Eastern parts of the country. Tethering system in not confined to any particular area but is common where crop production is a prime activity and cattle numbers are very few (FAO., 2000). There has been increasing intensification of dairy production systems in Uganda mainly resulting from increasing population pressure, growing market for milk and governments, NGOs and donor promotion. Improved cattle breeds that were primarily introduced for dairy production, are currently largely kept under intensive management systems on small and medium sized farms (FAO., 2000). The enterprise has been favoured by the ready market for milk and available crop residues and agro industrial by-products for additional feed resources.

Intensification is generally defined as "an increase in the use of one of the primary factors ie land, labour, capital with respect to others in a productive activity (Byerlee., 1990). Agricultural intensification can more specifically be defined as "an increase in the use of labour and/or capital with respect to land in an agricultural activity (*Staal., 2000). In this study intensification is discussed mainly in relation to crop-livestock enterprises and it refers to reduction of farm size, with diversification and high productivity per unit of land. As this is currently the general trend in sub-Saharan Africa. Intensification of agricultural practices

greatly contributes to increase of production, which is needful for the growing human population (Matson *et al.*, 1997). This is particularly so for developing countries where food production rarely matches the needs of the masses. Intensification, however, also has the potential to alter the biotic interactions and patterns of resource availability in ecosystems, which could cause serious environmental consequences at local, regional and global levels (Matson *et al.*, 1977). Consequences at the local level for instance on the smallholder dairy farms may include: increased erosion and lower soil fertility. However, this will depend on the management of the production unit ie where feed is largely imported into the system positive effects in the soil are likely to be realised. Intensification particularly in crop-livestock systems is highly complex and less studied than that in crop systems (Staal., 2000). It also offers more opportunities that can be enhanced towards soil conservation. Intensification on the whole, remains a target of research and development (Matson *et al.*,1997).

Integration of features of traditional agricultural knowledge and new ecological strategies within the intensification process is likely to yield ecologically sound production systems, which will meet the challenge of sustainability. Such features may include development of well integrated mixed arable-livestock systems. Efficiency of use of added nutrients is also very crucial and practices employed in the production processes need to be capable of enhancing nutrient supply to the plants in time of need and retaining excess nutrients. Such strategies require less advanced technology but are extremely sensitive (Matson *et al.*,1977; Power *et al.*, 1996; Woomer *et al.*, 1994) ie operations need to be timely, nutrients should be added in appropriate quantities, handling of some of materials such as crop residues and manure determines the quantities of nutrients that will be retained.

One of the current challenges is to understand how the ecosystems are altered by intensive agriculture and in turn develop strategies that take advantage of the ecological interactions within the production systems (Robertson., in press, as reported by Matson *et al.*, 1997). Sustainability is an issue of great concern in both developed and developing countries even if the approaches may differ in certain circumstances ie in systems that largely depend on inorganic fertilisers for production and those that do not.

Nutrient balances (nutrient budgets), which are the difference between the sums of nutrients inputs and nutrient outputs, are an effective means of assessing the vulnerability of land use systems to chemical soil degradation (Geurts *et al.*, 1999; Mohamed Saleem., 1998). Nutrient balances when integrated with analyses simulating dynamics of nitrogen, phosphorus and carbon in soils over time (Shepherd *et al.*, 1998), changes in quantities of nitrogen and phosphorus with time can also be studied. These changes have sufficient relationship to sustainability and together with the nutrient balances provide estimates that can be used to assess nutrient status of farming systems. This approach was also advocated by Watson *et al.*, (1999) when they indicated that nutrient balances alone do not show where the nutrients are stored and the time scale of their availability. Use of nutrient balances, delineates the risks a system is exposed to and provides entry points for technological interventions.

Nutrients are transported all over the world through trade in agricultural produce and fertilisers and at local level they are lost through erosion, deposition, volatilisation and leaching. Nutrient flows at farm level have over the years become unbalanced (de Jager *et al.*, 1999). On the African continent, average annual losses of nitrogen, phosphorus and potassium are estimated to be 22, 2.5 and 15kgha$^{-1}$yr$^{-1}$ of arable land respectively (Stoorvogel *et al.*, 1990). Losses for sub-Saharan Africa by the year 2000 were projected at 27, 8 and 25

$kgha^{-1}yr^{-1}$ for nitrogen, phosphorus and potassium respectively (Stoorvogel *et al.*, 1990). Crop-livestock systems, which are very common in sub-Saharan Africa have not been spared in the nutrient loss epic. These systems have over the past 10–15 years undergone various changes and with them acquiring new risks. There is a need therefore to focus on the nutrient flows within the different dimensions of these changes to identify risks and suggest methods to prevent nutrient drain.

Ruminant livestock are a major component of crop-livestock systems in the tropics where they are kept for milk and meat, providing cash income, as capital assets, manure for fertiliser and fuel and power for transport and cultivation. It has been observed in the tropics that dairy production is preferred over beef production. This is because dairy production is very efficient, converting large quantities of forage, which is easily accessible, to milk, which is the most wholesome food known to man. Also it provides a daily income for the producer (de Leeuw *et al.*, 1999). Cow milk production in sub-Saharan Africa (minus South Africa) rose from 10.454 to 11.200 million tonnes from 1995 to 2000. Seventy nine percent of this is produced in East Africa (FAO., 2001). The major dairy production systems in sub-Saharan Africa are pastoralism, agro-pastoralism and crop-livestock systems.

Diversification is considered a means towards sustainability as it allows more complete use of available resources in production systems and this is clearly presented in crop-livestock systems. However, diversification should not be seen in isolation rather it should be considered in close association with intensification among other factors (Utiger 2000). Diversification is a typical characteristic of smallholder dairy systems in sub-Saharan Africa and hence provide a conducive setting for integration of sustainability enhancing strategies. Prior to identification of these strategies it is crucial to seek means of estimating both nutrient status and sustainability of the production systems. Also a better understanding of the complex relationships between people and their management of land resources is an inevitable component of this process (Lambin *et al.*, 2000).

## 1.2 Justification for research

### 1.2.1 Problem definition

Crop-livestock systems in sub-Saharan Africa have over the past 15 years been changing from large extensive systems to smaller units on smaller pieces of land. The transition has particularly been evident in dairy production systems where situations of grazing cattle in open pastures is slowly being reduced or totally abandoned for the partially or fully stall-feeding system. In Uganda the transition has adopted various dimensions with variations arising from sources and types of feed resources, cattle breeds and actual sizes of the farms. Policy makers, extension agencies and NGOs such as "heifer project", "send a cow", "YWCA heifer project" and number of religious based organisations have been largely instrumental in promoting the transition towards intensification of dairy production. A study carried out among NGOs and CBOs in Uganda in 1995 showed that 50% of these organisations in central Uganda and 57% in western Uganda had their major activites linked with zero-grazing (DENIVA., 1995). The major aims for promotion of this production system was the anticipation that it would provide milk, a basic food, for households as well as a daily income through milk sales. It was also seen as a strategic source of resources for management

of crop fields through provision of manure and where possible a resource for biogas to be used by the households. It was therefore generally perceived as a highly integrated and sustainable system that even less resource endowed households could operate and realise benefit. The adoption of intensive and semi-intensive dairy production systems was deemed by a number of other households external to the developmental projects as beneficial and subsequently with their own resources converted to or started similar dairy units. Others adopted only certain aspects of the zero grazing management rather than the whole package ie feeding of cut and carry fodder while maintaining paddock grazing. This presented a scenario with a continuum of dairy production systems ranging from semi-nomadic pastoralism at one end to zero grazing at the other (UN/WFP., 1993).

The problems that this research seeks to address are the following:

1. *Limited information on the quality of nutrient management under each type of dairy production system.*

It is currently unclear which systems are superior in relation to nutrient management, for instance, in research carried out in 2 districts of Uganda, nutrient balances in Pallisa where livestock depend on crop residues and grazing outside the farm were found to be better than in Kabarole where cattle are fed in zero grazing units with elephant grass grown on the farms and fodder and crop residues from outside the farms. The N, P and K balances in Pallisa were 2.3, 1.5 and 15kg/ha respectively compared to -173.8, -60.8 and -41.3kg/ha for Kabarole (Walaga *et al.*, 2000). In Iganga district in eastern Uganda, animal production systems, N, P and K balances were found to be 1, 0 and 14 kg/ha with average number of cows per farm being 1.7head. The dominant cattle management system in this case was not documented (Esilaba *et al.*, 2001). It is necessary to study the various dairy production systems in relation to nutrient management, estimate their nutrient balances and identify the beneficial practices and opportunities for improvement. The information obtained will be useful in advising farmers on appropriate dairy production systems to adopt in given circumstances.

2. *Limited information on techniques for improvement of nutrient management under each type of dairy production systems.*

Techniques for improvement of nutrient management are rarely recommended for specific production systems but rather generally for agricultural production. Recommendations made such as application of compost and mulch, interplanting with legumes are beneficial however less time would be spent testing the different interventions on farms if clearer specification was made on the most appropriate circumstances for the interventions. Identification of unexploited opportunities among the various dairy systems is a more targeted approach for suggestion of recommendations for improvement of nutrient management.

Addressing those research problems will provide information that can also be incorporated in the efforts of the NGOs and CBOs for sustainable dairy production systems.

### 1.2.2 Proposed research

The problem defined above requires an understanding of the major interactions between plants, animals, soils and farmer management practices. This understanding will enable development of viable assessment of the nutrient status of the systems and socially acceptable interventions that will improve resource management (Powell *et al.*, 1996). Stangel (1995) also indicates the requirement of sufficient effort towards basic and applied research to complement nutrient recycling work done in pilot areas and similarly address nutrient cycling problems likely to occur in crop-livestock systems over the years ahead. In his account, studies on nutrient balances are mentioned as a significant area for relevant research and advocates for such studies to be carried out at numerous field locations.

Williams (2000) indicated that quantifiable estimates of current and future productivity potential of agricultural systems are essential in agriculture decision-making and planning from the field to the national levels. This is particularly so in Uganda where long term studies on status of soils, nutrient balances and crop and livestock productivity are lacking (Walaga *et al.*, 2000). A number of models have been developed over the past few years analysing ecological aspects of production systems management at farm level, however, they lacked consideration of long term effects of the management strategies on productivity and nutrient availability which would be key indicators for sustainability (Shepherd *et al.*,.1996; Young *et al.*,. 1990). Assessment of efficiency of utilisation of nutrients and sustainability, therefore, will require knowledge of nutrient status in the farm systems at the current points in time as well as the changes that could occur over time. It will also be necessary to identify potential interventions for improving nutrient management within the farming systems and here some aspects of "Integrated nutrient management" (INM) may be relevant.

Social aspects related to management of the crop-livestock systems also need to be understood before feasible interventions can be suggested towards development of sustainable systems. Farmer goals are highly diverse and include profit, quality of food or feed, accumulation of assets, reduction in nutrient losses, employment and land conservation. These social expectations should be studied and understood and given due consideration before suggesting interventions to successfully reduce nutrient losses and improve nutrient cycling. For instance, the likelihood of farmers implementing land conservation practices will largely be influenced by the extent of control they have over the land. Knowledge of these various goals, their relative importance and the ability to prioritise them at the operational level is of extreme importance for the limited resources available in the systems to be utilised effectively (Stangel 1995).

### 1.2.3 Proposed research sites

Three districts have tentatively been selected for the studies namely Mbarara, Masaka west of Kampala the capital city and Jinja east of Kampala. These sites will provide a representation of the various dairy production systems existing in Uganda.

**Mbarara district**

Cattle populations in Mbarara are estimated at 607,396 (Mugisha 1997/98).This area, has 3 dominant cattle production systems which also include the dairy production systems. The dominant system is characterised by large herds ie 80 -100 head, composed of Ankole (Sanga) breed and cross breeds between the Ankole and Friesian and large land holdings ie over 50 acres. In a study carried out in 2000 this system was found to be used by 56% of the sample (LSRP., 1999).This is followed by a system characterised by small herds ie 7-8 heads, composed mainly of cross breeds (Ankole and Friesian), small land holdings ie 2 acres, which are often fenced off. The third system is characterised by large herds composed of both Friesians and cross breeds (Ankole and Friesian), large land holdings and are fenced off (Pers. comm.).

**Masaka district**

Cattle population in Masaka has been estimated at 528,017 (Mugisha 1997/98).The dominant cattle production system here is communal grazing, which is often practised in rural areas, with low human population, low road density, less rainfall and where land holdings are large. The land is mainly utilised for food crop production rather than pasture. There are also dairy production systems with both Zebu and Friesian cross breeds and pure Friesian cattle with numbers of about 10-20 head and land holdings of 8-15acres, which are fenced off. Zero-grazing is practised within urban and peri-urban areas (Pers. Comm.). Among a sample of cattle keepers from the district, communal grazing was found to be practised by 95% of the sample, tethering by 17%, paddock fenced grazing by 12% and zero grazing by 10%. The major purpose for keeping the cattle was indicated as milk for domestic use in 86% of the cases, milk for sale in 67% of the cases and sale of whole animals in 17% of the cases (LSRP., 1999).

**Jinja district**

Cattle populations in Jinja are estimated at 14,031 (Mugisha 1997/98). Dairy production systems here include zero-grazing, semi-zero-grazing, fenced dairy farms as described for Masaka district, tethering and communal grazing (Pers. Comm.). A sample of cattle keepers from this district showed that cut and carry and paddock fenced system where the commonest. Communal grazing was practised by 9% of the sample. The major objectives for keeping cattle were reported as milk for sale by 56% of the sample, milk for home consumption by 42% and sale of whole animals by 20% (LSRP., 1999).

**Rationale for selection of sites**

Sites were selected strategically to have representation of the dairy management systems existing in Uganda as well as the circumstances within which they thrive. Some major circumstances considered are listed below:

I. Numbers of cattle kept

II. Cattle breeds

III. Sizes of land holdings

IV. Cattle management systems

V. Extent of integration between the crops and the livestock

VI. Milk marketing opportunities

VII. Annual rainfall

Detailed selection of sites for the studies will be made before on-set of the characterisation survey.

## 2. Objectives

I. To estimate nutrient balances at various levels of intensification of dairy production

II. To identify options for improving nutrient balances at various levels of intensification of dairy production

III. To develop indicators of nutrient management useful for decision making

## 3. Hypotheses

I. The intensive dairy systems have higher nutrient balances than the extensive systems

II. Improving nutrient management will raise nutrient balances in dairy production systems

III. Indicators of nutrient management are useful in decision making

## 4. Literature Review

### 4.1 Evolution of dairy production systems in Uganda

Prior to the mid 1980s commercial dairy production in Uganda was mainly on fenced farms with natural or improved pastures demarcated into paddocks. Animal breeds were exotic and cross breeds. These farms were few in number and many were government farms. Sufficient milk production was also realised from the pastoral areas where indigenous cattle breeds particularly the long horn Ankole cattle, (Sanga breed) were kept in large numbers by pastoralists and agro-pastoralists. Households with a few heads (1-5) of indigenous cattle

breeds particularly Zebu did not contribute substantially to the bulk of milk in the market as their output was low ranging from 1-3 litres of milk per day.

A shift in government in Uganda in 1986 stirred a number of new ideas and role players in the dairy sector through the National Rehabilitation and Development Plan (RDP) (UN/WFP.,1993). This included introduction of the zero-grazing systems of dairy production, which was promoted by the Ministry of Agriculture and NGOs. These NGOs operated at national and regional levels and included heifer project international, heifer project for women farmers, EDF micro-projects, send a cow and heifer projects in the catholic secretariat, YWCA and Anglican church (Fonteh ., 1998). In 1995, a study conducted by DENIVA revealed that 57% of NGOs in Western Uganda, 50% in the central region and 23% in the eastern part of the country, promoted zero grazing (DENIVA., 1995). Most of the project beneficiaries received an in-calf heifer, which they paid back by returning the first female calf to the project to be passed on to another beneficiary. Some beneficiaries ie EDF micro-project paid for the heifer in cash over a long period of time. Also some projects provided construction materials for the cattle stalls and these were part of the heifer loan and were often subsidised. All the projects required that the beneficiaries establish an acre of *Pennisetum purpureum* (elephant grass) and in some cases also a smaller field of a forage legume; *Lablab purpureus* (Lablab). The beneficiaries were given the relevant training on the management of the animals and received regular follow up by the project management.

Introduction of the zero-grazing management system was done with the aim of improving the food security and livelihood of households in the country. The cow given was expected to be the nucleus for a household herd that would provide milk for the household as well as income through sales of milk and animals when the herd became too large for the household resources or when unwanted bull calves were delivered. It was also anticipated that the households would utilise the manure in the fields to maintain soil fertility and hence sustain productivity from their crop and fodder fields. Production of biogas for cheap household energy was also seen as an opportunity, which was adopted by a number of households with zero grazing units.

Many of these ventures were successful assessing from the narration of the farmers who listed the numerous benefits they had realised from the zero-grazing cows.

As a result a number of other households with and without dairy production units decided to emulate the project beneficiaries using their own resources. Some households with local animals decided to upgrade them gradually through artificial insemination or through use of village bull schemes. Some of the farmers who shifted their dairy farming method retained part of their grazing pastures, converted some paddocks to fodder fields and constructed stalls in strategic sites on their farms allowing practice of both zero grazing and open grazing. These are normally referred to as semi-intensive management system. Some semi-intensive dairy farms retain a few paddocks and within the paddocks construct feed troughs where chopped fodder is placed for the animals.

This intensification of dairy production in Uganda exists in various dimensions and one of the current major concerns is to identify the opportunities and gaps in this and other dairy

production systems in relation to nutrient management. This information will be useful in improving the nutrient management within the dairy systems.

### 4.2 Intensification in dairy systems

Boserup (1990) as reported by Staal *et al.*, (2000) defines agricultural intensification as "productivity per unit of land" and in a model she developed intensification is perceived as a response to increasing population pressure. The decreasing ratio of land to population makes farmers realise an urgent need to produce more. In response they adopt new strategies for instance, land is cropped every season with no fallow periods. Yield per unit of land does increase, however this could be at the expense of mining the soil. This trend has been observed as true for most developing countries. Such changes in agricultural production systems may pose a threat to soil productivity particularly in terms of soil fertility with the risk only reduced where nutrients are imported into the system. However, Tiffen *et al.*, (1994), observed significant reduction in soil erosion in Machakos in Kenya with intensification of agricultural activities as a result of enhancement of soil conservation measures. According to their analysis, the increase in population created an increase in labour which provided the major resource required for construction of the terraces and other soil conservation structures. Changes in soil fertility were not equally positive.

Staal *et al.*, (2000) identifies 2 routes towards intensification in dairy systems: through increased milk production per cow or through increased number of cows per unit of land. These 2 pathways further define 4 possibilities within dairy systems with different levels of intensification:

Most intensified systems: high milk yield (milk production per cow) and high number of cow per unit of land

Intermediate level of intensification through on-farm feeding: high milk yield and low number of cows per unit of land

Intermediate level of intensification through "overgrazing": low milk yield and high number of cows per unit of land

Least intensified systems: low milk yield and low number of cows per unit of land

### 4.3 Potential for degradation of soils in Uganda

Agricultural production in Uganda is becoming increasingly market oriented and households select activities not only for subsistence but also for marketability of the products. Considering the diminishing sizes of farm land as previously discussed, this increases demand on the soil in efforts to reach the required quantity and quality targets (Ministry of Natural Resources., 1994). The most dominant soils in Uganda are ferralitic soils (FAO: ferralsols). They are very old and are in their last stages of development with low quantities

of mineral reserves left. Their productivity depends on the delicate balance of nutrient recycling within the land use systems (Ministry of Natural Resources., 1998).

The landuse pattern in an area largely determines the extent to which the productivity of the soil is preserved. Other factors of influence are the soil type, quantity of rainfall and slope. In Masaka, Mbarara and Jinja districts the areas tentatively selected for this research, soil types vary from those of very high to fair productivity. The former, which would be found in parts of Masaka district, are found in areas associated with volcanic activity, pre-Cambrian rock and recent alluvials. Their nutrient status indicates a high content of humus in the topsoil, high exchangeable bases and a pH of 6 or below. The areas are characterised by annual rainfall amounts of 1000 to 1375mm and rolling hills with summits at 1200 to 1500m a.s.l and slopes of 5 to 16%. Soils of fair productivity occupy the largest land area of Uganda (43%) and exist in all the 3 districts but mainly in Jinja and Mbarara. In Lukaya (part of Masaka district) these soils are of the yellow loam type and in Mbarara they are of the sandy loam type. The soils are of low nutrient status but with top soils being less acidic having a pH of about 6. Long fallow periods are recommended for this soil class to maintain productivity. They occur in areas where annual rainfall ranges from 1000 to 1250mm and relief is generally rolling to undulating hills with summits of 1140 to 1260m a.s.l and slopes ranging from 3 to 12% (Ministry of Natural Resources., 1998). Considering the fairly high rainfall and relief, these areas are prone to substantial quantities of soil loss through erosion. In the highlands of Uganda among those of other sub-Saharan countries soil losses have been estimated at 15-30 t/ha/year (Stangel 1995). Also the current nutrient status of the soil in most of the areas is low and requires farming practices with measures aimed at conserving or improving soil productivity.

Soils in Uganda like everywhere are at risk of degradation, Walaga *et al.*,(2000) for instance reports negative nutrient balances for nitrogen, phosphorus and potassium –173.8, -60.8 and –41.3 kg/ha respectively in Kabarole district at farm level. Losses of nutrients in this region were mainly owed to leaching, gaseous losses and erosion. Despite the high soil fertility reported for the area ie nitrogen, phosphorus and potassium stocks at 11,800, 14,400 and 12,200 kg/ha respectively the soil is slowly being degraded. Also soil analyses of 58 samples from smallholder dairy farmers in Masaka district revealed that there was inadequacy in nitrogen which averaged 0.1370ppm compared to the critical level of 0.2. The soils are also acidic with a pH of 4.9 compared to the critical value of 5.2 (LSRP-SHD., unpublished). It is crucial therefore to identify farming methods that will enable conservation and restoration of these production systems.

### 4.4 Farmers objectives and factors influencing their decisions

As discussed at the close of section 1.1, farmers' decisions and objectives are a major component of any farming systems studies. The major objectives of farmers in sub-Saharan Africa are rarely different. In Uganda farmers have indicated their objectives for farming as being a source of food for the household, earning an income from sale of excess produce, and in relation to livestock alone other objectives include prestige particularly for cattle, manure, security and resources for cultural rituals (Esilaba *et al.*, 2001; LSRP., 1999; Fonteh *et al.*, 1998).

Farmers decisions are largely influenced by their objectives as well as resources for instance in the Sahel, they were found to be influenced by, production goals, accessibility of grazing lands and watering points, quantitative and qualitative aspects of feed and water supply in different locations, security, property or user rights, herding and manuring contracts (Turner 1995). In Costa Rica, farmers' objectives and decision making were largely found to be influenced by a number of the characteristics of the farmer and the farm particularly, age, education level, distance of the farm from the population centres and the farm size.

According to Van den Bosch *et al.*, (1998), management decisions are influenced by the household objectives, available resources and socio-economic environment. Household objectives are constituted by a number of defined objectives such as food security, profit or cash maximisation, risk aversion and long term security of livelihood. Available resources include labour, cash, implements and natural resources (water availability and actual soil fertility).

Farmers objectives are rarely considered during development of decision making tools and yet in reality, the farmers together with their households are the final decision makers on management issues related to their holdings. It is necessary therefore to put them into context when developing decision making tools for use in relation to farms. Farmers' objectives in smallholder dairy systems in Uganda will therefore be given prominence in this study to enable formulation of viable nutrient management indicators and identification of feasible potential interventions for improved nutrient management.

## 5. Methodology

### 5.1 Gathering of secondary information

This will include gathering of information relevant to the fields of the proposed research. This will provide the relevant background, research carried out so far and methodologies that can be used in calculation of nutrient balances and quantification of sustainability and parameters relevant for the analyses.

### 5.2 Characterisation surveys

The proposed research is tentatively to be carried out in sites selected from Masaka, Mbarara and Jinja districts. The selection will give a caption of smallholder dairy systems at diverse levels of intensification and exposed to diverse opportunities. Structured characterisation surveys will be carried out in these areas with the aim of obtaining data that will be used to describe the dairy systems. Sub-counties will be selected randomly taking existing variation within the region into consideration. Households to be interviewed will also be selected randomly through mapping out key points in the sub-counties as well as routes, which will be followed, and selection of households for the survey will be done at regular intervals. Relevant data will be collected with participation of trained enumerators. These data will be used in conjunction with data previously collected during the Livestock Systems Research Programme (LSRP) diagnostic and baseline surveys. Households to be interviewed in each site will total 150-200.

A questionnaire to capture the relevant data for the characterisation exercise has been developed. Data will include issues related to household social structure, community, land, crop activities, livestock activities, economics, biophysical factors and off-farm activities. A sample of the questionnaire to be used for the survey is attached in Annex 3. The questionnaire is modified from that developed and used by the Smallholder Dairy Project (SDP) at the International Livestock Research Centre (ILRI) in Nairobi for similar purposes. The questionnaire will be tested before the actual implementation of the characterisation survey and will be revised for better achievement of the desired goal.

### 5.3 Longitudinal surveys

Results from the analysis of the data of the characterisation survey will be used to further select a sample of willing households to participate in the longitudinal survey. Selection of households will be based on the farm categories obtained from the data of the characterisation surveys and secondary information and may range from 20 to 40 in number. The major objectives of the research and the requirements will be discussed carefully with each of the households. Data will be collected from these households on their farming activities for a period of 14 months. Data sheets have been prepared also modified from those used by the SDP at ILRI for this purpose and a summary of these is attached in Annex 4. Records will be taken on a bi-weekly basis on each farm. Maps of the farms will be produced and soil samples will also be collected and analysed from each of the farms.

### 5.4 Data analysis

#### 5.4.1 Data from the characterisation survey

All data gathered from this survey will entered systematically and stored in access/excel programmes. Analysis will be carried out in SPSS and this will include descriptive statistics after which the data will be subjected to a cluster analysis to effect an unbiased categorisation of the farms in the data set. The categories may subsequently be revised to match the known trend from secondary data. Characterisation and clustering will give an impression of the broad groups of farms and the main features distinguishing them.

#### 5.4.2 Data from the longitudinal survey

These data will also be entered and stored as that for the characterisation survey. Flows of nitrogen, phosphorus and potassium into and out of the farm system for each farm will be estimated. This will be done using known values of the different nutrients in the various materials, results from soil and plant chemical analyses that will have been carried out in labs during the course of the surveys and calculations already established for obtaining some of the contents in the materials.

Nutrient balances will then be calculated for each whole farm and for the primary and secondary components of production for the farms. The calculation of the balances will be adopted from the NUTMON tool (Van den Bosch *et al.*,. 1998) and will be as below:

Box 1: Nutrient Balances

N balance = N OUT – N IN

P balance = P OUT – P IN

K balance = K OUT – K IN

Where N is nitrogen, P is phosphorus and K is

Movements to be measured or estimated for the farm units will be inflows and outflows. Atmospheric deposition, sedimentation, biological nitrogen fixation will be estimated and organic fertilisers, imported food, feeds (concentrates), external fodder will be measured. Outflows mainly leaching, gaseous losses, erosion will be estimated and exported farm produce, burning of crop residues and exported animal products will be measured. The N, P and K within each of these movements will be quantified and included in the calculation for the nutrient balances.

Information related to inflows of mineral fertilisers, imported food, organic fertilisers and feeds obtained from outside the farm as well as outflows of crop and animal produce, crop residues and manure will be extracted from data collected from the farm households. Amounts of N, P and K will be calculated using the nutrient contents of the various materials. Inflows of atmospheric deposition and biological N fixation and outflows of leaching and gaseous losses will be estimated using transfer functions adopted from Stoorvogel and Smaling (1990) and Smaling *et al.*, 1993. The estimates will be functions of mean annual precipitation and percentage clay content of the soil. Equations to be used are shown below:

Box 2: Equations for estimation of atmospheric deposition, biological N fixation, leaching and gaseous losses

$AD_N = 0.14p^{1/2}$

$AD_p = 0.023p^{1/2}$

$AD_N = 0.092p^{1/2}$

Where $AD_N$, $AD_p$ and $AD_k$ are the N, P and K input into the farm unit through wet and dry atmospheric deposition in $kgha^{-1}yr^{-1}$ and $p$ is the mean annual precipitation in $mmyr^{-1}$

$NS_N = 2 + (p\text{-}1350) \times 0.005$

Where $NS_N$ is non-symbiotic N fixation

$L_N = (\text{soil N} + \text{Fertiliser N}) \times (2.1 \times 10^{-2} \times p + 3.9)$ [clay < 35%]

$L_N = (\text{soil N} + \text{Fertiliser N}) \times (1.4 \times 10^{-2} \times p + 0.71)$ [35% < clay < 55%]

$L_N = (\text{soil N} + \text{Fertiliser N}) \times (7.1 \times 10^{-2} \times p + 5.4)$ [clay > 55%]

$L_k = (\text{Exch.K} + \text{Fertiliser K}) \times (2.9 \times 10^{-4} \times p + 0.41)$ [clay < 35%]

$L_k = (\text{Exch.K} + \text{Fertiliser K}) \times (2.9 \times 10^{-4} \times p + 0.26)$ [35% < clay < 55%]

$L_k = (\text{Exch.K} + \text{Fertiliser K}) \times (2.9 \times 10^{-4} \times p + 0.11)$ [clay < 55%]

Where $L_N$ and $L_k$ are amount of N and K leached in $kgha^{-1}yr^{-1}$, soil N is mineral soil N, and Exch. K is exchangeable K in $Meq100g^{-1}$

$G_N = (\text{Soil N} + \text{Fertliser N}) \times (-9.4 + 0.13 \times \text{clay} + 0.01p)$

Where $G_N$ is the quantity of N lost through gaseous losses in $kgha^{-1}yr^{-1}$ and clay the percentage of clay in the soil

Leaching of P will be assumed to be zero. Symbiotic nitrogen fixation will be estimated as a percentage of the N uptake in the legume crop fields. This will be obtained through addition of the N in the harvested crop and N in the crop residues. Losses through burning will be estimated by fractions of the residues burnt. In instances where animals are grazed off the farm holding periodically, estimation of the percentage of feed obtained from the grazing fields will be estimated depending on the quantity of feed eaten when than animals return to the farm. It will be assumed that the daily feed intake meets the daily feed requirement of the animals.

Losses through erosion will be estimated using the "universal soil loss equation" (USLE) developed by Wischmeier and Smith in 1965 as applied by Nisar *et al.*, (2000).

Box 3: Universal soil loss equation (USLE)

$$A = RKLSCP \quad (1)$$

where: A is the average soil loss per unit of area, R is rainfall and run off erosivity, K is erodibility, L is the slope length, S is the slope steepness, C represents the cover & management

Some flows may be absent in some farm units and some farm units may have some additional flows. For instance sedimentation may be absent in many farm units where deposition of soil does not occur.

Consideration is also being given to estimation of a few additional soil C, N and P dynamics which can be simulated partly using methods adopted from Shepherd and Soule (1998) which allows quantification of available N and P in the soil after the lapse of a given period of time. Assessment of these quantities is enabled through analysis of C:N ratios which influence availability of N and P and known movements of N and P in the soil with time (Shepherd and Soule 1998).

The analyses conducted will enable development of farm and farm units nutrient balances, soil nutrient balances. Knowledge of these will enable an assessment of ecological competitiveness of the farm categories.

A model similar to an analytical computer package will be developed using excel spreadsheets. It will be developed from data collected from the longitudinal survey and will include the various equations used in estimation of the various nutrient in-flows and out-flows within the systems. The model will be developed simultaneously while estimating the nutrient balances for the farms studied. Cells with the equations and entry titles will be protected and therefore will not be exposed to changes by any user of the model. The model will be compatible with the Ugandan situation ie in terms of the feed resources included, the cattle herd sizes and breeds, the land holdings and units used. It will be a useful tool in future exercises to estimate nutrient status and sustainability of farms from other locations and testing feasibility of proposed interventions with hypothesised data aimed at improving nutrient management in dairy systems.

Identification and quantification of major nutrient management indicators will be through study of the resulting nutrient balances in relation to the systems they are obtained from. Practices that create significant changes in the values of the nutrient balances within the systems will be identified and used in development of the nutrient management indicators. Use of some techniques adapted from a process known as "prototyping" as described by Vereijken (1999) in his manual is one possibility for creation of a set of nutrient management indicators ie mulching, manure application and crop rotation, taking into consideration the scientific and farmer perspectives. The process can also be used for identification of sustainability promoting farming methods directly derived from the indicators. This process is therefore being considered for use in the study.

On completion of the studies, farm households participating in the longitudinal survey will each receive copies of maps of their farms, soil analysis reports of their farms and summaries of outcome of the research relevant to them. In addition, on completion of the research a stakeholders workshop will be held with participation of farmers to share results from the research. Brochures will be produced and articles for bulletins and journals will be written in addition to the phd dissertation.

## 6 Expected outputs

I. Nutrient balances at various levels of intensification of dairy production estimated

II. Options for improvement of nutrient balances at the various levels of intensification of dairy production identified

III. A set of indicators of nutrient management developed

IV. Model useful for estimating nutrient balances in dairy farming systems developed

V. Capacity building: PhD

## REFERENCES

**Baltenweck I, 2000** Chapter 5 Intensifying the dairy activities: who and how In: Adoption of grade cattle technology by the Kenyan smallholders. PhD dissertation.Université d'Auvergne, Clermont Ferrand, France.

**Boserup E, 1990** Economic and demographic relationships in development/ Ester Boserup: Essays selected and introduced by Schultz P T, The John Hopkins University Press, Baltimore, MD

**De Jager A, Smaling E, Onduru D, Bekunda D and Rolling N, 1999,** Designing integrated nutrient management systems in sub-Saharan Africa In: Leeuwis, C (Ed.) 1999. **Integral design: an innovation in agriculture and resource management**. Mansholt studies 15, Wageningen University, Wageningen pp 173-93

**De Leeuw, Omore A, Staal S and Thorpe W, 1999** Dairy production systems in the tropics In **Smallholder dairying in the tropics** pp 19-44 Eds Falvey L and Chantalakhana C, Institute of Land and Food resources, The University of Melbourne, Thailand Research Fund, International Livestock research Institute

**De Leeuw P, Thorpe W, Staal S J and Omore A, 1999** Dairy production systems in the tropics In: L. Falvey & C. Chantalakhana (Eds.), *Smallholder Dairying in the Tropics.* pp. 19-44. Nairobi: ILRI.

**DENIVA, 1995** NGO and Agricultural Development. A study into the strengths and weaknesses of agricultural NGOs in Uganda Development Network of Indigenous Voluntary Associations (DENIVA) P.O Box 11224 Kampala Uganda Study executed by Bakema R J on behalf of DENIVA

**Esilaba A O, Byalebeka J B, Nakiganda A K, Mubiru S, Ssenyange D, Mbalule M, Bagambe F and Nalukenge G, 2001** A diagnostic survey of the farming systems in Imanyiro, Iganga district, Eastern Uganda (Draft) NARO-CIAT-BMZ project in improving integrated nutrient management on small-scale farms in Africa

**Esilaba A O, Byalebeka J B, Nakiganda A, Mubiru S, Delve R J, Ssali H and Mbalule M, 2001** Integrated nutrient management strategies in eastern Uganda

**Geurts P M H, Fleskens L , Loewer J, & Folmer E C R, 1999** Nutrient Balances at Field level of mixed cropping systems in various zones in Mozambique. In E.M.A. Smaling, O. Oenema, & L.O. Fresco (Eds.), *Nutrient Disequilibria in Agroecosystems Concepts and Case Studies.* (pp. 191-210). Cambridge: CABI.

**Lambin E F, Rounsevell M D A and Geist H J, 2000** Are agricultural land use models able to predict changes in land use intensity In *Agricultural ecosystems and Environment 82* pp 321-31

**LSRP, 1999** District diagnostic survey reports: Masaka, Mbarara and Jinja Draft Reports

**LSRP-SHD, unpublished**, Strategic utilisation of feed resources on smallholder dairy farms in Masaka district

**Matson P A, Parton W J, Power A G and Swift M J, 1997** Agricultural Intensification and Ecosystem Properties In: *Science* 25;277:504-9

**Methu J N and Romney D L, 2001** Use of low quality forages for ruminant animals in sub-Saharan Africa A paper presented at the *19th biennial meeting of the Royal Agricultural Society of the Commonwealth* in Durban, SA 6-8 May 2001

**Ministry of Natural Resources (National Environment Information Centre), 1994** State of the environment report for Uganda

**Ministry of Natural Resources, 1998** State of Environment Reporting in Uganda, Government of Uganda

**Mohamed Saleem M A, 1998** Nutrient balance patterns in African livestock systems. *Agriculture, Ecosystems and Environment, 71:* (1-3). 243-256.

**Mugisha O R, 1997/98** UGANDA DISTRICTS Information Handbook, Fountain Publishers

**FAO, 2000** Grassland and pasture crops, Country pasture/forage resource profiles, Uganda FAO by Mwebaze M N S

**FAO, 2001** FAOSTAT Agricultural DATA

**Fonteh F, Lammers W, Mmbaga A, Mubiru S and Tibayungwa F, 1998** Farm typology: Targeting development and research for smallholder dairy systems of the lake crescent region of Uganda, ICRA/NARO, Working document series 71

**Ministry of Finance Planning and Economic Development, 1996** Statistical Abstracts

**Nandwa S M and Bekunda M A, 1998** Research on nutrient flows and balances in East and Southern Africa: state of the art In *Agriculture. Ecosystems and Environment 71 (1998)* pp 5-18

**Nisar Ahmed T R, Gopal Rao K and Murthy J S R, 2000** Fuzzy class membership appraoch to soil erosion modelling In: *Agricultural Systems 63:*2 pp 97-110

**Powell J M, Fernendez-Rivera S, Hiernaux P and Turner M D, 1996** Nutrients Cycling in Integrated rangeland/Cropland System of the Sahel In: *Agriculture Ecosystems and Environment*, 52 pp 143-170

**Powell, J M and Williams T O, 1993** Livestock, nutrient cycling and sustainable agriculture in the West African Sahel. Gatekeeper Series No. SA 37, International Institute for Envirnment and development (IIED), London, U.K 12 pp.

**Power A G and Flecker A S, 1996** In: Biodiversity and Ecosystem Processes in Tropical Forests, Orians G H, Dirzo R, Cushman J H (Eds.) (Springer-Verlag, New York) pp173-94

**Robertson G P, 1998** in Agricultural Ecology Jackson L (Ed.) (Academic Press, New York, in press)

**Scoones I and Toulmin C, 1995** Socio-economic dimensions of nutrient cycling in agro pastoral systems in dryland Africa In: Powell J M, Fernandez-Rivera S, Williams T O and Renard C (Eds.) *Livestock and sustainable nutrient recycling in mixed farming systems of sub-saharan Africa*, Proceedings of an International Conference, ILCA, Addis Ababa, Ethiopia Nov. 22-26, 1993Vol II pp 353-69

**Shepherd K D and Soule M J, 1996** Systems Analysis: Agroforestry Applications In Mugah J O (Ed.) *Proceedings Of The First National Agroforestry Conference On People And Institutional Participation In Agroforestry For Sustainable Development* Kenya Forestry Research Institute, Muguga, Nairobi, Kenya pp 549-572

**Shepherd K D and Soule M J, 1998** Soil fertility management in west Kenya: dynamic simulation of productivity, profitability and sustainability at different resource endowment levels. *Agriculture, Ecosystems and Environment, 71:* (1 - 3). 131-145.

**Solano C, Leon H, Perez E and Herrero M, 2001a** Characterising objective profiles of Costa Rican dairy farmers In: *Agricultural Systems 67*: pp153-79

**Solano C, Leon H, Perez E and Herrero M, 2001b** Who makes farming decisions? A study of Costa Rican dairy farmers In: *Agricultural Systems 67*: pp181-99

**Staal S, 2000** Conceptual framework for studying patterns of intensification of smallholder crop-livestock systems: locally, regionally and trans-regionally Background paper for discussion

**Staal S, Delgado C and Nicholson C, 1997** Smallholder dairying under transaction costs in East Africa In: *World Development 25*: 779-94

**Stngel PJ, 1995**). Nutrient cycling and its importance n sustaining crop-livestock systems in SSA: an overview. In J.M. Powell, S. Fernandez-Riviera, T.O. Williams, & C. Renard (Eds.), *Livestock and Sustainable Nutrient Cycling in Mixed Farming Systems of sub-Saharan Africa.* (pp. 37-59). Addis Ababa, Ethiopia: ILCA.

**Stoorvogel J J and Smaling E M A, 1990** Assessment of soil nutrient depletion in Sub-Saharan Africa 1983-2000 Report 28, The Winand Staring Centre for Integrated Land, Soil and Water Research (SC-DLO), Wageningen

**Turner M D, 1995** The sustainability of rangeland to cropland nutrient transfer in semi-arid West Africa: ecological and social dimensions neglected in the debate In: Powell J M, Fernandez-Rivera S, Williams T O and Renard C (Eds.) *Livestock and sustainable nutrient recycling in mixed farming systems of sub-saharan Africa*, Proceedings of an International Conference, ILCA, Addis Ababa, Ethiopia Nov. 22-26, 1993Vol II pp 435-452

**UN/World Food Programme, 1993** A review of WFP-assisted project UGA 3325 and proposals for future WFP assistance to the dairy sector in Uganda UN/WFP, P.O Box 7184, Kampala

**Utiger C, ICRAF, 2000** The roles of Diversification, Intensification and Extensification in Agriculture and Agroforestry. A seminar presented at ICRAF on 18:02:2000

**Van den Bosch H, De Jager A and Vlaming J, 1998** Monitoring nutrient flows and economic performance in African farming systems (NUTMON) II. Tool development. *Agriculture, Ecosystems and Environment, 71:* (1-3). 49-62.

**Verejken P, 1999** Manual for prototyping integrated and ecological arable farming systems (I/EAFS) in interaction with pilot farms Wageningen, The Netherlnads

**Walaga C, Egulu B, Bekunda M and Ebanyat P, 2000** Impact of policy change on soil fertilty management in Uganda In **Nutrients on the move, Soil fertility dynamics in African farming systems** pp 29-44, Eds Hilhorst T and Muchena F

**Williams, J.R. (2000).** The physical components of the EPIC model. In S.A. El-Swaify, W.C. Moldenhauer, & A. Lo (Eds.), *Soil Erosion and Conservation.* (pp. 272-284).

**Woomer P L and Swift M J Eds., 1994** The Biological Management of Tropical Soil Fertility (Wiley, Chichester, UK)

**Watson C A and Atkinson D, 1999** Using nitrogen budgets to indicate nitrogen use efficiency and losses from whole farm systems: a comparison of 3 methodological approaches In: *Nutrient Cycling in Agroecosystems 53* pp 259-67

**Wortmann C S and Kaizzi C K, 1998** Nutrient balances and ecpected effects of alternative practices in farming systems of Uganda In: *Agricultural Systems and Environment 71* pp115-29

**Young A and Muraya P, 1990**, Soil changes under Agroforestry: A predictive model. Computer program with user's handbook, Version 2. International Centre for Research in Agroforestry. Nairobi Kenya 124pp

**Tiffen M, Mortimore M and Gichuki F, 1994** More People, Less Erosion Environmental Recovery in Kenya African Centre for Technology Studies (ACTS, Nairobi, Kenya) Press in association with the Overseas Development Institute (ODI), London

# INCENTIVES TO INTENSIFICATION OF DAIRY PRODUCTION IN UGANDA

**A PhD RESEARCH PROPOSAL**

**SUBMITTED TO THE**

*Research Advisory Committee - LSRP*

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## 1 - Background and Justification

### 1.1 Livestock and the Ugandan Economy

Uganda's total population is about 18 million with annual population growth rate of about 2.5 per cent. The GDP growth rate ranged between 3 per cent and 7 per cent between 1987 and 1992 and was projected to stay at 5 per cent (Uganda Investment Authority 1994). In Uganda, livestock production accounts for about 16 percent of the GDP and about 30 percent of the agricultural GDP (ILRI, 1996). The total cattle population is estimated at about 5.1 million (Mbuza *et al.*, 1996). In many parts of the north, east and southwest livestock production is a major occupation and source of livelihood for the population. This notwithstanding, the ratio of cattle per capita has dropped from 0.6 in 1931 to 0.25 in 1990 (Nsubuga 1990).

The traditional extensive nomadic pastoral management system where indigenous animals are constantly moved in search of grass and water has phased out in Uganda (Bank of Uganda 1984 and World Bank 1993). The pastoral and agro-pastoral (PAP) areas of Soroti, Mbarara, Sembabule and part of Masaka are currently largely characterised by agro-pastoralists, and to some extent transhumants and Semi-transhumants keeping mainly Ankole (sanga), Nkedi, Nganda and Karamojong and their intermediates. In the smallholder dairy (SHD) production areas of Jinja and Masaka semi-intensive and intensive systems with mainly purebred exotic, grade and crossbreds exhibit varying levels of intensification and integration of dairy enterprises with fodder, subsistence and commercial crops. The common breeds kept in SHD systems are Friesians, Jerseys, Guernseys, Aryshire, and Brown Swiss

Uganda's aggregate milk production (that is milk sales plus domestic consumption but excluding suckled calf consumption) is estimated to be 420 million litres. About 12.4 per cent of this is obtained from improved breeds which represent about 4 per cent of the national herd (MAAIF, 1992; World Bank, 1993). Average annual per capita consumption of whole fresh milk for Uganda was about 40 litres in 1970. The national average is currently about 22 litres except for Kampala and Entebbe with 39 litres (ILRI 1996 and Mbuza *et al. 1996*). This level of consumption is far below that of Kenya with 125 litres and the UK of 175 litres, (Uganda Investment Authority 1994). It is also lower than the FAO recommendation for milk consumption per capita of at least 400 litres and that of its subsidiary UNDP of a minimum of 200 litres per capita annually (MAAIF 1995 and African Farming 1998). Nevertheless, according to MAAIF (1989) and Uganda Investment Authority (1994) in Uganda milk constitutes the most important source of animal protein (37 percent) followed by beef (24 percent), pork/goat/mutton (11 percent), fish (21 per cent) and poultry/eggs (7 per cent).

### 1.2 Uganda's Dairy industry

Average daily milk yields (excluding calf consumption) are 10 to 15 litres for Friesian purebred; 5 to 9 litres for Friesian grade and crossbred and 1 to 4 litres for the indigenous (MAAIF 1992 and Atokple *et al.* 1995).

Dairy processing is a liberalised business with five plants namely Ra milk (Mbarara), G.B.K (Mbarara), Western Highlands (Mbarara), Country Taste (Mbarara) and Jesa Farm (Mpigi) (ILRI, 1996). Dairy Corporation (with plants at Kampala, Entebbe and Mbale) had dairy processing monopoly. They still handle the bulk of the milk marketed and supply a wide variety of dairy products. Dairy plants produce a range of dairy products including pasteurised milk, UHT milk, ice cream, butter and yorghut (ILRI, 1996). On individual farms, milk is extracted for domestic consumption and sale as fresh milk. Surplus milk is

commonly processed into ghee on the farm. This is normally women's activity from which they retain the proceeds for their cash needs especially in Mbarara dairy shed.

### 1.3 Justification of the Study

. Uganda's rapidly growing human population has put pressure on land to provide more food, incomes and to meet higher demand for agricultural products from the idustrial sector. Traditional sole cropping and extensive livestock production systems are being replaced by intensive crop-livestock integrated systems. Intensification leads to increase in yields per unit of land and causes higher uses of labour per unit of land and output. It is also often associated with more crop-livestock synergism.

In Uganda, there are two major dairy sheds Mbarara and Kampala-Jinja. Each of them contributes about 35 per cent of the national aggregate milk supply. The two areas are, however, faced with different land, labour, feed resource endowments and farm labour and milk prices. The Kampala-Jinja milk shed located in the more densely populated area closer to the main urban and peri-urban consumption centres of Kampala, Jinja and Entebbe, receives higher milk market prices. Labour costs are also higher and smallholder semi-intensive and intensive dairy management systems are dominant. Mbarara milk shed situated in a less densely populated region away from the major demand centres has relatively lower milk market prices and farm labour costs. Pastoral and agro-pastoral perimeter fenced and open grazing extensive dairy management systems are predominant.

Economic growth is often associated with increase in the opportunity cost of labour. This automatically increases farm labour costs. At the demand side, per capita income growth could be offset by a population growth rate if the latter is higher than that of GDP. With regard to market farm supply and price relationship liberalising marketing and processing of dairy products has yielded price incentives to the dairy industry. This has encouraged increased milk production through upgrading of dairy cattle, new entrants especially through increasing women's ownership, management and control of dairy business especially zero grazing in peri-urban areas. This combined with diminishing effective demand could cause lower farm gate milk prices.

Seasonally fluctuating labour costs, milk market prices and yields have a strong bearing on milk unit costs of production and short-term farm profitability. Long-term viability of intensification is based on the systems competitveness under adverse milk price, land and labour opportunity costs. Such factors hence characterise economic incentives or justification for intensification.

### 1.4 Objectives of the Study

The major objective of the study is to examine the short–term and long term economic viability, crop-livestock synergism and gender derived benefits in dairy based farming systems in Mbarara and Kampala-Jinja dairy sheds.

**Specific Objectives**

(i) To examine the economic incentives for intensification or extensification of dairy production,

(iv) To assess crop-livestock synergistic interactions and their role on reducing milk and crop yield losses in the zero-grazed, perimeter and paddock fenced grazing systems,

**(v)** To determine the appropriate level of intensification, farm enterprise sizes and combinations for each of the two major dairy sheds

### 1.5 Hypotheses of the study

The process of investigation and interpretation of findings of the study will be based on the following hypotheses:

1. Crop-livestock synergism increases with intensification of dairy production. Farmers using fodder and crop residues as dry season feed reserves experience lower negative deviations in milk yields compared to farms with no dry season feed buffers. Likewise, mean crop yields are higher for farms where cattle manure is used for soil fertility amendments.

2. Current levels of intensification of dairy production are justified by farmers' milk unit cost of production and market prices economic ratinale.

3. Changes in labour costs, milk market prices, land and feed resources costs influence the long-term competitiveness of a dairy – based production system.

## 2 - Literature review

### 2.1 The Production Function and Resource allocation

Production functions (Derbetin, 1986) describe technical relationships that transform resources (inputs) into outputs (commodities). Use of production functions serves two main purposes; computing input - output ratios for guiding the analysis of farm practices and as benchmarks of how efficiently resources are being used (Heady *et al.*, 1956). The production function underlying an activity in a linear programming model is a fixed proportion production function. It differs from a linear production function in that in the former one input does not substitute for another, but rather inputs must be in fixed proportions with each other (Derbetin 1986 and Simpson 1988).

### 2.2 Farm Enterprise Budgets and Marginal analysis

The use of budgeting techniques to help a manager to select the best crop, forage and livestock enterprise combinations has been discussed by Castle *et al.* (1972), Lipton (1987), Simpson (1988) and Nsubuga (1990). Budget analysis is, however, static and does not account for fluctuations in prices, yields and costs.

Van der Valk (1985) using a cash flow budget calculated labour income per man-day/man-year as being the difference from total revenues and total costs excluding labour costs. In addition, cash-flow surplus per cow per annum was obtained from total cash receipts per cow (value of annual milk sales and changes in herd value) minus expenditures per cow on feeds, supplements, treatments, fodder and other fixed costs.

Hanjra *et al.* (1987) calculated cost of production per litre of cattle and buffalo milk by small farms in Pakistan. They included family labour cost in the total costs of milk and concluded that cattle keepers were making a net loss per litre of PRs 0.29 whereas there was a net profit of 0.26 PRs per litre of Buffalo milk.

Widodo *et al.* (1994a) used annual income (gross margin) to estimate the proportions of crop (29 %), off-farm (29%) and dairy incomes (42 %) to total household incomes; and establish prospects for dairy production by mainly zero grazing dairy farmers in East Java using year round longitudinal data. Average returns to dairy labour of about 1 US $ per were equal to those of unskilled labour and hence dairy returns were low given that it is a complicated and risky enterprise (Widodo *et al.* (1994b).

Rijk de Jong (1996) stated that milk production depends on the breed or type, age, lactation number and stage, lactation yield and length, and environmental factors like nutrition, housing and health care. He discussed technical and economic productivity of dairy and linked the technical productivity to milk production per cow, per hectare and per man - day and economic productivity by assessing gross and net margins and comparing milk costs and actual producer prices, and returns to labour.

In Uganda, Muwanga (1994) and Kabugo (1997) obtained dairy physical and financial output and input, farmer, household and herd characteristics data from farmers by recall methods using single visit formal survey by direct interviews. Estimates of calving intervals, lactation periods, production levels, revenues from milk and expenditures were used to calculated gross margins and established profitability of dairy production for both stall fed and paddock fenced dairy farms, respectively. Using the Cobb-Douglas production function they regressed milk production on costs, management, herd and farmer characteristics.

There are contradictory findings from studies conducted on unit costs of production and profitability of dairy enterprises. MAAIF (1992) indicated that the high intensity system is associated with the lowest unit costs of production and highest profits whereas the low intensity system has the highest unit costs of production and lowest returns. Conversely, (ILRI 1996)) reported the very opposite. On the other hand results from Mbuza *et al.* (1997) indicate that the fenced semi-intensive system is the most efficient and profitable.

### 2.3 Intensification and Crop-Livestock Interactions

The interrelationships between and areas of complementarity in mixed crop-livestock production for efficient and sustainable food and income generation are exploited in situations of high human population densities, emerging markets and developed infrastructure and increasing use of improved technology and inputs. Consequently, this leads to increase in land use intensity (Boserup, 1965, Shapiro (1991); Winrock, 1992; Bezibih and Storck, 1992; Griffith and Zepeda, 1993; Okoruwa *et al.,* 1996; Atokple *et al.* 1995; and Smith *et al.* 1997. Boserup (1965) quoted by Pingali and Binswanger (1987) argued that population pressure in the main determinant of agricultural intensification. According to Odhiambo (1998) intensification involves increasing the intensity with which a piece of land is used over time and/or increasing in the amount of inputs applied to the same piece of land. He also argues that intensification can be demand–driven and market-oriented. Population growth and increased urban (or export) demand provides incentives for farmers to intensify food production systems (Pingali 1995). Increase in population raises the demand for land and stimulates input use per unit of land. Also, higher farm gate revenues provide farmers with incentives to increase their productivity through intensification. Intensification involves more labour (increase in agricultural employment), improved genetic stock and traction and fertiliser use to gain more output per unit of land (Winrock, 1992). Fitzhugh and de Boer (1981) in Gass and Sumberg (1993) stated that in ideal intensive systems resources are concentrated to expand productivity of the producing unit. Intensive livestock systems provide high output of animal product per unit hectare, capital and time. As fallow and

pasture contract farmers adjust to maintain soil fertility by applying manure and feed more crop residues to livestock. Manure application and soil and water management practices together with cutting, feeding and exclusion of outsiders from access to crop residues raise labour use per unit of land and per unit of output (Pingali and Binswanger, 1987 and Shapiro, 1991). Pingali (1995) argues that as economic development takes place, there is general withdrawal of labour from the agricultural sector to the industrial and urban sectors. The result of this is that the opportunity cost of labour increases.

### 2.4 Whole-Farm Analysis, Goal and Linear Programming Approaches

The approach of whole farm modeling takes into consideration direct, indirect and interactive effects of all elements of the farm. The approach embodies farmers' resources, constraints, attributes, objectives and goals.

The strength of linear programming (LP) in the analysis of constrained optimisation of agricultural farm problems to achieve the desired objective function is discussed by Heady and Candler (1966); Shweigman (1979); Witkowski and Wells (1979); Hazell and Norton (1986); Upton (1987); Jefferson and Boisvert (1989); Anderson *et al.* (1994). LP can ably handle a large number of interrelated variables and cope with peasant farming systems which exhibit close interdependence between production, consumption, investment, resource availability, social and cultural constraints. Linear programming involves maximisation or minimisation of an appropriate linear function subject to linear constraints. LP models require the following specifications Hazell and Norton (1986) and Castle *et al.* (1987). (I) The alternative farm activities, their units of measurement, (ii) resource requirements (demands of each activity on each constraint)/ input-output technical coefficients, and any specific constraints to their production (iii) fixed resource (total capacity) constraints of the farm (iv) Expected activity returns net of variable costs in case of gross margin. Bagamba (1994) used LP to establish optimum farm plans in Banana-based farming systems in two regions in Uganda using data from 14 sites collected for 12 months. The LP Profit maximising model based on annual gross margins was used to generate optimum crop combinations and resource allocation efficiency in a crop-livestock mixed farming setting.

Use of LP in crop-livestock integrated production and livestock rearing systems has been done by Griffth and Zeppeda (1993); Okoruwa *et al.* (1996); Mengistu (1997); Ika (1997); and Omore *et al.* (1997).

Griffth and Zeppeda (1993) used primary data collected over a 12-month period supplemented by secondary sources to obtain technical coefficients to develop a cost minimising mixed integer linear programming with extension of sensitivity analysis. Mengistu (1997) assessed the effect of using crossbred cows for milk and traction on farm productivity in the highlands of Ethiopia. The constraining access to land and food grain feed resources due to increase in human population would favour use of fewer breeds but capable of meeting both milk and draft requirements. Farm-level daily data was collected from a total of 14 farmers for 2 years to develop a mixed integer LP that was used to determine gross margin maximising combinations of both crop and livestock enterprises. Comparisons were made for livestock use under traditional, dairy only and dairy-draft arrangements.

Okoruwa *et al.* (1996) used the constraint technique of Multiple Objective Planning (MOP) together with a mixed integer LP model to assess the pace of evolution of agropastoralism into mixed farms as a result of diminishing land access due to high population in West Africa.

Ika (1997) evaluated the viability and profitability of feeding choices in Ethiopia maximising cash flows obtained from cattle from different feed sources and technologies using on farm trial data collected in a one- year period. Labour and feed resource availability and milk production were subdivided into four periods to cater for seasonal resource availability.

Omore *et al.* (1997) compared optimum combinations of dairy and major crop enterprises in smallholder crop-dairy farms in Central Kenya. Crop-livestock interactions were incorporated by estimating that crop residues provide 3000 kg per acre per year of land-under-forage equivalent and an increase in crop production of 10 per cent as a result of using manure

### 2.5 Risk Programming Models in Agriculture

In the course of their operations, farmers face a variety of price, yield and resource risks that are connected with:

(a) Changes in demand and government policies; (b) variable weather and environmental conditions; (c) animal diseases; (d) feed and water shortages; and (e) uncertain procurement of variable inputs (Hazell and Norton 1986, Boisvert and McCarl 1990 and Bezabih and Storck 1992). Boisvert and McCarl (1990) discussed right hand side and technical coefficient uncertainties as well as objective function (price and yield) risks.

Mathematical programming models have been advocated for land use decisions that involve allocation of resources under risk. Quadratic risk programming (QRP) models would be the most suitable in solving farm problems involving maximisation of expected revenue from competing land uses subject to resource (land, labour and capital) limitations, and cost of risk taking. In these non – linear programmimg models (NLP) the ranking of income variability, or spread of income distribution is used as a measure of risk, with the assumption that farmers preferences are based on expected income, E (Y) and the associated income variance V (Y) (Hazell and Norton 1986). A farmer rationally chooses a farm plan for which associated income variances are at a minimum for the given expected income levels. Overhead costs are assumed to be constant in short-run planning models thus income distribution under quadratic programming is specified by gross margin distribution (Hazell, 1971). From the discussion on expected utility theory Boisvert and McCarl 1989 stated that farmers prefer more wealth to less wealth, and that based on the E – V criterion given distributions of equal means a farmer who is risk averse will prefer a distribution with the smallest variance. The quadratic programming approach generates a set of efficient E -V farm plans which minimises the variance (V) for each possible level of expected income (E). Hardaker *et al.* 2001 noted that one drawback of QRP models is that the quadratic utility convex function implies rising marginal utility of wealth of risk aversion (that farmers become less risk averse as incomes increases) in the utility – income relationship - which is not the case in reality. Rabin, 1999 also observed that risk aversion is traditionally modeled from the expected – utility theory with a concave utility – wealth function with the diminishing marginal utility of wealth of risk aversion is considered to psychologically intuitive. Vast uncertainty is disliked – a dollar that helps us avoid is more valuable than a dollar that helps us become very rich.

Computational difficulties and lack of suitable algorithms then led to transformation of the quadratic risk programming (QRP) variance-covariance matrix into mean absolute deviations that can be solved by LP algorithms – the most successful being the Linear MOTAD objective function risk models. These models -discussed by (Hazell 1971, Tauer,

1983; Hazell and Norton, 1986; Jeffereson and Boisvert, 198; Boisvert and McCarl (1990) and Hardaker *et al.* 1991) – incorporate both the stochastic nature of farm revenues and farmer's risk aversion. There are two linear MOTAD models namely Minimisation of Total Absolute Deviations (MOTAD) and Target MOTAD models. MOTAD models are based on the notion of expected income and negative deviations from expected income. Risk is measured as a product of standard deviations of expected income and risk aversion factors. Target MOTAD models take into account expected income and a pre-specified level of target income. A maximum acceptable shortfall in target income given by summing negative deviations in expected income per period and the probability for that deviation occuring, and target level of income are the two attributes of risk. Tauer (1983) proved that whereas Target MOTAD solutions are risk efficient based on second degree stochastic dominance tests (SSD) linear MOTAD solutions may not necessarily be SSD efficient. Myles *et al.* 1984 observed that minimising negative deviations from a target is congruent with actual behaviour of decision -makers. Risk adjusted income maximisation of a 400 acre mix of irrigated fodder and cash crops constrained by land and field labour time by season were used to compare MOTAD and Target MOTAD models. Target MOTAD solutions were superior indicating that risk models that consider negative (compared to both negative and positive) deviations from a fixed (rather than a moving) risk reference point are better – higher dis-utility is attached to low income years rather than high-income years.

Abenet *et al. 1992* used a MOTAD risk programming model to assess the importance of risk and other inhibiting constraints like credit to adoption of chemical fertilisers to farm outputs and incomes of small scale farmers in Ethiopian highlands.

Maleka (1993) used a target MOTAD model to identify optimal cropping patterns in the drought prone Gwembe valley region of Zambia.

McCamley and Kliebenstein (1987) noted that the Target MOTAD model has been proposed by several authors for computing stochastically efficient mixtures of risky alternatives.

## 3 - Methodology

### 3.1 Conceptual Framework

Dairy producers in Uganda are exposed to income instability due to seasonal weather and milk price changes. Farm milk yields and prices fall to as low as 45 and 30 per cent of their corresponding figures during dry and wet seasons, respectively. Ugandan farmers are also constrained by land, labour, and feed resources yet farm production services subsistence, social and income obligations and requirements. This state of affairs can be structured in a gross income maximisation linear programming model constrained with farmer's subsistence and social needs.

The general form for a linear programming maximization problem is:

Maximiz $Z = \sum c_j X_j$

Subject to: $\sum a_{ij} X_j \leq b_i$; $\quad i = 1$ to m

$X_j \geq 0$; $\quad j = 1$ to n

**Where: Z = the total gross margin of a production system**

$c_j$ = the gross margin per unit of the $_j$th activity

$X_j$ = level of activity j,

$a_{ij}$ = the quantity of ith resource requirement to produce a unit of $_j$ th activity

$b_{i,}$ = the fixed endowment of the ith resource

### 3.2 Empirical Model Development

Apart from resource constraints, production objectives and income instability risks play a major role in determining the scale and form of management as well as farm enterprise combinations. Optimality under risky environments in farm production can be determined by a risk-adjusted whole farm programming model that accounts for farm resources, activities economic and social constraints.

In this study emphasis is placed on objective function risks because:

They are the main causes of farmers' risks; the risk-Target income solutions generated conform to expected utility decision criteria; and solutions generated can be used to adjust farm plans and to deal with long-term strategic policy issues concerning variations in market and resource conditions. The target MOTAD risk modeling approach will be used in this study because:

It conforms to the expected utility theory and efficiently ranks decision - making alternatives under risk, and generates solutions meeting the Second Degree Stochastic Dominance (SSD) tests. Secondly, unlike the linear MOTAD models, its notion of risk in terms of target income and negative deviations on expected income and restrictions on target income is appropriate for modelling dairy farmers' behavior in Uganda. In Uganda dairy farmers are not fully commercialised. Being quasi- subsistence they are therefore expected to consider household subsistence requirements prior to selling milk, other livestock products and crop products. Nevertheless, dairy farmers use purchased inputs during production. They are concerned about selling farm produce at prices below the cost of production. This is consistent with having target incomes.

### 3.3 The Target MOTAD Risk-adjusted LP Model will be specified as:

**Maximise E (Z) = $\sum c_j x_j + \sum c_k x_k$**

**Subject to:**

- Land constraint on Cropland: $\sum a_j \leq A$
- Land constraint on own Pastureland: $\sum p_k \leq P$
- Consumption constraint: $x_j + x_k \geq h_j + h_k$
- Labour Constraint: $\sum l_{ij} x_j + \sum l_{ik} x_k \leq L_i + H_i$,

**Risk constraints:**

Negative deviation from target income per period:

$\sum c_{rj} x_j + y_{rj} + \sum c_{rk} x_k + y_{rk} \geq T; r = 1,\ldots, s$

Maximum income shortfall acceptable in a planning period:

$\sum p_r y_{rj} + \sum p_r y_{rk} = \lambda$ and $\lambda \rightarrow 0$

Where:

E (Z) = expected gross returns of crop and livestock activities

$c_j$ = expected gross returns per unit the $j^{th}$ crop activity;

$c_k$ = expected gross returns per unit the $k^{th}$ livestock activity,

$x_j$ = quantity of marketable crop output of $j^{th}$ crop activity.

$x_k$ = quantity of marketable output of the $k^{th}$ livestock activity

A = total cropland available

$a_j$ = the amount of crop land used for the jth crop activity

P = the total individual pastureland available to the farmer

$p_k$ = the amount of pastureland used for livestock grazing activity k

$h_{j/k}$ = the minimum output quantities of crops j and milk from livestock activity k for subsistence

$L_i/H_i$ = total family/hired labour per $i^{th}$ season;

$l_{ij}/_k x_j/x_k$ = labour required per jth/Kth crop/livestock activity

$c_{rj}$, $c_{rk}$ = return of crop j/livestock activity k for state of nature or observation r.

$y_{rj}$, $y_{rk}$ = negative deviation of crop j and livestock k incomes under state of nature/observation r

T = target level of farm income per annum

$p_r$ =probability that the state of nature or observation will occur

$\lambda$ = the maximum amount of income shortfall from T acceptable by the farmer

$x_j$ , $y_{rj}$, $y_{rk} \geq 0$ and $x_k$ integer.

### 3.4 Area of study

The study will be conducted in Mbarara dairy shed and Masaka districts in Kampala-Jinja dairy shed.

### 3.5 Sampling Procedure and Data Collection Methods

In this study a multi-stage stratified sampling procedure will be adopted. Dominant dairy management systems viz; perimeter fenced open grazing, paddock fenced semi-intensive, and intensive (zero and semi- zero grazing- will be the stratifying factors.

Parishes in the districts to be sampled will be stratified according to the distribution of intensification in the cattle management.

In order to get qualitative and quantitative view of the farm families, farm resources, constraints and enterprises the first phase of the study will be in form of a characterisation study. Characterisation surveys will be conducted on sample of 35 respondents to be selected from each stratum in each dairy shed to give a total of 210 respondents. Women headed and managed farms will be purposively included in the sample.

The second part of the study will involve a more detailed and intensive longitudinal surveys Data will be collected on bi-weekly intervals for a period of 13 months on representative

farms among the sample of 210 selected for characterisation. A total of 48 respondents will be selected for the longitudinal surveys. This will comprise of 8 farmers each from the perimeter fenced, paddock fenced and zero (semi-zero)-grazing in Masaka and Mbarara dairy sheds.

### 3.6 Data Types and Sources

Primary data will be collected from both characterisation and longitudinal studies. Characterisation data will include:

- Farm household demographic and socio-economic characteristics;
- Gender related access and control of livestock resources; land allocation to farm enterprises and non-production labour time and benefits of farm products and returns;
- Production factors like land, financial and physical capital; labour and feed resources, factor and product markets, Livestock and crop management activities including livestock species, cattle/goat breeds, classes, production purposes, productivity levels, disease, vector, water, parasite and feed constraints and coping schemes; and
- Supporting institutions and facilities like credit, farmer training, extension services and group or community dynamics.

Longitudinal surveys will elicit seasonally disaggregated data on farm resources. A calendar year will be divided into four seasons namely short and long dry; and short and long wet periods. Data will be collected to track seasonal variations with respect to:

- Allocation of land for food, commercial and fodder crops, grazing areas and pasture;
- Participation of gender in farming activities and livestock keeping;
- Capital and labour profiles;
- Crop and livestock production and consumption activities;
- Farm and domestic selling and buying activities including input schedules

### 3.7 Methods of Data Analysis

Economic incentives for farm production in different dairy sheds will be based on unit crop and milk production costs vis–a–vis farm gate prices. Enterprise budgets will be drawn to work out gross margins, net farm incomes and cost of production per litre/acre for zero grazing, paddock fenced and perimeter fenced systems of in each milk shed.

Crop-livestock synergism will be examined by comparing means and variances of milk yields for farmers with dry season feeding of crop residues and/or fodder with those who do not have dry season feed buffer. Crop yields where manure is applied on food, commercial and fodder crops as opposed to farms where such interactions do not exist will also be compared using t-tests. Herd returns from farms with and without active women participation in livestock keeping activities will be examined by use of logistic regression analysis. Annual livestock yields will be the independent variable with calf survival, lactation yields, fodder resources, supplementation, livestock disease management skills, pasture improvement by weeding, and provision of water from individual wells or domestic sources as the dependent variables.

A Generalised Arithmetic Model Systems (GAMS) Mixed Integer Target MOTAD linear programming technique will be used to determine the risk-adjusted optimum crop and livestock enterprise combinations for each dairy management system. Extensions on GAM by sensitivity analysis will assess the effect of potential adverse milk prices and labour costs on the long-term competitiveness of dairy management intensification in each of the dairy sheds.

**4 - Expected outputs**

1. Results of this study will outline distribution of livestock ownership, management, access to and control of livestock resources and benefits with respect to gender as laid down by cultural, traditional and socio-economic criteria in the major dairy shed

2. Information on livestock production efficiency contingent upon gender based differences with respect to herd management

3. Information on benefits of crop-livestock integration and synergism for various levels of dairy management intensification

4. Recommendations on development planning and policy based on long-term optimum crop and livestock enterprise sizes, combinations and level of dairy intensification in each dairy shed.

**5 - Proposed budget and requirements -US Dollars)**

| Item | Months | | | |
|---|---|---|---|---|
| | 0 – 12 | 13 – 24 | 25 - 36 | Totals |
| University Fees | 2000 | 2000 | 2000 | 6000 |
| Stipend | 4200 | 4200 | 5150 | 13550 |
| International travel to ILRI by student | | 400 | | 400 |
| Accomodation in Kenya | | 2250 | | 2250 |
| Medical insurance | | 1000 | | 1000 |
| International travel by ILRI supervisor | | 400 | 400 | 800 |
| Supervisor (2) local field costs | | 1050 | 1050 | 2100 |
| Book Allowance | 1000 | 1000 | 1000 | 3000 |
| Field work – Scientist allowances | | 2100 | 500 | 2600 |
| Field work – technician allowances | | 10800 | 900 | 11700 |
| Field work – driver allowance | | 2100 | 500 | 2600 |
| Field work – Fuel | | 5000 | 400 | 6400 |
| Field work - Other expenses | | | | |
| Computer – w – accessories and email account | | 6950 | | 6950 |
| Stationery – assorted | | 1000 | | 1000 |
| Thesis production | | 1000 | | 1000 |
| Contigency (10 %) | | | | 6135 |
| Total | | | | 67485 |

Enumeration includes 6 enumerators each earning $ 150 salary & transport per monthS. Staal will make 2 trips to Uganda during the course of supervision Student stipend is supplementary to existing salaries, stipends reflect in-country and out of country ILRI PhD students and 1 trip to ILRI-Kenya for 5 months for final data analysis and thesis write-up.

## 6. Workplan

| | Year and Quarter | | | | | | | | | | | | Outputs and responsible |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 2000 | | | | 2001 | | | | 2002 | | | |
| Activity | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | |
| Submit proposal to Makerere | X | | | | | | | | | | | | Registration;W. Nanyeenya |
| Sample development | | X | | | | | | | | | | | Sampling frame; W. Nanyeenya |
| Farm characterisation | | X | | | | | | | | | | | Farm typologies; W. Nanyeenya |
| Enumerator Training | | | X | | | | | | | | | | Skilled enumerator; W. Nanyeenya |
| Characterisation data collection | | | | X | | | | | | | | | Cross sectional data; W. Nanyeenya |
| Model adjustments | | | | X | | | | | | | | | Refined model; Nanyeenya, Staal |
| Longitudinal survey numerator training | | | | | X | | | | | | | | Trained enumerators, W.Nanyeenya |
| Site and farmer selection | | | | | X | | | | | | | | Longitudinal sample, W. Nanyeenya |
| Longitudinal data collection | | | | | X | X | X | X | X | | | | Longitudinal Data; W.Nanyeenya |
| Data cleaning | | | | X | X | X | X | X | | | | | Formatted data; W.Nanyeenya |
| Data analysis | | | | | | | | X | X | | | | Study findings; Nanyeenya, Staal |
| Thesis write-up | | | | | | | | | X | X | | | PhD thesis; W.Nanyeenya, Staal |
| Defend Thesis | | | | | | | | | | X | | | Study validated; W. Nanyenya, FAF |
| Submission of thesis to Makerere | | | | | | | | | | | X | | Thesis certified; W. Nanyeenya, Staal |

## 7. Bibliogaphy

Abenet Belete, Dillon, J. L and Anderson, F. M (1992): "Impact of Fertiliser Use on Production and Cash Income of Small – Scale Farmers in the Highland Areas of Ethiopia". *Agricultural Systems 40 (1992) 333 - 343*

African Farming and Food Processing Magazine (1998): Milk: Spreading the Message. Issue No. 9 June 1998 (13).

Anderson D. R, Sweeney D. J and Williams T. A (1994): An Introduction to Management Science. Qualitative Approaches to Decision-Making. 7th Edition West Publishing Company

Atokple, I., Byenkya, S., Wameotsile Mahabile, Sebojtja, I, and Aart-Jan Verschoor (1995): Towards revitalising the livestock industry in Mukono district, Uganda. ICRA/NARO Working Document series 45.

Bagamba, F. (1994): An Economic Assessment of Banana-based Production Systems in Uganda. An MSc Thesis Submitted to Makerere University

Bank of Uganda Agricultural Secretariat (1984) Livestock Development and Marketing in Uganda

Bank of Uganda Agricultural Secretariat (1988): The Economics of Livestock Production in Uganda – Dairy and Beef Cattle.

Bank of Uganda Agricultural Secretariat (1994): The Economics of Crop and Livestock Production.

Bernet T, Ortiz o, Quiroz R and Swinton S. M (2001): "*Tailoring agricultural extension to different production contexts: a user –friendly farm household model to improve decision – making for participatory research*"Agricultural systems 69 (2001) 183 - 198

Bezabih Emana and Storck, H (1992): "Improvement Strategies for Farming Systems in the Eastern Highlands of Ethiopia." *Agricultural Economics, 8 (1992) 57 – 77.*

Birge J. R and Louveaux F(1997) Introduction to stochastic programming. Springer series in operations research

Boisvert, R. N and McCarl, B (1990): Agricultural Risk Modeling Using Mathematical Programming. Southern Cooperative Series. Bulletin No. 356

Boserup, E (1965): The Condition of Agricultural Growth. Chicago: Aldine Publishing Company

Castle, E. N; Becker, M. H and Smith, F. J. (1972): Farm Business Management. Second edition

Derbertin .D. L. (1986): Agricultural Production Economics. Macmilan Publishing Co., New York

Fitzhugh, H.A & de Boer, A. J (1981): Physical and Economic Constraints to Intensive Animal Production in Developing Countries, in Smith & Gunn, (eds.) Intensive Animal Production in Developing Countries, British Society of Animal Production.

Gass, G. M and Sumberg, J. E (1993): Intensification of Livestock Production in Africa: Experience and Issues, Overseas Development Group, University of East Anglia, Norwich, UK.

Griffith, K and Zepeda, L (1993): "Farm -level Trade-offs of Intensifying Tropical Milk Production". *Ecological Economics 9 (1994) 121 – 133.*

Hanjra S. H, Rajar M. A and Igbat M (1987): The Economics of Milk Production on Small Farms in Pakistan. On-farm Animal Research/Extension and Its Economic Analysis. Perviaz A and Knipscheer H. C (Eds) . January 1987

Hardaker J. B, Pandey. S and Pattern L. H (1991): "Farm planning under uncertainity: A review of planning models" *The Australian economics society inc.* pp 9 - 22

Hazell, P. B. R. (1971): A linear Alternative to Quadratic and Semi-variance Programming for Farm Planning Under Uncertainty

Hazell, P. B. R, and Norton, R. D (1986): Mathematical Programming for Economic Analysis in Agriculture. Macmillan Publishing Company.

Heady, E.O and Candler, W. (1966): Linear Programming Methods. The Iowa State University Press, Ames, Iowa, U.S.A.

Ika Darn Hofer (1997): Tagasaste and Oats-Vetch Production for Crossbred Dairy Cows in the Ethiopian Highlands. Animal Feeding, Farmer Decision making and Economic Considerations. A PhD Thesis Submitted to University of Agricultural Sciences Vienna, Austria.

International Livestock Research Institute – ILRI (1996): The Ugandan Dairy Subsector. A Rapid Appraisal Report.

Jefferson, R. W, and Boisvert, R. N (1989): A Guide to Using the Generalised Algebraic Modeling System (GAMS) For Applications in Agricultural Economics. Cornell University Macmillan publishing company., Inc New York

Lien G and Hardaker J. B (2001): "*Whole –farm planning under uncertainity: impacts of subsidy scheme and utility function on potifolio choice in Norwegian agriculture*" European review of agricultural economics Vol 28 (1) (2001) pp. 17 - 36

Kabirizi, J. M (1997): The Beauty of Zero Grazing Dairy Production System. NARO Bulletin. Vol. # 7

Kabugo, F. N (1997): Economic Evaluation of Friesian Dairy Cattle Enterprises in Uganda: A Case of Nangabo Sub-county in Mpigi District. An MSc Thesis Submitted to Makerere University

Kisamba Mugerwa, W. (1992): Rangeland Tenure and Resource Management: An Overview of Pastoralism in Uganda. Makerere Institute of Social Research (MISR)

Maleka P (1993): "An application of Target MOTAD Model to Crop Production in Zambia: Gwembe Valley as a Case Study. *Agricultural Economics, 9 (1993) 15 - 35*

Mbuza, F. M. B; Akwang, A and Nalukenge, I (1996): The Dairy Subsector as a Tool for Modernising Agriculture in Uganda. ASARECA/ILRI/IFPRI dairy policy workshop, ILRI Ethiopia

McCamley, F and Kliebenstein, J. B (1987): "Describing and Identifying the Complete Set of Target MOTAD Solutions." *American Journal of Agricultural Economics, pp (669-676) 1987*

Mengistu Buta (1997): Use of Crossbred Cows for Milk and Traction in the Highlands Ecoregion: A Whole – Farm Evaluation

Ministry of Agriculture Animal Industry and Fisheries –MAAIF (1989): Livestock and Fisheries Policy and Development Programme Towards the year 2000.

Ministry of Agriculture Animal Industry and Fisheries-MAAIF (1992): Master Plan for the Dairy Sector volume II.

Ministry of Agriculture Animal Industry and Fisheries-MAAIF (1995): The National Cattle Breeding Policy: Background Information.

Muwanga, J. W (1994: An Economic Evaluation of Zero Grazing Dairy Production System of Mpigi and Mukono Districts. An MSc Thesis Submitted to Makerere University.

National Agricultural Research Organisation (NARO) and ILRI (1996): Economic and Structural Analysis of the Dairy Subsector in Uganda. A Rapid Appraisal Report.

Nsubuga, H. S. K (1990): Cattle Diseases and Husbandry in Tropical Africa. A Case for Uganda. Makerere University.

Nyaribo, F. B. and Young, D. L (1992): "Impacts of Capital and Land Constraints on the Economies of New Livestock Technology in Western Kenya."*Agricultural Economics", 6(1992) 353 – 364.*

Odhiambo, W. (1998): Productivity, Market Orientation and Agricultural Intensification: A Comparative Analysis of Smallholder Farmers in Meru and Machakos Districts of Kenya. A PhD dissertation submitted to the University of Hohenheim, Germany

Okoruwa. V, Jabbar. M. A. and Akinwumi. J . A. (1996): "Crop-livestock competition in the West African derived savanna: Application of a Multi-Objective Programming Model." *Agricultural systems, 52 (1996) pp 439 – 45*

Omore A. O, McDermott J. J, Kilungo J, Gitau T and Staal S. (1997): A Comparison of the Relative Returns to Different Enterprises on Mixed Smallholder Crop-Dairy Systems in Central Kenya. Epidémiol. Sante´anim. 31-32

Pingali, P. L and Binswanger, H. P (1987): Population Density and Agricultural Intensification: A Study of the Evolution of Technol;ogies in Tropical Agriculture. In Dale, J. D and Lee, R. D (eds) Population growth and Economic Development Issues and Evidence. Social Demography Series, Madiso, Wis.: University of Winsconsin Press pp 27–56.

Pingali, P.L (1995): Crop-Livestock Systems for Tomorrow 's Asia: From Integration to Specialisation. Proceedings of an International Workshop on crop-Animal interaction. C. Devendra and C. Sevilla Eds IRRI Manila Phillipines.

Rabin, M (1999): Risk aversion and Expected – Utility theory: A calibration theorem Department of Economics University of California - Berkeley

Rijk de Jong (1996): Dairy Stock Development and Milk Production With Smallholders. A PhD thesis submitted to Wageningen Agricultural University, the Netherlands.

Romero, C (1991): Handbook of Critical issues in Goal Programming. Pergamon Press.

Saamanya, J. P. (1996): Evaluation of Feed Resources for Zero-grazing Dairy Production In the Fertile Lake Crescent Zone of Uganda - A Case of Jinja Womens' Heifer Project. An MSc Thesis submitted to Makerere University.

Schweigman C. (1979): Doing Mathematics in a Developing Country

Shapiro, K. H, (1991): Assessment of Animal Agriculture in Africa: Economic issues, University of Wisconsin

Simpson J. R (1988): The Economics of Livestock Systems in Developing Countries. Farm and Project level analysis. Westview Press

Smith, J. W, Naazie, A, Larbi, A, Agymang, K and Tarawali, S (1997): Integrated Crop-Livestock Systems in Sub-Saharan Africa: an option or an imperative. Outlook on Agriculture Vol. 26 No 4,237-246

Staal, S. J and Davis, C. G (1992): :"Effects of Resource Constraints on the Production Systems and Earnings Potential of Small Farm Households in the West Province of Cameroon". *Farm and Business 1(2)*

Stotz, D.(1975): Milk Production Systems in Kenya, Their Economic Features and Management Traits. MALD Naivasha, Kenya.

Tauer, I. W. (1983): "Target MOTAD". *American Journal of Agricultural Economics, 65: 606-609*

Toure, S. M (1991): Nomadism and Pastoralism and the Protection of Natural Resources. Seminar on Intensification of Agiculture and the Environment in Tropical areas. Brussels 5-6 June 1990. R. Dellere and J. J. Symeons, Eds. CTA pp 49-71(1991).

Uganda Investment Authority (UIA). (1994): Uganda Trade and Investment Opportunities. Dairy Sector Profile

Upton, M (1987): African Farm Management. Cambridge University. Cambridge

Van der Valk, Y.S (1985): Ministry of Livestock Development. Dairy Development Project, Naivasha, Kenya

Vanegas, M, and A. A. Akwang (1992): An Economic Analysis of Milk Production Costs and Pricing in Uganda. FAPU Research Series. Makerere University

Myles J. W; Larry J. H and Glenn A. H (1984*): A comparison of MOTAD and Target MOTAD* Canadian Journal of Agric. Economics 32(175 – 185)

Widodo. M.W, R. de-Jong and Udo. H.M.J (1994a): "Smallscale Dairying in Three Farming Systems in East Java: Farmer's Incomes and Household Characteristics". *AJAS 1994 vol n. 1 pp 19 – 29*

Widodo, M.W, R. de Jong and Moll, H.A (1994b): "Smallscale Dairying in Three farming Systems in East Java: Economic Analysis of Dairying". *AJAS 1994 vol. 7No(1) pp 31-39.*

Winrock International (1992): An Assessment of Animal Agriculture in Sub-saharan Africa

Winrock International Institute of Agricultural Development. Morrilton Arkansas, USA

Witkowski E and Well A. (1979): The Economics of Agricultural Production. Alfred Publishing Co. Inc.

World Bank (1990): Dairy development in Sub-saharan Africa. A Study of Issues and Options. Africa technical Department, Agriculture Division

- ANNEXE 3 -

# Adaptation of the Farmer Field School methodology to improve adoption of livestock health and production interventions

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## Introduction

Conventionally, scientists are primarily involved in generating new information and are rarely involved in the dissemination of their results other than to fellow scientists. Although the so-called "baskets of options" are actually full with technologies, most research programmes record very poor adoption rate and insignificant impact. The challenge facing the research and extension services in the livestock sector of developing countries is to help farmers to increase productivity while sustaining and enhancing the productive potential of the available natural resources. Unfortunately, conventional information dissemination projects or programmes have also very poor success rates in changing or improving animal health and production practices. Dissemination has traditionally been seen by research and extension as finding effective ways of transferring technology, and passing on relevant, usable information to farmers. In complex situations, where farmers need to adjust to a changing situation, such as crop protection, soil nutrient management, animal health and production, this approach has been shown to be inadequate because farmers are generally insufficiently involved in identifying problems, or in selecting, testing and evaluating the possible solutions. In a climate of declining governmental support and the lack of success of traditional means of extension, the need is recognised for alternative methods to identify the problems faced by farmers and more effectively disseminate technologies appropriate to addressing those problems.

Farmer Field Schools (FFS) are based on an innovative, participatory and interactive learning approach. The FFS approach was developed by FAO in South East Asia as a way for small-scale rice farmers to investigate and learn for themselves the skills required for, and the benefits to be obtained from, adopting integrated pest management (IPM) practices in their paddy fields. The aim of the FFS is to build the farmers' capacity to analyse their production systems, to identify their main constraints, and to test possible solutions, eventually identifying and adopting the practices most suitable to their farming system. The knowledge acquired during the learning process can be used to build on existing knowledge enabling farmers to adapt their existing technologies so that they become more productive, more profitable, and more responsive to changing conditions, or to adopt new technologies. The current ILRI/DFID-AHP/FAO livestock FFS project is developing the methodology for similarly complex situations found in animal health and production where responses to interventions may not be as fast. The purpose of the project is to adapt and test FFS methodology for animal health and production, focussing upon smallholder dairy farmers. The approach is applied to developing integrated methods to control vector-borne diseases

and helminth infections and to improve the efficiency of utilization of available feed resources and the management of nutrients within the crop-dairy system.

## Material and Methods

Ten FFS groups of 30 to 35 farmers with similar interests were established in five different agro-ecological zones in Central, Rift Valley and Coastal Provinces of Kenya. Facilitators trained in FFS approaches worked with established groups to prioritize the main constraints to improved efficiency of milk production using participatory pairwise and matrix ranking techniques. Based on the results of this exercise, individual grant proposals were prepared by each group including a detailed work plan with a corresponding budget. A maximum grant of US$600 was deposited in an account controlled by elected members of the FFS group to cover the cost of field activities and the cost of facilitation, i.e. the transport and lunch allowances to enable the extension worker to visit. Management of this budget empowered the farmers to demand and control activities covered by the FFS and ensured that the extension services offered responded to farmers' actual priority problems and needs. All FFS groups meet weekly, from 9 to 12 am. In each session farmers work with the extension facilitator in a structured manner, organized by a different group of farmers each week nominated from the group. The main activities are participatory technology development (PTD) in which farmers focus on solving local problems through a process of collective and collaborative inquiry using comparative studies and the special topic.

The PTDs are implemented to empower participants (both farmers and facilitators) with analytical skills to investigate cause and effect relationships of problems in farming practices. Since the main objective of the PTD is to develop farmers learning skills rather than just increase knowledge of a particular technical issue, record keeping and accurate observation are an important component. For this the AESA technique (Agro-ecological system analysis) is an integral component of the PTDs. The AESA technique is used to record and observe the results of the PTD experiments and is designed to improve observation skills and to develop decision-making skills, through analysis of a field situation. It is the establishment of an understanding of the interactions between livestock and other biotic and abiotic factors co-existing in the field through observation as they relate to the problem or technology being studied. For example, where the subject is expected to have a direct outcome on the animal, such as a feeding or health management practice, the AESA is focused on the animal. Practically, farmers are divided into small groups and observe an animal from one of their farms. Observations are guided by a check-list including general information, giving the life history; parameters defining the level of production: and observations describing the health status of the animal. Each group presents their results in a standardized format to the rest of the school, where the findings are discussed allowing farmer-to-farmer information dissemination as well as evaluation of progress as part of the PTD.

## Results

The establishment of PTD is one of the biggest challenges for livestock FFS. Indeed, while it is relatively easy to design a comparative study for crop integrated pest management, the high economic value of cattle does not allow any experiment involving any risk or even short-term losses in animal productivity. Therefore, one of the objectives of the on-going livestock FFS project is to establish what type of PTDs could be performed without any risk or detrimental effect and still allow farmers to experiment with new technologies. Three type of PTDs have emerged from on-going activities:

### Classical PTDs

**Although livestock are the focus for the FFS, a lot of activities of the livestock keeper are crop related. This is particularly the case for fodder production and grazing improvement and PTDs include**

1 Establishment of alternative sources of fodder. A range of fodders are planted using different planting methods, treatments and/or different fertilizer regime.

2 Preservation of fodder using different techniques such as silage making and the box baler for hay.

### 2) Comparison of existing farmer practices

Observation and evaluation of the different practices of farmers, in and outside the FFS group, provide the opportunity for farmers to address issues that do not lend themselves to experimentation because of the high risk in terms of animal well-being or high cost of implication. Examples include:

1 Tick control: comparison of efficacy of different acaricides and/or of different application regimes.

2 Vaccination efficacy: comparison of disease incidence in immunised and non-immunised animals

3 Comparison of milk quality and losses due to milk spoilage in relation to the quality of the milk parlour infrastructure.

### 3) Ex-post PTD analysis

**In ex-post analysis, farmers compare actual experimental results with practices that were used before. Results may be quantitative if records are available from the past or from similar situations or qualitative where farmer perceptions are evaluated. This also include the "Stop and Go" method, where the treatment is stopped and re-introduced several times to show its effect using an animal as its own control. Those tested include:**

1 Water availability: the amount of water available to the dairy animal is changed according to the calculated needs. Milk production on the new regime is compared with previous records of production on the old regime.

2 Genetic material: artificial insemination is used to compare calf birth weight with other calves or with the expected weight.

3 Prophylactic programme: a prophylactic programme is applied to a group of cattle and their performance is compared with previous productivity and with neighbouring herds. This could include deworming, trypanocide and/ or vaccination against prevalent diseases.

Not every problem can be easily dealt with by a "learning by doing" approach. Some problems, dealing with contagious diseases, for example, are not suitable or too dangerous for experiment. Others may be too abstract to be demonstrated physically, such as the importance of epidemiological status or immunological reactions and these can be addressed in special topic sessions where issues are discussed. Since the facilitator cannot be an expert in every subject, he will help the farmer group to invite the right person to talk about the subject

chosen by the farmers. This empowers the FFS group to contact other organisations such as NGOs, national or international research institutes. Special topics can also include livestock and non-livestock related issues, giving the chance to farmers to access the information responding to their priority at a particular moment. For example, talking to the community about trypanosomiasis when the village is threatened by a cholera outbreak is unlikely to be addressing a priority issue, when advice about cholera control may be more relevant.

## Conclusions

If scientific research is to achieve real impact on farm productivity and livelihoods, new methodologies for dissemination of information have to be developed. Participatory approaches, which facilitate farmer demand for knowledge, give the opportunity to the end users to choose, test and adapt technologies according to their needs. Through participation in FFS, farmers develop skills, which allow them to continually analyse their own situation and adapt to changing circumstances. The ILRI livestock FFS project, funded by the DFID Animal Health Programme is testing and adapting a participatory method to create a sustainable relation between farmers, extension officers and research institutes. These relationships are thought to be a fundamental tool for scientists to collect appropriate data and to transform developed technologies into products adapted to the end user needs.Using the FFS approach, the project is developing an innovative process through which farmers adapt existing technologies and try out new ideas, which are developed through interactions between farmers, scientists and extension workers. This unique relation is an excellent platform for epidemiology studies using participatory methods to disseminate information on diseases prevalence, to design relevant participatory technology development, and to introduce more successful disease surveillance and control strategies.

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