More informed decisions for livestock keepers in dry areas

RIU

Validated RNRRS Output.

Decision-support tools have now been developed to help decision makers and livestock keepers address the difficult question of how to cope in semi-arid areas where forage levels can fall to critically low levels. Deciding how to manage livestock in these areas, and how many animals to keep, are difficult choices when rainfall cannot be predicted from one year to the next. This means that you can't be sure that there will be enough grazing for your livestock. Using tools like the SimSAGS Decision Support System will make it easier to balance the many factors that have to be taken into account when keeping livestock in areas where rainfall is very variable.

Project Ref: **LPP23:**
Topic: **4. Better Water Harvesting, Catchment Management & Environments**
Lead Organisation: **University of Edinburgh, UK**
Source: **Livestock Production Programme**

Document Contents:

Description

LPP23

Research into Use
NR International
Park House
Bradbourne Lane
Aylesford
Kent
ME20 6SN
UK

Geographical regions included:

Kenya, UK, Zimbabwe,

Target Audiences for this content:

Livestock farmers,

A. Description of the research output(s)

1. Working title of output or cluster of outputs.

Environmental variability and productivity of semi-arid grazing systems / Environmental Variability Phase 2

2. Name of relevant RNRRS Programme(s) commissioning supporting research and also indicate other funding sources, if applicable.

Livestock Production Programme

3. Provide relevant R numbers (and/or programme development/dissemination reference numbers covering supporting research) along with the institutional partners (with individual contact persons (if appropriate)) involved in the project activities. As with the question above, this is primarily to allow for the legacy of the RNRRS to be acknowledged during the RIUP activities.

R6984 / R8476 / ZC0291
Institutional partners:

- Department of Research & Specialist Services, Matopos, Zimbabwe (R6301)
- Macaulay Land Use Research Institute, UK (R6301)
- International Livestock Research Institute, Kenya
- Eastern Steppe Biodiversity Project / Wildlife Conservation Society, Mongolia
- Commonwealth Scientific and Research Organization, Australia
- World Bank, Mongolia

*4. Describe the RNRRS output or cluster of outputs being proposed and when was it produced? **(max. 400 words)**. This requires a clear and concise description of the output(s) and the problem the output(s) aimed to address. Please incorporate and highlight (in bold) key words that would/could be used to select your output when held in a database.*

Highly variable **rainfall** scenarios require **livestock** breeders to find strategies for coping with periods when **forage** supply is critically limited. Livestock breeders must choose between fixed **stocking rates** to minimise risk of loss in **drought** and opportunistic selling as an alternative to bearing high **mortality** in drought. They must also determine how access to forage is constrained by the availability of drinking water and other constraints on range use, choose what resources to use in which season, and when and how much **dry season supplementation** is required. Policy analysis of this type can be conducted using the SimSAGS **Decision Support System** (DSS) devised under the LPP program. Early phases of development focussed on integration of scientifically-rigorous concepts of **semi-arid grazing systems** into the underlying **ecosystem model**, validation of that model against real-world data, and packaging of the model within an easy-to-use user interface.

Through application of the DSS, and in parallel with its development, the project has made an important contribution to the understanding of livestock survival during dry seasons and droughts, and of the effect of **key resources** and supplementation on animal populations, particularly in combination with the determinants of grazing land **condition**. This work is internationally recognised as a cornerstone of contemporary **rangeland**

science.

The project showed that flexible stocking strategies alone are not likely to be successful in **coping with droughts**. For **subsistence pastoralists**, the traditional policies of maintaining the maximum number of breeding stock, and of hoping that most of them will survive drought, may be as close as 'opportunistic' management can get to dealing with **climatic variability**. In seasonally variable environments, the supply of dry-season forage determines the numbers of livestock that can be carried. Wet season resources may be important for production, but maintaining livestock numbers depends on dry-season nutrition towards which **browse** could make a significant contribution. Browse is a dependable forage that is available over a longer growing season than **grass**. Its production may equal or exceed that of grass, and it may be the only forage available in heavily-utilised areas. Assessment of browse biomass is quite easy and methods of estimation we developed could be used as a rapid means of field assessment of range capacity in terms of animal numbers and species differences in the utilization of **forage resources**. However, heavy dependence on supplementation may possibly increase the impact of animals on forage resources, because more animals are being supported than the system could otherwise sustain.

Most recently, a help system for the DSS software was developed incorporating a dedicated website <http://sags.bio.ed.ac.uk/> with user's forum, and further model extensions. During this phase there was also wide dissemination to an initial trial group of end users at semi-arid locations selected for their environmental diversity and the variety of livestock and wildlife maintained there (**Kenya**, **Mongolia** and **Australia**). The project has a long history of successful delivery on contractual obligations plus real term delivery of beneficial contributions to research into pastoralist systems involving resource-poor farmers within the programme geographic focus (**South Africa**, **Zimbabwe**, **Botswana**, **Namibia** and Kenya) and in comparable contexts outside of it (Mongolia and Australia). The work has been published at all levels of accessibility: through institutional partnerships, online via third-party websites and the project's own official website, and with dissemination of scientific content via peer-reviewed journal articles and wide distribution of project reports.

The focus of the project is to now put the many years of investment in developing novel scientific (ecological and computing) technologies and successful trial applications into active use by the broad potential user community. There is the need for close collaboration with target institutions, providing training and guidance as part of the capacity-building intention of the project. In summary, the project comprises an Information [Decision Support] System product incorporating new technologies (scientific concepts, quantitative biology, **spatial ecology** and ecological architecture) and methods (**spatial modelling**-based assessment of livestock producer strategies). The project services include its outputs and training, plus the tailoring of the DSS during application to new contexts.

5. What is the type of output(s) being described here?
Please tick one or more of the following options.

Product	***Technology***	***Service***	***Process or Methodology***	***Policy***	***Other Please specify***
X	X	X	X		

6. What is the main commodity (ies) upon which the output(s) focussed? Could this output be applied to other

commodities, if so, please comment

Livestock, wildlife and mixed livestock-wildlife systems.

7. What production system(s) does/could the output(s) focus upon?
Please tick one or more of the following options. Leave blank if not applicable

Semi-Arid	***High potential***	***Hillsides***	***Forest-Agriculture***	***Peri-urban***	***Land water***	***Tropical moist forest***	***Cross-cutting***
X							

8. What farming system(s) does the output(s) focus upon?
Please tick one or more of the following options (see Annex B for definitions).
Leave blank if not applicable

Smallholder rainfed humid	***Irrigated***	***Wetland rice based***	***Smallholder rainfed highland***	***Smallholder rainfed dry/cold***	***Dualistic***	***Coastal artisanal fishing***
				X		

*9. How could value be added to the output or additional constraints faced by poor people addressed by clustering this output with research outputs from other sources (RNRRS and non RNRRS)? (**max. 300 words**).*

The DSS has been developed consistently over the course of a decade, through advances in scientific content and extension of the DSS when applied to various trial contexts. The DSS is now primed for its long-term intended use by the end user community and the project requires partnership funding to allow this goal to be met. It is particularly heartening that the RIUP shares the same objectives and brings with it the opportunity for collaborative work through which the DSS may benefit a wide user community.

The vast majority of the many projects progressed under the RNRRS do not use simulation modelling but have established working relationships with end user groups for which these projects have the shared ambitions of capacity building and delivering real solutions for poverty alleviation. The DSS has been developed as a readily available tool to assist in livestock management decisions and has enjoyed an enthusiastic welcome from the trial groups of end users, but currently the DSS is not in use. This situation would seem to lead to a naturally mutually beneficial arrangement where the project can extend the tools and information services currently in use by other projects, while those other projects can expose new end user groups to the DSS.

Please specify what other outputs your output(s) could be clustered. At this point you should make reference to the circulated list of RNRRS outputs for which proformas are currently being prepared.

The project would welcome assistance in identifying and nurturing potential partnerships during this early stage. Inspection of the projects lists provided by RIUP does reveal several obvious alliances, for example, from LPP,

§ *Sustainable use of wild land resources: ecological, economical and social interactions - an analysis of illegal hunting of wildlife in Serengeti National Park, Tanzania* (R7050, R6300).

is a project sharing a modelling component, and the DSS is suited to such mixed livestock / wildlife systems and any semi-arid region within the geographic focus.

There is a cluster of projects under the LPP that concentrated on smallstock production and secondary products (*e.g.*, milk). The DSS is versatile, and large and small livestock are equally easy to include through the model parameters and milk yield is one of the numerous outputs from the model that may contribute towards supported decision making by smallholders. Examples of projects in the cluster are,

§ *Increasing the productivity in smallholder owned goats on Acacia thornveld* (R7351)
§ *Use of tanniniferous feeds to improve smallholder goat production* (R7798)
§ *Husbandry strategies for improving the sustainable utilisation of forages to increase profitable milk production from cows and goats on smallholder farms in Tanzania* (R6619)
§ *Easing seasonal feed scarcity for small ruminants in semi-arid crop/livestock systems through a process of participatory research* (R6953)
§ *Community based goat productivity improvement in central and south Meru districts of Kenya* (R7634)
§ *Increasing the contribution that goats make to the livelihoods of resource poor livestock keepers in the Himalayan forest region* (R7632)
§ *Livestock in Challenging Environments: Coping Strategies for Progress / Development of a toolbox on smallstock* (ZC0243)
§ *Development of a Dairy Toolbox* (ZC0261)

There is the potential for forming a partnership with a non-RNRRS project co-ordinated from the University of Zululand which is also investigating aspects of both wild land resources and browse-browser interactions.

Another type of project that may benefit from sharing the DSS could be projects aimed at dissemination of information and support services, particularly for livestock production. For example, the Livestock Guru project (ZC0262) is exemplary at delivering information services directly to end users. Likewise, the DSS could be included in a suite of end user tools for dissemination to target institutions and end user groups as part of a dedicated dissemination project, for example,

§ *Linking demand with supply of agricultural information in Uganda* (R8429, R8281)

Of course, exactly what is needed will not be known until the RIUP Demand Assessment surveys have been returned and assimilated, but experience shows that smallholders, ranchers, NGOs, research institutes and policy makers welcome the opportunity to apply the DSS to directly address the issues surrounding livestock production also considered by these other projects (such as drought survival, diet selection and intake including browse utilization, and milk yield). The DSS is highly versatile, providing a wealth of information for semi-arid livestock production and wildlife systems in the geographic focus.

The initial step of contacting some of the above potential partner projects and the suitability of the DSS for application to those project contexts is summarized below.

1. Project: *Sustainable use of wild land resources: ecological, economical and social interactions - an analysis of illegal hunting of wildlife in Serengeti National Park, Tanzania (R7050, R6300).*
Contact: *Ken Campbell (Natural Resources Institute)*
Partnership potential: *this project has ended although uptake is active through contribution to policy. Poaching is financially motivated (e.g., payment of taxes) rather than directly for meat, and in a similar situation on the Eastern Steppes of Mongolia our simulation modelling clarified poacher impacts on wildlife numbers and consequential economic benefits to household welfare, which helped inform recommendations towards a National policy on hunting quotas.*

2. Project: *Spatial variation in resources and plant-animal interactions in a southern African savanna* and *Browse-browser interactions in savannas (non- RNRRS)*
Contact: *Peter Scogings (University of Zululand)*
Partnership potential: *these projects are investigating core elements of resource use in semi-arid savanna, namely, spatial foraging ecology and browse utilization. The semi-arid grazing systems model within the DSS explicitly deals with the growth, spatial and temporal distributions, and utilization of woody (browse) species and has contributed widely to our appreciation of the importance of browse products (especially seed pods) in livestock / wildlife dry season survival in combination with the browse utilization experiments carried out by the project.*

3. Project: *Livestock in Challenging Environments: Coping Strategies for Progress / Development of a toolbox on smallstock (ZC0243).*
Contact: *Ken Campbell (Natural Resources Institute) / Tim Smith (University of Reading) / Wyn Richards (NR International)*
Partnership potential: *this is a cluster of LPP / AHP and link projects that produced a CDROM and accompanying website <http://www.smallstock.info/> that has experienced similar problems to our own in disseminating essentially academic findings to a large, often non-technical target audience. A partnership between projects would seek to disseminate project products, broadening the resource-base by integrating their use as companion tools, and ensure that the packaged information is readily accessible (being both available and understandable) to target audiences.*

4. Project: *Increasing the productivity in smallholder owned goats on Acacia thornveld (R7351).*
Contact: *Tim Smith (University of Reading)*
Partnership potential: *this project focussed on dry season nutritional constraints to goat production specifically highlighting the benefits of supplementation with browse, a major conclusion independently reached by our project through fieldwork and application of the DSS. This information and the DSS could play an important role as part of a smallstock / livestock toolbox (see ZC0243, above).*

5. Project: *Development of a Dairy Toolbox (ZC0261).*
Contact: *Peter Thorne (Stirling Thorne Associates)*
Partnership potential: *this project has developed a suite of outputs ranging from information provision to decision support software and an associated website <http://www.agritools.co.uk/sdtb_access.html> as part of a Smallholder Dairy Toolbox. This project does not offer a simulation tool for estimation of milk yield under variable conditions and the DSS would lend itself well to this application.*

Validation

B. Validation of the research output(s)

*10**. How** were the output(s) validated and **who** validated them?*

*Please provide brief description of method(s) used and consider application, replication, adaptation and/or adoption in the context of any partner organisation and user groups involved. In addressing the "who" component detail which group(s) did the validation e.g. end users, intermediary organisation, government department, aid organisation, private company etc... This section should also be used to detail, if applicable, to which social group, gender, income category the validation was applied and any increases in productivity observed during validation **(max. 500 words)**.*

The project primary objective was to discover how much existing knowledge of underlying processes could explain and replicate the dynamics of semi-arid grazing systems. Modelling was used to assess the components and processes to which the system is most sensitive. The initial findings were reported in Illius *et al.* (1995).

Modular construction of the integrated grazing systems model followed a rigorous development pathway involving verification (accuracy testing) of separate components. The original scientific validations (testing the integrated systems model for realism) were carried out against empirical benchmarks and initially reported in Illius *et al.* (1996) with subsequent improvements presented in Illius *et al.* (2000). Significantly, these reports illustrate how results from the model contribute to Decision Support for semi-arid rangeland and show that "rainfall … can be used to predict vegetation growth and hence animal population dynamics. The predictions are close to observed carrying capacity, and in fact this model still maintains a world lead in its predictive ability", and continues to do so.

Consequently, the DSS attracts global interest. The system has been used towards fundamental re•evaluations of pastoralist management strategies (*e.g.*, Illius *et al.* 1998) with its most striking message, that the traditional approach of maximizing herd sizes is an optimal solution for dealing with climatic variability, being well received by potential end user groups of subsistence farmers working on South African communal rangeland. Although in this particular case the development team alone carried out the work, following these initial successes, other applications of the DSS have always been through close collaboration with the end user community and target institutions.

When applying the model to Maasai pastoralism and habitat fragmentation as a result of infrastructure incursions into a mixed livestock-wildlife system near Nairobi, end users at ILRI were impressed by the accessible user interface and the model's speedy parameterization during a study intended to inform Government policy (Derry 2004a). The similar problems faced by Mongolian pastoralists from railroad development transecting the Eastern Steppes also threaten the migratory Mongolian Gazelle as an added concern beyond the constant high losses to illegal hunting. There was general agreement amongst stakeholders (Mongolian pastoralists and Government ministers, plus representatives of the Eastern Steppe Biodiversity Project and the Wildlife Conservation Society) that the DSS made realistic predictions for a complex system under various scenarios of habitat change and increased hunting quotas (Derry 2004b) and that these results would contribute to environmental policy. These are examples of DSS usage contributing towards policy recommendations at the National level.

Another example is the application of the DSS to the problems of sediment deposition onto the Great Barrier Reef resulting from the Queensland cattle industry. The work carried out in collaboration with CSIRO has made advances in the spatial modelling of cattle foraging and has developed a novel technique to statistically assess model predictions.

On the global stage, the components dealing with soil moisture, animal populations and herbivory in the DSS have been used in collaboration with the World Bank to provide evidence for protection of the Lake Hövsgöl ecosystem. The lake has now been nominated as a World Heritage Site.

Derry J.F. (2004a) Presentation to ILRI Annual General Meeting of the 'Belgian Project' 2004: Modelling Component. J.F.Derry, University of Edinburgh 24/11/04.

Derry J.F. (2004b) Report on attendance of 2004 Symposium/Workshop on Conservation and Management of Mongolian Gazelles and presentation of LPP Project R6984 model by J.F.Derry, University of Edinburgh 08/12/04.

Illius, A.W. Derry, J.F. & Gordon, I.J. (1995) Components, processes and dynamics of semi-arid grazing systems. A review of current knowledge. Report to NRI. University of Edinburgh. pp 46.

Illius, A.W., Derry, J.F. & Gordon, I.J. (1996) Modelling the dynamics of semi-arid grazing systems. Report to NRI. University of Edinburgh

Illius, A.W., Derry, J.F. & Gordon, I.J. (1998) Communal Rangelands in southern Africa: a synthesis of knowledge. Dept of Livestock and Pasture Science, University of Fort Hare. Alice, Eastern Cape, June 1998.

Illius, A.W., Gordon, I.J., Derry, J.F., Magadzire, Z. and Mukungurutse, E. (2000) Environmental variability and productivity of semi-arid grazing systems. Final Technical Report.

*11. **here and when** have the output(s) been validated?*

*Please indicate the places(s) and country(ies), any particular social group targeted and also indicate in which production system and farming system, using the options provided in questions 7 and 8 respectively, above **(max 300 words)**.*

Validation of the project outputs has involved assessment of the Decision Support System's capacity to be applied to a broad range of contexts and make realistic predictions. The validation process has been ongoing since the project started in 1995, each development phase benefiting the next, thereby building on each previous innovation, and defining the progressive nature of the DSS development. While much of the initial validation work was carried out by the development team 'in-house', some early validation and test applications were delivered directly to potential end user communities (*e.g.*, Illius *et al.* 1998). However, following this intensive model development, the focus has been on outreach for which a definitive trial period (2002-2006) was scheduled when target institutions and end user groups were selected for their locations to provide a wide range of application contexts within semi-arid biomes.

Throughout, project outputs have been formally demonstrated predominantly through presentations to stakeholders and at stakeholders' conferences and workshops, *e.g.*, conferences of communal rangeland users (*e.g.*, Illius *et al.* 1998) and other pastoralists (*e.g.*, Derry 2004a), ILRI annual general meetings (*e.g.*, Derry 2004b) and CSIRO workshops (*e.g.*, Derry 2005 and 2006), although informal dissemination (training and guidance) directly to end user communities has proved most effective in empowering those individuals in the use of the DSS.

Derry J.F. (2004a) Presentation of LPP Project R6984 Model to 2004 Symposium/Workshop on Conservation and Management of Mongolian Gazelles by J.F.Derry, University of Edinburgh 26/10/04.

Derry J.F. (2004b) Presentation to ILRI Annual General Meeting of the 'Belgian Project' 2004: Modelling Component. J.F.Derry, University of Edinburgh 24/11/04.

Derry J.F. (2005) Presentation to CSIRO Workshop on Modelling Animal Distribution, Townsville, Australia. J. F.Derry, University of Edinburgh.

Derry J.F. (2006) Presentation to CSIRO Workshop on Spatial Grazing Behaviour, Rockhampton, Australia. J. F.Derry, University of Edinburgh.

Illius, A.W., Derry, J.F. & Gordon, I.J. (1998) Communal Rangelands in southern Africa: a synthesis of knowledge. Dept of Livestock and Pasture Science, University of Fort Hare. Alice, Eastern Cape, June 1998.

Current Situation

C. Current situation

12. ***How and by whom*** *are the outputs currently being used? Please give a brief description* ***(max. 250 words****).*

In order to deliver targets for the LPP, all active use of the DSS by the initial trial user groups was concluded for the close of the most recent (and final) phase of the program (the LPP ended in March 2006), however the legacy of the project endures mainly through the contributions made to the general understandings of rangeland dynamics and pastoralist stocking strategies. It is highly probable that other projects (RNRRS and non RNRRS) will be using outputs from this project, directly and indirectly.

This project's main focus is now towards identifying and working closely with new groups of end users within the geographic focus. While this is a continuation of the project's outreach work initiated during the previous phases of the program, the reality of allocating personnel time to the project and specifically the lack of funds to do so has all but halted the present progress.

What is apparent is the need for personal interaction by project workers with target institutions and end user groups, and so the funding to afford employment of a specialist in the use and application of the DSS who can

continue the dissemination process. Therefore, currently dissemination is in a passive mode; the DSS is documented and explained, and is available through its official project website <http://sags.bio.ed.ac.uk/> but there is no active outreach program operating.

*13. **Where** are the outputs currently being used? As with Question 11 please indicate place(s) and countries where the outputs are being used **(max. 250 words).***

Presently there are no current end user groups for the DSS and the project now looks towards this RIUP program as the way forward to contacting and collaborating with new end user groups for new applications of the DSS for any semi-arid livestock production in the geographic focus.

Recently, DSS non-spatial model components dealing with soil moisture, animal populations and herbivory have been included in a systems model of the Lake Hövsgöl ecosystem in Mongolia, and the spatial modelling aspect of the DSS was particularly effective in its recent applications to Maasai pastoralism in Kenya and soil erosion in Australia.

*14. What is the scale of current use? Indicating how quickly use was established and whether usage is still spreading **(max 250 words).***

The product was designed to expedite its customization to new contexts. Extensions requested by stakeholders (new features within the software to account for particular local circumstances) have taken longest to implement, but simple tailoring of the DSS is effective as soon as local data can be provided.

Explanation of DSS use plus the scientific content within the underlying model are available at the official project website. This material is organized to allow the end user to encounter topics firstly at an introductory level before pursuing them to a more advanced understanding.

The official project website is attracting attention but currently it is not possible to make a distinction between casual traffic and parties genuinely interested in the DSS's applications. Under the RIUP program it would now be possible to be more welcoming of individual contact than the present project staffing can allow.

*15. In your experience what programmes, platforms, policy, institutional structures exist that have assisted with the promotion and/or adoption of the output(s) proposed here and in terms of capacity strengthening what do you see as the key facts of success? **(max 350 words).***

The official project website offers a comprehensive help system in support of users applying the DSS to their own local contexts. However, at least in the preliminary stages of such an undertaking, guidance in use and modification of the DSS, and especially in collection of the base data required to parameterize the model is invaluable but not critical. This type of training is desirable in spite of the DSS's comprehensive help system as there are aspects of quantitative methodology that cannot be taught via the official project website but such knowledge can easily be transferred in person. The project therefore packages more than the DSS, through the processes peripheral to application of the DSS. The project also provides the transfer of skills that will have benefits for end users over a longer term than the lifespan of their first application using the DSS.

However not all of the skills and resources can be provided by the project team. Typically, the biggest barrier to automatic use of the product tends to lie in the abilities of the end users to extract the necessary data for use by the model.

In an attempt to avoid extended delays, the trial user groups were selected for location *and* with the basic requirement that data was readily available. Even so, one project in Kenya was delayed for over a year while data was being extracted, compiled and collected. This suggests the need for involvement of a dedicated data manager for each context, perhaps a GIS specialist in an associated target institution, who will be responsible for expediting the data collection.

Current Promotion

D. Current promotion/uptake pathways

*16**. Where** is promotion currently taking place? Please indicate for each country specified detail what promotion is taking place, by whom and indicate the scale of current promotion **(max 200 words).***

Currently the project is published on the World Wide Web global platform. The official project website is organized into 8 sections: *Home*, *About*, *User Guide*, *Documentation*, *Requirements*, *Downloads*, *Site Map* plus a user community *Forum*, in total comprising over 1600 pages, but in spite of this extensive information about the DSS, and perhaps partly because there is so much, uptake suffers from there being no current activity to engage target institutions and end user groups directly. In the project's experience this requires an individual to contact and disseminate the DSS material, as illustrated by the success of the projects receiving guidance in applying the DSS during the last few years.

*17. What are the current barriers preventing or slowing the adoption of the output(s)? Cover here institutional issues, those relating to policy, marketing, infrastructure, social exclusion etc. **(max 200 words)**.*

Simply put, there is currently no-one identifying and contacting potential new end user groups because the project has no funds to employ someone in that capacity. The RIUP would provide that financial leverage necessary to continue the project, realize the previous decade of investment and get the DSS back out into the user community and in to use.

The other aspect of the RIUP that will have an immediate impact for this project will be the development partnerships between the RNRRS projects. Through experience, livestock producers place trust in programs run by local institutions where communication channels are already established. The project would seek to join these workers in the field and be directed in the needs of livestock producers by people familiar to them because they have already worked with, and gained the trust of, those end user groups.

*18. What changes are needed to remove/reduce these barriers to adoption? This section could be used to identify perceived capacity related issues **(max 200 words).***

The project needs partnership funding to move forwards and to make use of the previous decade of investment and development. A full-time member of the team will correspond with partner projects, assess their users' requirements and guide user groups in application of the DSS to their local contexts. The emphasis will be on transferring the skills necessary to use the DSS and associated technologies to the end users whilst ensuring that they receive appropriate support.

19. What lessons have you learnt about the best ways to get the outputs used by the largest number of poor people? ***(max 300 words).***

End user groups and target institutions may already have technical personnel working for them, but the techniques involved in data retrieval, data preparation and DSS application are diverse and experience has shown that some level of personal guidance for those end user teams is the most effective way to elicit results from the application and generally promote the use of the DSS.

Impacts On Poverty

E. Impacts on poverty to date

20. Where have impact studies on poverty in relation to this output or cluster of outputs taken place? This should include any formal poverty impact studies (and it is appreciated that these will not be commonplace) and any less formal studies including any poverty mapping-type or monitoring work which allow for some analysis on impact on poverty to be made. Details of any cost-benefit analyses may also be detailed at this point. Please list studies here.

While no direct poverty studies have been possible (the timeframe for assessing response to drought is clearly dependent on drought frequency and the lag effects in animal population dynamics), desk-based equivalents were carried out, for example the DSS has been used towards fundamental re-evaluations of pastoralist management strategies (Illius *et al.* 1998).

The assessment compared annual sales designed to limit stocking rate, pre-emptive sales triggered by insufficient rainfall, and variable sales and stocking-rate regimes determined by the current season's rainfall. Although the flexible stocking strategies did reduce mortality losses, compared with fixed stocking, they did not increase average annual sales. The main reasons for this are that major losses of stock are associated less with one-year than with two-year droughts, which are difficult to track, and that de-stocking can be really effective only if the productive potential of the herd can be re-established more rapidly than is possible from depleted herd resources. Policies designed to track climatic variation have minimal advantage in terms of sales and yet experience about twice the inter-annual variability. A CV of 140% implies zero sales in nearly one year in four. Inter-annual variability in sales is an obvious consequence of policies that aim to track climatic variation by varying stocking rate.

Other project output technologies about rangeland dynamics and environmental variability have been taken up by the broad scientific community and have undoubtedly influenced their outputs and impacts on poverty. It is clearly

impossible to state the impacts of these project outputs, but numbers of citations give some indication of uptake: 88 citations for Illius & O'Connor (1999), 31 citations for Illius & O'Connor (2000), 14 citations for Illius *et al.* (1998), 5 citations for Derry (1998), plus Derry (2004) is the 9th most popular item across all disciplines in the Edinburgh Research Archives with 641 downloads.

Derry, J.F. (1998) Modelling ecological interaction despite object-oriented modularity. Ecological Modelling, 107, 145-158.

Derry, J.F. (2004) Piospheres in semi-arid rangeland: consequences of spatially constrained plant-herbivore interactions. PhD thesis. University of Edinburgh.

Illius, A.W., Derry, J.F. & Gordon, I.J. (1998) Evaluation of strategies for tackling climatic variation in semi-arid grazing systems. Agricultural Systems, 57, 381-398.

Illius, A.W. and O'Connor, T.G. (1999) On the relevance of nonequilibrium concepts to semi-arid grazing systems. Ecological Applications, 9: 798-813.

Illius, A.W. and O'Connor, T.G. (2000) Resource heterogeneity and ungulate population dynamics. Oikos, 89 283-294.

21. Based on the evidence in the studies listed above, for each country detail how the poor have benefited from the application and/or adoption of the output(s) ***(max. 500 words):***

We are unable to provide a response to this question that fits within the designed feedback framework; simply, our project has broad reaching consequences for pastoralist societies across the geographic focus.

Climatic variability is the single largest cause of poverty in pastoral societies, resulting in increased livestock mortality and low productivity. Droughts that are severe enough to cause livestock mortality result in the destruction of wealth and loss of potential output. Furthermore, climatic variation causes the long-term stocking rate to be lower than could be maintained under more reliable climatic conditions, because livestock populations take time to rebuild after die-offs. Environments which are arid or semi-arid are prone to a high degree of climatic variability and low primary production with the result that pastoralism is the principal form of land-use. Clearly, ways need to be found of combating the economic and social effects of drought.

The project has contributed to general understanding of the effects of climatic variability on rangeland dynamics and the consequences for pastoralism and the DSS now provides a tool to assess coping mechanisms for drought survival.

Environmental Impact

H. Environmental impact

24. What are the direct and indirect environmental benefits related to the output(s) and their outcome(s)? ***(max 300 words)***

This could include direct benefits from the application of the technology or policy action with local governments or multinational agencies to create environmentally sound policies or programmes. Any supporting and appropriate evidence can be provided in the form of an annex.

More efficient use of rangeland resources, and more sustainable use, should have a strongly positive environmental impact.

25. Are there any adverse environmental impacts related to the output(s) and their outcome(s)? ***(max 100 words)***

Localised negative impacts on vegetation and soils from concentrations of livestock at waterpoints are small in scope.

26. Do the outputs increase the capacity of poor people to cope with the effects of climate change, reduce the risks of natural disasters and increase their resilience? ***(max 200 words)***

Adaptation to climate change under diminishing (and therefore increasingly variable) rainfall scenarios requires livestock breeders to find strategies for coping with periods when forage supply is critically limited. That is the central focus of our work on identifying critical nutritional periods and the associated resources: to exploit spatial variability to diminish the negative effects of temporal variability.
