GRAZING RESOURCE INFORMATION FOR SAHEL

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Approved by Geo and Ecosystem Sciences:_____

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Background and aim

Grasslands, mainly in drier areas cover extensive parts of the globe and are the home of the majority of the 1 billion people, many of them poor, depending on livestock for their livelihoods [1]. In Africa are 40 % (ca 12 millon km^2) of the land dedicated to pastoralism, a majority of this in semi-arid areas as grassland and savannas. In the Sahel region, pastoral and agro-pastoral systems are very important parts of the economy and a crucial activity in local and regional food production, supplying essential proteins (milk and meet).

Additionally, drylands, grasslands and rangelands deserve greater attention, not only for their large extent, severe degradation and limited resilience to drought, but also for their potential for carbon sequestration [2] and hence support mitigation of and adaptation to climate change while simultaneously supporting sustainable pastoral and agropastoral livelihoods [1]. Sustainable management of rangelands must be based on scientific assessments and mapping of productivity in order to secure future production and stability [3]. Combining sound assessment with state of the art information technology may provide help for sustainable resource management [4].

The overall aim is to develop a monitoring system quantifying supply and demand of grazing resources in the Kordofan region of the Sudan. It includes data assimilation, processing and information distribution to the end user (pastoralist and regional manager). Specific aims;

1. Quantification of available supply of grazing resources (ton dry matter per ha) with an 8-day temporal resolution and 1x1 km spatial resolution.
2. Estimation of current demand for grazing resources based on national and regional animal statistics and by mapping spatial patterns of seasonal grazing demand through tracking of animal herd movement using GPS collars.
3. Dissemination of grazing resource information via a web map service and mobile phones.

Relevance

Effect studies of climate change in developing countries have identified Africa as one of the most vulnerable continents, due to both ecological and socio-economic factors [5]. IPCC predict that by 2020 between 75 million and 200 million Africans will suffer from increased water stress and in some African countries, the yield from rain-fed agriculture could be halved [6].

The amount of scientific data and literature on observed climatic changes from Africa is small [7]. Compared to North America, Europe and Asia is the amount of relevant data low (i.e. the number of climate stations, eddy covariance stations, long term ecological research sites etc), and the number of relevant studies related to vegetation productivity, vulnerability and adaptation to climate change is comparatively low.

Generally, this project relates to key questions of sustainable resource utilization, information communication and handling as well as management possibilities in poor, fragile agro-ecosystems, covering large areas of Africa and predicted to suffer from climatic changes [1, 3].

Based on the knowledge that *"Climate change affects biodiversity and ecosystem functioning, threatening ecosystem services important for human well-being."*[1], we must acknowledge that focus on vulnerable people, directly depending on ecosystem services producing their livelihoods, in vulnerable regions, is a reasonable study subject.

Specifically, this project focuses on applying existing state-of-the-art remote sensing methodology for vegetation productivity assessment [8-11] in combination with current Sudanese livestock resource assessment research [12] and information dissemination utilizing the rapidly increasing communication infrastructure being develop in Africa. In combination we will supply functional data and information supporting a sustainable future for pastoralism in Sahel.

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[1] Ansökan till FORMAS, Dnr 2009-141

Additionally the project relates to and collects quantitative data regarding the carbon cycle in Africa, a current important topic [13].

Research plan

Supply (Aim 1)

Quantification and mapping of vegetation productivity, distribution and seasonality are key issues in this project and areas where we have experience [8-11, 14-18]. Remote sensing will be used to determine gross the fraction of absorbed photosynthetic active radiation (FPAR), a quantity linearly related to vegetation productivity [10]. Additionally will empirical biomass-reflectance regression relationships [12, 19] be applied.

We will apply, recent, in-house developed, state-of-the-art remote sensing based mapping in order to quantify available grazing resources (kg DM ha^{-1}) using time series of satellite[2] data at 500 meter spatial resolution and 8-day temporal resolution for the period 2012 – 2014. A processing chain with the following steps will be set up:

1) Data collection of latest available satellite data (every week).
2) Basic preprocessing of data for quality control[3] and geometry.
3) Time series analysis for more robust and less error sensitive mapping of vegetation seasonality using TIMESAT[4] [8].
4) Deriving primary production and biomass from satellite data [10, 11, 20].
5) Make resource data (biomass, water points and other relevant infrastructure) available on a mobile phone accessible web map service (Live geography).

The supply is not only a function of biomass, but forage quality in terms of energy, protein and nutrient content do vary spatially. This variation is a function of soils, precipitation, land cover and land use determining plant communities and agro-ecological zoning. Relevant information is available and will be used for stratification of the study area enabling additional data retrieval [12].

Demand (Aim 2)

The demand of resources, (e.g. grazing and water) for animal herds, is a function of the number and type of animals and their nutritional need[5]. Access to grazing/browsing resources may be restricted by water availability and vice versa as animals need both. Hence grazing resources in areas without drinking water (or other restricting factors[6]) within ca 10-12 km will be deemed as inaccessible (may vary depending on other factors as type of animals etc).

Regional statistics for the study area (Kordofan in Sudan) are already available and complementary data will be collected from the Range and Pasture Administration and from the State Ministry of Agricultural Statistics [12].

Most animal statistics are regional, occasionally unreliable, with low spatial and temporal resolution and hence give a poor picture of the real distribution of animals. Reliable data on spatial distribution of animals/herds are needed and can partly be derived from projects recently performing livestock census.[7] Decision support tools within resource assessment and management, dedicated for pastoral systems will be used while analyzing land and forage

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[2] MODIS, the Moderate Resolution Imaging Spectroradiometer is a satellite borne sensor producing free, high quality data that can be used to derive vegetation amount (biomass) and vegetation types.

[3] Include information on sensor malfunction, clouds and aerosols.

[4] TIMESAT is a dedicated program package for time series analysis of satellite data, http://www.nateko.lu.se/TIMESAT/timesat.asp

[5] Vary over time due to lactation and pregnancy.

[6] Areas with poisonous and unpalatable vegetation occur, as well as salty water.

[7] Western Sudan Resources Management Programme (IFAD), http://operations.ifad.org/

resources based on supply (see above) and demand [21]. In addition, the seasonal migration of ca 10 large herds of animals will be mapped using GPS[8], further described below.

Mapping of herds (Aim 2, cont)

Current migration patterns of nomads and transhumance pastoralists vary from year to year due to resource availability and may change in order to avoid conflict areas[9]. Migration goal is to secure feed and water for the animals while avoiding high incidence of biting insects and muddy clay areas during the wet season [12]. Considerable amount of animal feed are obtained from grazing in fallow-land in crop areas after harvest in addition to crop residues, grains and concentrates. During the cropping season, grazing must be avoided in cropping areas in order to protect the harvest.

A suitable way of mapping these migration patterns is to equip the herds with GPS collars measuring and sending the position at regular intervals [22, 23]. Existing GPS units[10] can be mounted on animals that send their position which then can be received and stored within a Geographical Information System (GIS). Mounting these in hot dusty environments require robust systems as well as solar driven power supply for battery charging.

This is all based on existing technology, the challenge is to get it running in a harsh environment such as the Sahel, ensuring durability and reliability during data collection. This will be partly accomplished through making participants benefit from free access to all relevant information within the project via internet enabled mobile phones. Hence this will be a type of participatory sensing [24], where participants support the user community (and themselves) through providing data (e.g. on water availability status, grazing status) and hence are rewarded through receiving up to date information in return. Note that this pilot project is rather small and that benefits from participatory sensing are related to the number of participants [24].

Dissemination of information (Aim 3)

Collected information on supply and demand of resources within the study area will be made available through a web map service (WMS) based on free open source software [25]. This will ensure flexibility and portability as well as ensure that the WMS are reachable using internet enabled mobile phones[11]. Project information will be accessible for all project participants and other relevant stakeholders. All collected information originating from individuals will be depersonalized to secure personal integrity.

Research cooperation

The project is performed in cooperation between Dept. of Earth and Ecosystem Sciences at Lund University, Sweden and the Agricultural Research Corporation (ARC, Dr Babiker and MSc. Khatir) in Sudan. The two organizations have had an intense cooperation since the year 2000, finalizing project funded both by Swedish donors and EU[12]. Cooperation with International Livestock Research Institute (ILRI, Dr Jan de Leeuw) and Action Contre la Faim (ACF, Dr. F. Ham) has been established through contacts with CIGAR[13].

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[8] Global Positioning System
[9] I.e. Darfur and in the Abyei region, both in Sudan.
[10] E.g. GTU 10 from GARMIN, Herdview from Sweden (http://www.tannak.se/), Tracker from Finland (http://www.tracker.fi/) or even smaller systems available from http://www.gsm-modem.de/M2M/
[11] Today 77 percent of the world population are mobile subscribers and one in five global mobile subscribers have access to fast mobile Internet (3G or better) services and the number of 3G handsets is growing fast. (http://mobithinking.com/mobile-marketing-tools/latest-mobile-stats)
[12] Funded by EU: CARBOAFRICA, CLIMAFRICA.
[13] Consultative Group on International Agricultural Research

Implementation

This project will be implemented as a PhD project[14] under supervision by Ardö. Technical assistance will be provided by our WEB/GIS engineers (Dr Hellström and MSc Selander) as well as support (GPS, GSM communication systems) from the Dept. of Electrical and Information Technology (Dr Anders Ardö) are available upon request. Co-supervisors will be assigned from the remote sensing group at Earth and Ecosystem Sciences.

Khatir, Babiker and an unnamed PhD candidate will be responsible for quantification of the demand for grazing resources. Activities in the Sudan will be coordinated by Dr Babiker and MSc Khatir, both at the Agricultural Research Corporation and with extensive hands on experience of inventories and mapping of environmental issues in semi-arid environments. MSc Khatir also has a good network within the Range and Pasture Administration as well as with a diverse group of pastoralist and agro-pastoralists in Kordofan. Additional livestock research support and advice will be given by International Livestock Research Institute (ILRI) and Action Contre la Faim (ACF).

Sudan, in general, and Kordofan region in particular is the home of the largest remaining traditional pastoralist population in the African Sahel. Most of this pastoral population inhabits the sparsely populated, dry marginal areas, furthest from centers of economic and political power. Hence is Kordofan, with its 370000 km^2 is a very suitable area for project implementation.

Potential future add-ons

Distribution of environmental educational[15] material related to grazing issues would be possible to implement as an add-on to this system. Text, images, lectures movies etc. could be made available and distributed to remote areas, to illiterate pastoralists and hence provides skills and knowledge to currently unreachable groups.

Satellite based estimates of precipitation, i.e. data from the TRMM[16] could be integrated in addition to estimates on where the grass is today. This would provide information on where the grass will be two weeks ahead, hence an additional planning information to consider.

Market information as supply and demand, transportation of livestock, remote veterinary services, all issues where relevant information could be disseminate and shared, at a low price with current available technology.

Financing

The PhD-candidate position will be financed for one year by Geo and Ecosystem Sciences and for one year from pending applications (CRAFOORD, FORMAS, SIDA and SNSB submitted but not yet approved) in addition to the two years in this application. As this is a new topic for the applicant is no additional grants available.

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[14] Recruitment will start as soon as possible. University will pay year 4 for the PhD candidate.

[15] Education, especially for women, is the most needed resource securing environmental stability in developing countries.

[16] Tropical Rainfall Measuring Mission, http://trmm.gsfc.nasa.gov/

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