IMPLICATIONS OF GLOBAL CLIMATE CHANGE FOR INDIAN AGRICULTURE

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KEYWORDS: Climate change, Indian agriculture, Impact, Adaptation, Mitigation.

ABSTRACT:

Recent IPCC report and several other studies indicate a probability of 10-40% loss in crop production in India and other countries of South Asia with increases in temperature by 2080-2100 and decrease in irrigation water. India could lose 4-5 million tons wheat production with every rise of 1^{o}C temperature throughout the growing period even after considering carbon fertilization (but no adaptation benefits). The losses would be even higher in case irrigation would decrease in future. Losses for other crops are still uncertain but they are expected to be smaller, especially for monsoon season crops. These modeling-based estimates are in line with the recent field observations.

Droughts, floods, tropical cyclones, heavy precipitation events, hot extremes, and heat waves are known to negatively impact agricultural production, and farmers' livelihood. The projected increase in these events will result in greater instability in food production and threaten livelihood security of farmers. Increased production variability could be perhaps the most significant impact of global impact change on India. All agricultural commodities even today are sensitive to such variability.

Early signs of decrease in yields due to changing weather have started becoming visible. Analysis of the historical trends in yields of crops in the Indo-Gangetic plains using regional statistics, long-term fertility experiments, other conventional field experiments and crop simulation models has shown that rice yields during last three decades are showing a declining trend and this may be partly related to the gradual change in weather conditions during last two decades. Apple yields are showing a declining trend in lower hills of Himachal Pradesh due to non-fulfilment of chilling requirement essential for proper flowering and fruiting.

Producing enough food for meeting the increasing demand against the background of reducing resources in a changing climate scenario, while also minimizing further environmental degradation, is a challenging task. This would require increased adaptation and mitigation research, capacity building, changes in policies, regional cooperation, and support of global adaptation and mitigation funds and other resources. Simple adaptations such as change in planting dates and crop varieties could help in reducing impacts of climate change to some extent. Losses in wheat production can be reduced from 4-5 million tons to 1-2 million tons if a large percentage of farmers could change to timely planting. This may, however, not be easy to implement due to constraints associated with wheat planting time in rice-based cropping systems. Additional strategies for increasing our adaptive capacity include bridging yield gaps to augment production, development of adverse climate tolerant genotypes and land use systems, assisting farmers in coping with current climatic risks through providing weather linked value-added advisory services to farmers and crop/weather insurance, and improved land and water use management and policies.

INDIAN AGRICULTURE UNDER CLIMATE CHANGE SCENARIO

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KEYWORDS: Climate change, Adaptation, Mitigation measures.

EXTENDED ABSTRACT:

In India, climate change could represent an additional stress on ecological and socioeconomic systems that are already facing tremendous pressures due to rapid urbanization, industrialization and economic development. With its huge and growing population, a 7500-km long densely populated and low-lying coastline, and an economy that is closely tied to its natural resource base, is considerably vulnerable to the impacts of climate change.

Studies conducted in the country have shown that the surface air temperatures in India are going up at the rate of 0.4^0C per hundred years, particularly during the post-monsoon and winter season. Using models, they predict that mean winter temperatures will increase by as much as 3.2^0C in the 2050s and 4.5^0C by 2080s, due to Greenhouse gases. Summer temperatures will increase by 2.2^0C in the 2050s and 3.2^0C in the 2080s.

Extreme temperatures and heat spells have already become common over Northern India, often causing loss of human life. In 1998 alone, 650 deaths occurred in Orissa due to heat waves. Climate change has had an effect on the monsoons too. India is heavily dependent on the monsoon to meet its agricultural and water needs, and also for protecting and propagating its rich biodiversity.
The arrival and performance of the monsoon is no insignificant matter in India every year, and is avidly tracked by the national department/organization. This is because most of the states in the country are largely dependent on rainfall either for rainfed agriculture or for irrigation. Any change in rainfall patterns poses a serious threat to agriculture, and therefore to the country's economy and food security. It is predicted that because of global warming, this already fickle weather system could become even more undependable. Semi-arid regions of western India are expected to receive higher than normal rainfall as temperatures soar, while central India will experience a decrease of between 10 and 20 per cent in winter rainfall by the 2050s. Agriculture will be adversely affected not only by an increase or decrease in the overall amounts of rainfall, but also by shifts in the timing of the rainfall. For instance, over the last few years, the Chattisgarh region has received less than its share of pre-monsoon showers in May and June. These showers are important to ensure adequate moisture in fields being prepared for rice crops. Agriculture will be worst affected in the coastal regions of Gujarat and Maharashtra, where agriculturally fertile areas are vulnerable to inundation and salinization.

Increased temperatures will impact agricultural production. Higher temperatures reduce the total duration of a crop cycle by inducing early flowering, thus shortening the `grain fill' period. The shorter the crop cycle, the lower the yield per unit area. In Rajasthan, a 2°C rise in temperature was estimated to reduce production of pearl millet by 10-15 per cent. The state of Madhya Pradesh, where soybean is grown on 77 per cent of agricultural land, could dubiously benefit from an increase in carbon dioxide in the atmosphere. According to some studies, soybean yields could go up by as much as 50 per cent if the concentration of carbon dioxide in the atmosphere doubles. However, if this increase in carbon dioxide is accompanied by an increase in temperature, as expected, then soybean yields could actually decrease. If the maximum and minimum temperatures go up by 1°C and 1.5°C respectively, the gain in yield comes down to 35 per cent. If maximum and minimum temperatures rise by 3°C and 3.5°C respectively, then soybean yields will decrease by five per cent compared to 1998. Changes in the soil, pests and weeds brought by climate change will also affect agriculture in India. For instance, the amount of moisture in the soil will be affected by changes in precipitation, runoff, and evaporation.

Due to rise in temperature the coastal states of Maharashtra, Goa and Gujarat would face a grave risk from sea level rise, which could flood land (including agricultural land), and cause damage to coastal infrastructure and other property. Goa will be the worst hit, losing a large percentage of its total land area. A one meter rise in sea level will adversely affect 7 per cent of the population in Goa, and cause damages to the tune of Rs 8,100 crore. In the state of Maharashtra, over 13 lakh people are at risk. The cost of damages for Mumbai, the business capital of India, is estimated to be Rs 2,28,700 crore.

Apart from monsoon rains, India uses perennial rivers, which originate and depend on glacial melt-water in the Hindukush and Himalayan ranges. Since the melting season coincides with the summer monsoon season, any intensification of the monsoon is likely to contribute to flood disasters in the Himalayan catchment. Rising temperatures will also contribute to the raising of snowline, reducing the capacity of this natural reservoir, and increasing the risk of flash floods during the wet season.

Food crop production in tropical and temperate regions is sensitive to changes in climate. Most of the world's supply of staple food crops such as rice and maize is produced in the tropics where climate can vary dramatically from year-to-year. Reliable seasonal forecasts of crop yield would be of real benefit to government planners, agri-business and farmers. Further ahead, the impacts of climate change also pose a serious threat to food security and need to be much better understood. Therefore, developing models that will be able to produce crop forecasts a season ahead is crucial for future food security, especially in very vulnerable regions. Under climate change, crops in many regions will be prone to environmental stresses not observed in today's climate. For example, by the end of this century short periods of hot temperatures that are found in some regions in the current climate will be found over a wider area. If these occur at flowering time, then the harvest of annual crops, such as groundnut and wheat, can be seriously reduced. As well as being influenced by weather and climate, crops and other vegetation can themselves exert an influence on regional and local climate. Current impact studies do not consider these feedbacks between crops and climate. We have quantified this response and so defined temperature thresholds for wheat and rice crops. With growing population there is increasing trend in food demands of wheat and rice ranging from 103.6 to 122.1 million tons for rice and 85.8 to 102.8 million tons for wheat in 2010 to 2020. The projected wheat production shows steady trend upto 2020 and thereafter it shows decreasing trend in all wheat growing regions of India. The Northern India shows slight increasing trend upto 2020 and thereafter decreasing trend of wheat production. Similarly eastern and rest of India also show decreasing trend.

Vulnerability to climate change varies across regions, sectors, and social groups. Understanding the regional and local dimensions of vulnerability is essential to develop appropriate and targeted adaptation efforts. At the same time, such efforts must recognize that climate change impacts will not be felt in isolation, but in the context of multiple stresses. In particular, the dramatic economic and social changes associated with globalization themselves present new risks as well as opportunities. Adaptive capacity for agriculture is considered to be an outcome of biophysical, socio-economic, and technological factors. This study deals with regional problems under climate change scenario and adaptation at the local, regional, and national scales to improve our understanding of current adaptation processes and options in Indian agriculture. It provides an estimate of current adaptive capacity and processes, and to help decrease vulnerability to future impacts of extreme events and integrated water nutrient and other cultural management planning for reducing vulnerability to water scarcity and higher water demand in the agricultural sector.

INFLUENCE OF CHANGE IN WEATHER ON PHENOLOGY AND GRAIN YIELD OF *KHARIF* SORGHUM AT PARBHANI IN MAHARASHTRA

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KEYWORDS: Crop weather relationship, Kharif Sorghum, Phenology, Yield.

ABSTARCT:

A field experiment was conducted at Department of Agricultural Meteorology farm to study the crop weather relationship in *Kharif* Sorghum**.** The variety CSH-9 was used for the experiment and the crop was sown on four different environments. It is observed from the seven years data (2002 to 2008) that the crop sown in MW 26 (25th June to 01 July) recorded highest grain yield followed by the crop sown in MW 24 (11 to 17th June). The highest yield was recorded due to optimum weather conditions prevailed during the crop growing period. The reduction in rainfall, its distribution and relative humidity and increase in temperature and sunshine hours reduces the grain yield of *Kharif* sorghum. The number of days required for attaining maturity reduces with delayed sowing due to increase in maximum temperatures and sunshine hours.

VARIABILITY OF RAINFALL AND CROPPING PATTERN CHANGES OF MAJOR KHARIF CROPS IN SEMI ARID TROPICS OF INDIA: A CASE STUDY OF ANANTAPUR AND MAHABUBNAGAR DISTRICTS OF ANDHRA PRADESH STATE

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KEYWORDS: Rainfall, Cropping pattern, Kharif crop, Semi arid tropics.

ABSTRACT:

The livelihood of more than sixty percent of the Indian population is from rainfed areas, where rainfall during monsoon season plays a vital role by limiting the option of crop diversification. The effect of monsoon rainfall variation on the national food grain production is high, with significant reduction in food grain production during deficit monsoon rainfall years. In the future also it would not be possible to provide irrigation for more than half of the existing cultivated area (Katyal, 1998). NATCOM report (2007) says that, monsoon rainfall is showing increasing trend along west coast, north Andhra Pradesh and northwest India and declining trend over east Madhya Pradesh, north-east India and parts of Gujarat and Kerala, however, at all India level no significant trend is observed. During the green revolution era, the production potential of irrigated regions, improved rapidly but in rainfed regions the progress was rather slow. For instance, in Andhra Pradesh State, Anantapur and Mahabubnagar districts still remain far behind the developed districts in respect of income, employment and living conditions (Planning Commission Report, 2004). Narasimha Reddy (2004) reported that the entire Anantapur district and 89 per cent of Mahabubnagar district are drought prone and percent-irrigated area to the net sown area is only 15 and 19

respectively, in these two districts. Further in the State of Andhra Pradesh, more than 75 percent of canal irrigation is available to Coastal Andhra followed by 17 percent in Telangana 7.5 percent in Rayalaseema regions (Planning Commission Report, 2004). This triggered the numbers of borewell and dugwell in Telangana and Rayalaseema regions, which in turn resulted in heavy depletion of ground water table. On the other hand, the cropping pattern as well as area under major kharif crops had also been changed in favour of water intensive / economically remunerative crops and creating problems of irrigation water and further depletion of ground water since last three decades in Andhra Pradesh. The most common and striking point is the wide gap in productivity levels of crops between irrigated and rainfed areas. Some strategies such as fertilizer and pesticide application, which have enhanced the production level in irrigated areas failed to produce the same impact in rainfed areas (Gadgil *et. al*., 2002). This may be attributed to abysmal level of economic position of the farmers over this region. Hence, it is imperative to find out strategies that can attain and sustain high levels of production in the rainfed regions, in the context of climatic variability/climate change. The climate change projection reported by Intergovernmental Panal on Climate Change (IPCC) depicts only macro level scenarios and there is a need t downscale and analyse them at regional and still further lower to study localized impacts on agriculture and allied sectors. Therefore, the present study has been taken up to find out the changes or variability in annual and monsoon seasonal rainfall and cropping pattern over Anantapur and Mahabubnagar districts of Andhra Pradesh. The results of 38 years of daily rainfall analysis revealed that the annual average rainfall is on the higher side in Mahabubnagar (638 mm) when compared to Anantapur (535 mm). Both districts are getting maximum amount of rainfall during southwest monsoon and Anantapur district receiving more rainfall in northeast monsoon season than Mahabubnagar district. In the other two seasons i.e. summer and winter seasons the rainfall amount is insignificant in these two districts. The maximum negative departure of southwest monsoon rainfall from normal was observed in 1994 (-57%) followed by 2002 (-51%) in Anantapur and in the case of Mahabubnagar, the maximum departure was noticed during 1994 (-47%) followed by in 2004 (-46%). The Mann-Kendall trend analysis showed no significant trend in Anantapur and Mahabubnagar districts for both annual and monsoon rainfall. The meteorological drought analysis during monsoon period revealed that the frequency of occurrence of mild drought is stable around three per decade during the last four decades (1971-80, 1981-90, 1991-00 and 2000-08) in Anantapur district but in Mahabubnagar district it is increased particularly in the last two decades. In the case of change in area under major crops during the last three decades, the area under paddy (staple food crop) has shown significant reduction in both the districts. The same is also noticed for jowar and millet crops with further steep declining trend. In contrast, the maize area has shown slight improvement in Anantapur and giant leap in Mahabubnagar particularly after 2000. Area of major kharif pulse crop redgram is increasing constantly in both the districts. There is tremendous increase in area of groundnut in Anantapur district (from 276 thousand hectares in 1971-80 to 762 thousand hectares in 2000-08) but opposite trend is seen in Mahabubnagar for the same crop. However, castor another oilseed crop, area has increased rapidly in Mahabubnagar district (from 81 thousand hectares in 1971-80 to 165 thousand hectares in 2000-08. Though variability in monsoon season rainfall influences the changes in the cropping pattern mainly but some other factors like demand for the particular crop, unavailability/paucity of agricultural laborers, better price and development of irrigation facilities also govern the interest of the farmers to go for a particular crop or cropping pattern. Detailed study has been carried out about the impact of the rainfall variability and related factors on cropping pattern changes in Anantapur and Mahabubnagar districts in this paper.

CLIMATE VARIABILITY AND YIELD FLUCTUATIONS OF SOME MAJOR CROPS OF JORHAT (ASSAM)

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KEYWORDS: Weather parameters, Monsoon season, Upper Brahmaputra Valley Zone, Rainfall variability.

ABSTRACT:

Rainfall is considered to be one of the most important and significant weather parameters is agricultural production. Its variability particularly during monsoon season is of great significance especially with reference to the north-eastern region of the country. Rainfall variability during the months of monsoon at Jorhat in the Upper Brahmaputra Valley Zone (UBVZ) of Assam was, therefore, studied . Rainfall data for about 105 years covering the period from 1901 to 2005 was analyzed for this purpose It is observed that there has been a decreasing trend in rainfall during the months of June and August. However, rainfall for the months of July and September were found to be relatively more stable. The impact of this variability in rainfall in the area has been reflected in the gradually decline in the yield of most of the important crops in the State. Decline in yield is observed to the tune of 15 to 25% in all major crops of the area including rice which is being the most predominant crop of Assam.

SEASONAL EFFECT ON REPRODUCTIVE BEHAVIOUR IN JAFFRABADI BUFFALOES

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KEYWORDS: Jaffrabadi buffaloes, Reproductive behaviour, Seasonal effect.

EXTENDED ABSTRACT:

Effect of different seasons on the number of animals coming to estrus and pregnancy was studied over a period of five years among pure jaffrabadi buffaloes with a view to establish seasonality if any in the breeding behavior of *Jaffrabadi* buffaloes. It was found that the estrus and the ensuing pregnancy was lowest during summer and rainy season and highest in autumn followed by winter thus there existed a significant difference with respect to these characters between seasons. The occurrence of estrus and pregnancy in various seasons was observed to be negatively correlated with temperature and relative humidity. The best reproductive performance in this breed during autumn may be due to lowest relative humidity.

ECOLOGICAL CONSEQUENCES OF HUMAN IMPACTS IN MAHI RIVER BASIN OF WESTERN INDIA

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KEYWORD: Deforestation, Drought index, Hydrological regime, Mahi river basin, Soil erosion, vegetation change.

ABSTRACT:

This study aims to reveal the consequences of human impact and climate variability on the tropical dry forests of the Mahi river basin, western India, over the past 3000 years. To date there has been little research to assess the impact of climate variability and human impact on the vegetation dynamics of this region. There has also been little work to link changes in vegetation cover to documented changes in the basin hydrology over the past 100 years – although it is assumed that the two are closely linked. The key objective of this research project therefore is to understand the driving mechanisms responsible for the abrupt changes in Mahi river basin as detailed in historical documentation. The Mahi river basin is located in western India (22° 11'-24° 35' N 72° 46'-74° 52' E). Mahi river arises in the Malwa Plateau, Madhya Pradesh near Moripara and flows through the uplands and alluvial plain of Rajasthan and Gujarat provinces before draining into the Gulf of Cambay. The plan is to use palaeoecological techniques (pollen, plant macrofossil and diatom records) on sedimentary sequences collected from lakes in the Mahi basin in order to reconstruct the vegetation changes and drought index for over the last 3000 years. It is also proposed to reconstruct the burning regimes through microfossil and macrofossil charcoal analyses and to examine soil erosion using geochemical analysis from the same sedimentary sequences. Historical documentation detailing changes in demography, climate and landscape use over the past 100 years in this region will also be collated to compare with the most recent palaeoecological records. The results provide a detailed record of vegetation change, changes in aridity, burning regimes and soil erosion in the region over the past 3000 years. This research study aims to determine the drivers of change and natural variability in the basin. Such information is essential for its current and future management including restoration.

PRODUCTION POTENTIAL OF WHEAT VARIETIES UNDER CHANGING CLIMATE IN RICE BASED CROPPING SYSTEM IN CHHATTISGARH, INDIA

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KEYWORDS: Production potential, Wheat, Rice based cropping system, Chhattisgarh.

EXTENDED ABSTRACT:

Wheat (*Triticum aestivum* L.) is an important cereal crop not only in the world but also in India under command irrigated area in Indo-gangatic plains and under controlled irrigated conditions in all the northern states. In Chhattisgarh, which lies in eastern Central India, wheat is grown in Mahanadi Reservoir Project, Hasdeo Bango command area and under assured irrigation in rice based cropping system. The sowing of wheat in the state is often delayed due to delay in harvesting of late duration rice varieties and thereby field preparation. Apart form the delayed sowing the productivity of wheat fluctuates considerably due to shorter winter span and temperature fluctuations. Late sown crop faces high temperature during ripening phase which can not be manipulated under field condition. However seeding time can be adjusted to fit the existing temperature best suited to different growth stages. The adverse effect of high temperature can also be minimized by selecting a suitable variety as the magnitude of yield reduction varies with varieties. Therefore, it is necessary to identify suitable thermal stress tolerant varieties of wheat for optimum productivity even under delayed sown conditions which can tolerate higher temperatures during reproductive and grain filling stages. In view of this a field experiment was conducted at Research farm, I.G.K.V., Raipur to assess the production potential of wheat varieties under different thermal regimes in rice based cropping system. To provide different thermal regimes six wheat varieties were sown on four different dates starting from 26th November to 26th December during the winter season of 2006-07 in a randomized block design with three replications. All the recommended cultural practices were followed to raise the crop.

The results revealed that all the growth, yield contributing parameters and grain as well as straw yield reduced considerably when the sowing was delayed beyond 6 December. Sowing of wheat on 26 November produced significantly higher grain yield as compared to sowing on 06, 16 and 26 December in decreasing order. This was due to favorable weather condition for optimum growth of early sown crop. Among the varieties Sujata and Ratan were found to be inferior then other varieties i.e. Kanchan, GW-273 Lok-1 and Arpa which were found identical to each other. Higher temperature during reproductive and grain falling in delayed sowing caused forced maturity of the crop and resulted in lower grain weight, less field grains/ ear head and ultimately lower yield. Wheat variety Kanchan produced higher yield under 26 November sowing followed by GW-273. Whereas, Lok-1 produced higher yield in 6 and 26 December sowing. Arpa also performed better under delayed sown condition. This showed that Lok-1 and Arpa were found to be more stable for delayed sown condition in rice based cropping system. The thermal stress by the crop plants is mainly expressed through its duration and plant height. To assess the thermal stress, thermal sensitivity index (TSI) and thermal stress status (TSS) have been developed. TSI was taken as the ratio of the difference in days taken for maturity to average duration and TSS was taken as the percentage decrease in plant height under different thermal environments. The duration of seedling, vegetative, reproductive and maturity phase decreased considerably when the sowing was delayed from 26 November to 06, 16 and 26 December. Similarly the growing degree days, photo thermal units and heliothermal units also decreased considerably. Different wheat varsities showed differential response in respect of above parameters. The duration of varieties are mainly governed by their genetic coefficient at the prevailing weather conations particularly temperature. Hence, wheat crop matured earlier under the agro climatic conditions of Chhattisgarh as compared to traditional wheat growing areas, which ultimately resulted into lower yield potential.

To have an idea of the effect of changing climate on wheat productivity, crop simulation model, CERES-Wheat has been used to simulate the effect of climate change on wheat productivity. The results showed that anthesis, physiological maturity, biomass, grains per ear and grain yield were highly sensitive to change in temperature. The biomass and grain yield decreased at varying degree ranging from 7 to 44 % in case of biomass and from 10 to 48 % in case of grain yield, when the temperature was increased in the range of 1 to 3 ^{o}C. When temperature was decreased up to 3 ^{o}C, the increasing trends in the biomass and grain yield were observed to the tune of 20 to 80% and 19 to 79%, respectively.

MODERN TENDENCIES OF CLIMATE, LAND COVER AND LAND USE CHANGES IN STEPPE ZONE OF KAZAKHSTAN

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KEYWORDS: Land Cover/ Land Use, Long term, Landsat, Vegetation condition, Kazakhstan.

EXTENDED ABSTRACT:

The Kazakhstan is the great Eurasian country with the cropland size more then 200 thousands sq. km. The satellite monitoring of the Kazakhstan steppe zone represents the special interest. The steppe lands are traditionally used for the grain production that promoted by the favorable soil types: chernozems and dark-chestnut. The agricultural production of a steppe zone of the Kazakhstan is presented by the monoculture cultivation of the spring wheat and barley on the great fields (400 hectares) that creates exclusively favorable conditions for the satellite data application.

In this research the satellite data during 1985-2008 years were analyzed. The four LANDSAT images were used as a basis (July 1986, November 2000, June 2001 and 2007). MODIS-monitoring (2001, 2007) was used for the definition of the field land use types. NOAA/AVHRR/NDVI data during 1985-2008 were used for the estimations of a vegetation condition. The instrumental registration of the climate change impact is a complex. Variations of the years' weather conditions are typical for the steppe zones. The droughts are replaced by the humidified years that masks the long-term tendency caused by the climate change impact.

The test site is located within the Kostanay province of the Northern Kazakhstan (LANDSAT WRS2 path 160 row 24). On this territory there are the hundreds of the lakes, the majority from which salty. The steppe lake state depends on the two key parameters. The first is a long-term humidity regime: rainfall, temperature, evaporation. The second is the calendar date of an estimation of a lakes state. The spring (freshet) lake size maximum, with water reduction by the end of a season is usually observed. The lake size has been chosen as the parameter connected with a long-term humidity regime of site. The lakes state and its changes are easily registered on LANDSAT images. It has been made the three comparative estimations: July 1986 against November 2000; July 1986 against June 2001, July 1986 against June 2007. All lakes were ranged on 3 classes: increased, stable, decreased. The simple scheme of the analysis should provide the small bias in the satellite estimations of the lake system changes.

The typicalness of the weather conditions of 1986, 2000, 2001, 2007 years is the important factor providing a results reliability. NOAA/AVHRR/NDVI monitoring in the form of the vegetation indexes - VCI [Kogan] and IVI [Spivak], were used for the analysis of the average vegetation conditions in these years. It has been shown; that 1986 entered during droughty years (1985-1988), but on the vegetation condition essentially was not allocated. 2000, 2001 and 2007 years have got during rather raised humidifying, also, not being allocated with an abnormal vegetation condition among other years of this period. The results have shown that the majority of the lakes in site have a modern tendency in the sizes increase. Even at the comparison of a years condition (July 1986) with an autumn level (November 2000). There demonstrates the presence of a humidity increase trend as the result of the modern climate change impact.

The cropland masks for 1986, 2001 and 2007 years have been constructed with help of the photointerpretation of LANDSAT-TM (1986) and MODIS (2001, 2007) data. A key attribute of the land use type recognition to MODIS data was the tilling registration and date of its carrying out. The spring tilling procedure was an attribute of the annual spring cultures, summer ones does the fallow fields. The grain crops in a season of 1986 occupied the area about 10 thousand sq. km (42 % from site territory). The land use has dramatic changes that have been caused by the disintegration of Soviet Union (1991). The cropland area in a season of 2001 has made only 36 % from a level of 1986. In season of 2007 year the some improvement of the agriculture parameters was observed. The cropland area size has increased up to 45 % from a level of 1986.

The Kazakhstan government declares the purpose of the cropland areas increase in the nearest years for 70 thousands sq. km. In this connection the abandoned land ranging for the optimization of their return to a crop rotation becomes the important task. The period of 2001-2007 years was characterized for the site by the different processes in agricultural land using. Approximately 550 sq. km of arable land it has been deduced from a crop rotation, and 1200 sq. km of abandoned land it has been again involved in the use. Such situation allows using the changed type lands as the etalons for the search of the parameters for abandoned land ranging.

In site the distance up to the nearest lake has been certain as the key agriculture landscape attribute, allowing ranging the abandoned land on a degree of usefulness of the cultivation of the grain crops. The optimum range of the minimal distances up to lake is certain, is lead the agriculture landscape rayoning of the abandoned land in site. The additional parameter describing the arable land can be their ability to produce a green biomass. The archives of the 10-day's composites of NOAA/AVHRR/NDVI during 2000-2008 and the integrated vegetation index (IVI), describing seasonal a green biomass productivity, were used for creation of the corresponding maps for cropland and abandoned land of the site territory. Research was conducted with support from NASA LCLUC program (grant NNG06GF54G).

USING GBIF TO ASSESS THE LIKELY IMPACT OF CLIMATE CHANGE ON WILD RELATIVES OF MAJOR FOOD CROPS

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KEYWORDS: Climate change, Wild relatives, Biodiversity, Suitability, Changes.

EXTENDED ABSTRACT:

Primary biodiversity records accessible through the Global Biodiversity Information Facility (GBIF) portal can be coupled with modeling and earth observation to assist in decision-making to conserve wild genetic resources. This is critical to maintaining food security in the face of significant threats to genetic diversity from climate change.

Wild relatives of modern and traditional crops have proved to be a useful source of genes for crop breeding for developing resistance to a range of biotic and abiotic stresses. The wild relatives harbor an abundant supply of useful genes, and thanks to molecular biology, demand for wild relatives in crop improvement programmes is on the increase as it becomes easier to introduce useful traits without also introducing a number of undesired traits that wild relatives also tend to contain. A significant proportion of these invaluable genetic resources have already been lost due to anthropogenic activities such as expansion of agricultural systems, overgrazing, burning, oil and gas exploitation, infrastructural development, and urban development, and these pressures are increasing.

The IPCC Fourth Assessment Report states that changes in climate will turn currently suitable environments into stressful environments for a number of species, from which the most endangered are those that survive in the wild. Global temperatures are predicted to increase between 2-6ºC within the next 100 years, while precipitation patterns (in terms of intensity, and temporal and spatial distribution) will variously shift towards extremes of wetting and drying depending on the region. This will have profound effects on agriculture, creating new challenges for society, but also on biodiversity of which crop wild relatives are one important component. It is therefore paramount that as climates change we develop long term conservation strategies that can conserve crop wild relatives through both *in situ* (protected areas, on farm) and *ex situ* (seed storage in genebanks) mechanisms.

We present analyses on the impacts of climate change on 17 wild genepools from 16 of the most agriculturally important crops worldwide: cassava, groundnut, potato, rice, chickpea, common bean, barley, cowpea, wheat, maize, sorghum, pearl millet, finger millet, pigeon pea, faba bean, and lentil. We analyzed 28,751 herbarium and genebank species occurrences accessible through the Global Biodiversity Information Facility (GBIF) for 643 wild taxa belonging to the 17 genepools. We used a maximum entropy climate envelope model to create distribution maps for each species under current climates using the WorldClim database. We then projected the likely shift in geographic distribution using 18 statistically downscaled Global Climate Models (GCM) from the fourth and third IPCC assessment reports, under the emission scenario A2 (business as usual). We modeled the geographic shifts under three different migration scenarios (unlimited dispersal, no dispersal, limited dispersal). We describe the impacts of climate change by identifying the hotspots at the continental level in terms of the percent of area losing species diversity, and determine the most threatened genera and species. The results are used to indicate areas that should be prioritized for either *ex situ* and *in situ* conservation or both.

The greatest current species diversity was found within Sub-Saharan Africa, Asia, Latin America and Australia, with the Caribbean being the least diverse (in terms of the taxa under analysis). The suitable geographical area for all species will change significantly. Assuming unlimited dispersal, globally, 53% of the areas were found to be losing at least one suitable species, with Sub-Saharan Africa being the most negatively impacted (reaching losses of 15 species in some areas) and North America being the least negatively impacted area (with a maximum loss of 6 species). The overall change of species diversity (richness) ranges between –21 and 14 wild species, with significant losses in Sub-Saharan Africa, northern Australia, the Mediterranean basin, eastern Turkey, and some parts of Mexico, which we consider are key areas for further conservation of plant genetic resources.

A concerted conservation effort is needed to address the possible extinction risks that may come from climate change, particularly in wild species and especially for those taxa more likely to provide novel adaptations to biotic and abiotic stresses or those that are not adequately represented in genebanks. *Ex situ* conservation efforts should start in those areas that currently hold a considerable amount of diversity, and in which changes in species diversity will be of high significance. Evaluations of the status of *ex situ* collections and *in situ* conservation (gap analyses) of wild relatives of important food crops and vulnerable wild genepools are also needed to assess priority species and areas to be conserved either *ex situ* or *in situ*.

IMPACT OF CLIMATIC VARIABILITY ON HIGH-PRODUCTIVITY WHEAT REGIONS OF PUNJAB

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KEYWORDS: Wheat, Productivity, Punjab, Extreme climate events.

EXTENDED ABSTRACT:

Recent evidence clearly show significant changes in inter and Intra-seasonal climatic variability in the Indo-Gangetic plains of South Asia. The occurrences of extreme climatic events, such as gradual rise in minimum temperature during specific growth period of rice and wheat have shown increase in the last couple of decades. The increased variability in winter rainfall fluctuates the winter crops productivity in north-western parts of India. Continuous or abrupt change in minimum temperature along with increased variability in rainfall during winter is one of the causes of stagnation/or decline of wheat yields in Doab region of Punjab (Wheat bowl of India). We have collected block wise yield data of wheat, soil & water parameters of last 20 years to observe the spatial-temporal change in productivity and its relationship with determining factors. The Punjab state was divided into seven productivity zones ranging from 1000 to 6500kg/ha (low to high). Kriging interpolation method along with different geo-statistical analyses were performed to achieve spatial pattern of change in soil, water and productivity levels. Initial results of study indicate that climatic fluctuations have high negative correlation with high productivity zones (Doab region). Productivity of wheat is declining mainly in high-productivity zones (parts of Ludhiana, Patiala, Amritsar, Jalandhar and Kapurthala, Fatehgarh Sahib and Sangrur districts). However, khandi regions (terai & foot hills of lower Himalayan range) are having increasing trend in wheat productivity due to favorable change in temperature, technological interventions, and development of irrigation facilities. Overall, the yield gap among different regions of Punjab is bridging due to increase in productivity in low and medium productivity zones.

IMPACT OF CLIMATE CHANGE ON SOIL DEGRADATION PROCESSES

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KEYWORDS: Soil erosion, SOM degradation, Salinization, Soil moisture, Desertification.

EXTENDED ABSTRACT:

Climate change may cause direct effects such as change in abiotic soil factors such as available moisture, soil nutrients, temperature and soil biotic factor such as microorganism responsible for decomposition activity and nutrient cycling. Climate change may likely will alter the micro-climate and may have impact on soil flora and fauna their growth, population, interaction with other species and further their ecological function. Climate parameters such as rainfall and temperature are mainly responsible to change in soil processes at different scale. Climate change may affect key soil processes such as respiration, mineralization and thus the key ecosystem functions such as corbon storage and nutrient cycling. Soil temperature and moisture will largely influence fauna activities responsible for decomposition and nutrient cycling in the soil. The soil microbial community is involved in numerous ecosystem functions such as nutrient cycling and OM decomposition and plays an important role in the terrestrial C-cycle.

Sustainability of soil, soil quality and climate change are closely linked phenomenon and are key global issue. Climate change may result significant consequences on soil degradation processes . Land degradation is one of the important problems related to sustainability of natural resources. Degraded soils loss their capacity to produce crops due to processes such as soil erosion, nutrient runoff, leaching losses, acidification, desertification, salinization, organic matter reduction and accumulation of toxic substances.

Soil erosion: Soil and water resources are managed at watershed scale for sustainable crop production. Watersheds severely degraded due to soil erosion are expected to most affect by climate change. The relationship of climate to erosion will depend on the effect of climate at

different scales. Rill erosion is directly related to the amount of precipitation. The severity, frequency and extent are likely to be influenced by change in amount and intensity due to climate change. Soil erosion may results in loss of organic matter and reduction in water holding capacity which may tends to increase the magnitude of nutrients and water stress. Water holding capacity of soil is most affected due to degradation and affects soil moisture availability to plant growth. Alteration in timing and distribution of rainfall pattern and its intensity due to climate change may significantly affect watershed response for sustainable agriculture. In drought prone and low fertile soils, its effect will be aggravated due to erosion. Soil erosion and degradation are likely to aggravate the detrimental affects of rise in air temperature on crop yield. Climate change may increase erosion in some regions, through heavy rainfall and increased wind speed. Wind erosion may increase sharply due to reduction of organic matter as result of increased oxidation as of rise in temperature. It will lead to loss of soil productivity through removal of nutrients rich surface soil.

SOM degradation: Soil Carbon sequestration plays an important role in mitigating climate change impact. SOC stock is major sink of carbon and plays major role in C-cycle. SOM status in soil govern soil fertility, nutrient availability, water holding capacity, physical conditions, soil structure, soil tilth etc. SOC sequestration governed by soil texture, soil moisture, temperature and soil nutrient availability. Predicted increased air and soil temperature can be expected to increase the mineralization rate of soil organic matter. It may lead in the long term of negative effects on structural stability, water holding capacity and nutrients availability. Climate change is likely to affect SOM dynamics and susceptibility to erosion. Dry land soil predicted to severely deteriorate its quality. High temperature and low precipitation in the dry lands lead to poor organic matter production and high oxidation. Climate change will aggravate the problem of soil erosion in most part of the world. Climate change will results or necessitates change land use and agricultural management practices that may likely will increase severity of soil erosion. Soil erosion will impact on SOM sequestration and nutrient cycling will affect plant growth and soil potentiality.

Salinization: Land degradation problems such as water logging, salinity and sodicity development, are emerging due to rapid land use pattern and land cover changes. In coastal area, coastal aquifers are important source of fresh water. Due to excessive use of fresh water for agriculture and horticultural purposes may result fall in fresh water table below sea level, therefore, water from sea will flow and replace fresh water volume. De to rise in temperature, evaporative demand for water will increased and matter will be worse and salinity area may increase. There may also be salinity intrusion due to rise in sea water level due to increase in temperature. Climate change will significantly alter ground water recharge rates of major aquifers in function of the reduction of ground water recharge and result in a reduction of fresh ground water resources. The effect of rise in temperature in salt affected area will increase the severity of salinity on plant growth. Due to high temperature, evaporative demand od of plant will increased and will tend to increase transpirational volume flow which will tend to salt damage to plants.

Soil Moisture: Changes in rainfall due to a climate change may affect surface moisture availability, which becomes for germination and crop stand establishment in the rainfed areas. Modifications in the surface and ground water availabilities with the rainfall change seen difficult to notice when the land use and land cover is so rapidly changing. Soil processes, relating to moisture availability in relation to climate change have not been studied in depth as for instance, modifications of soil structure and associated moisture retention, release and transmission characterisics

Desertification: Desertification results from various factors, including climatic variations and human activities which lead to the diminution or destruction of the biological potential of land which can ultimately lead to desert like conditions. It reduces the biological or economic productivity resulting from land uses or a process of combination of processes of soil degradation resulting in determination of the physical, chemical and biological properties of the soil or long term loss of natural vegetation. Climate change might exacerbate desertification through alteration of spatial and temporal patterns in temperature, rainfall, solar radiation and winds. Several climate models have predicted that rise in temperature will reduce soil moisture and negatively affect vegetation growth. High temperature and low rainfall in the drylands lead to poor organic matter production and rapid oxidation. Low organic matter will lead to poor aggregation and low aggregate stability leading to a high potential for wind and water erosion. It may cause in increase in area under desert land.

RECENT TRENDS IN CLIMATE AND IMPACT OF CLIMATE CHANGE ON FOOD SECURITY OF NORTH WEST INDIA

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KEYWORDS: North West India, Rice, Wheat, Multiple linear regression models, Climate change impact.

EXTENDED ABSTRACT:

North West India is part of the food bowl of the country contributing to its food security and rice-wheat cropping system, among others, is the major production system followed. Besides ecological, technological and socio-economic drivers, climate change/variability has become an important determinant of crop yields in this region. In this study, an attempt has been made to (a) quantify the recent climatic trends and climate variability in North West India, (b) develop sensitivity models of crop yield to climatic elements and (c) using these models for impact assessment of future climate change. The homogenous monthly rainfall and maximum (Tmax) and minimum (Tmin) temperatures for past 40 years were used to determine climatic trends/variability. Using regression techniques, linear trends were fitted to the time series of weather variables at monthly, seasonal (Kharif & Rabi) and annual time scales. The slope of the trend gave the annual rate and direction of change. For trend in climate variability, changes in maximum and minimum values and coefficient of variation (CV) for each five-year period were computed. Using district level historical rice yield and monthly rainfall, Tmax and Tmin for five stations, multiple linear regression models of yield sensitivity to climatic variables were developed after segregating the effect of technology These models were used with future climatic anomalies as per six IPCC SRES Scenarios for 2020, 2050 and 2080 generated by Hadley Centre global climate model HadCM3. The required climatic anomalies forecast were input into the crop sensitivity model for each station and the impact on yield was calculated in terms of change in crop yield from technological determined yield level. Both Tmax and Tmin showed increasing trends at annual, kharif and rabi time scales with different rates. The rate of increase is significantly higher during kharif than during rabi for Tmax and vice-versa for Tmin. The variability of Tmax, in terms of CV, increased for both kharif and rabi seasons, whereas variability of Tmin increased for kharif and decreased for rabi season. At annual and seasonal scales, rainfall did not show any significant trend but at monthly scales during monsoon, it showed significant increasing trend during June, no change during July, and a significant decreasing trend during August and September. The results of the climate change impact assessment showed that in general rice and maize yields will be adversely affected in future in this region. The range of rice yield reduction from technological determined level may range from 7% in 2020 to 25% in 2080. No significant impact was found on wheat yields in this region.

CLIMATE CHANGE IMPACT ON AGRICULTURE PRODUCTION IN INDO-GANGETIC PLAIN OF INDIA

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KEYWORDS: Indo-gangetic plain, CERES, CANEGRO, A2 scenario, RegCM3, Adapation.

EXTENDED ABSTRACT:

With the growing recognition of the possibility of climate change and clear evidence of observed changes in climate especially disasters such as drought, flood, heat and cold wave during 20th century, an increasing emphasis on food security and its regional impacts has come to forefront of the scientific community. In recent times, the crop simulation models have been used extensively to study the impact of climate change on agricultural production and food security. The results obtained by the models can be used to make appropriate management decisions and to provide farmers and others with alternative options for their farming system. In the present study validated CERES and CANEGRO simulation model has been used to simulate the impact of climate change on rice, wheat and sugarcane crop in Indo-gangetic plains of India. The projected A2 scenario from RegCM3 climate model for the Indo gangetic plains have been used in the present study. The result obtained on the adaptation options for reducing the negative impacts of climate change indicates that the delaying of sowing dates and development of new varieties would be favorable for increased yields.

CLIMATE CHANGE IMPACT ANALYSIS ON CROP GROWING PERIODS AND RICE YIELDS OVER INDIA

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KEYWORDS: Variability, Rainfall, Temperature, Rice yield, Crop growing period.

ABSTRACT:

The study investigated the trends and variability of rainfall, maximum and minimum temperatures over India right from 1871 to 2006 in case of rainfall and 1901 to 2003 for the later two elements. Using the concept of Higgins and Kassam (1981), the crop growing periods are obtained over India and are compared to understand the climate change mechanism involved during the recent decades and globally teleconnected years as well. The study revealed the decline in the humid days during the prevalence of El Nino where as a substantial increase during La Nina. The final part of the paper involves in relating the rainfall, maximum temperature, minimum temperature variations to the interannual variability of rice yields which could be the manifestation of altering crop growing periods over India.

IMPACT OF RAISING TEMPERATURES ON YIELDS OF DRYLAND GROUNDNUT IN SOUTHERN AGROCLIMATIC ZONE OF ANDHRA PRADESH

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KEYWORDS: Raising temperature, Groundnut, Water requirement, Yield.

ABSTRACT:

India is divided into different agroecological zones which induce varied stability in crop productivity due to climatic change. In India 60% of agricultural areas are under drylands. There is considerable uncertainty associated with productivity of dry lands due to present climatic change. Any observed or predicted temperature changes fundamentally concerned in concurrent changes in other variables such as rainfall, humidity, wind ect., there by influencing the crop growth. To asses the impact of raising temperatures on evapotranspiration and water requirement of *kharif* groundnut crop a study was conducted in dryland alfisols of Southern Agroclimatic Zone of Andhra Pradesh. In this study, the rise in evapotranspiration was computed by modified Penman empirical method with the predicted temperatures of 1, 2, 3 and 4^o C raise above the normal temperatures and same was utilized in estimating water requirement of kharif groundnut crop. The research results showed that each degree of enhancement of temperature over and above the normal temperature enhances the evapotranspiration loss by 1-2 mm/day, cumulatively hiking the water requirement of the crop by 20-25 % with 8-12 % yield reduction.

MITIGATION AND ADAPTATION TO CLIMATE CHANGE IN RICE-WHEAT SYSTEM WITH RESOURCE CONSERVING TECHNOLOGIES

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KEYWORDS: Mitigation, Adaptation, Resource conserving technologies, Zero tillage, Direct seeding, Crop diversification.

EXTENDED ABSTRACT:

Climate change poses serious threats to productivity and sustainability of the rice-wheat cropping system, the backbone of food security of south Asia. Conservation agriculture involving continuous minimum mechanical soil disturbance, permanent organic soil cover and diversified crop rotations provides opportunities for mitigating greenhouse gas emission and climate change adaptation. Recent research efforts have attempted to develop resource conserving technologies (RCTs), which are more resource efficient, use less inputs, improve production and income, and reduce greenhouse gas (GHG) emission compared to the conventional practices. Resource conserving practices like zero-tillage (ZT) can allow rice–wheat farmers to sow wheat sooner after rice harvest, so the crop heads and fills the grain before the onset of pre-monsoon hot weather. As average temperatures in the region rise, early sowing will become even more important for wheat. Field results showed that the RCTs are increasingly being adopted by farmers in the rice-wheat belt of the IGP because of several advantages of labour saving, water saving, and early planting of wheat. The RCTs in rice-wheat system has pronounced effects on mitigation of GHG emission and adaptation to climate change. It has been showed that global warming potential (GWP) varied between 2290 kg CO_2 eq. ha^{-1} in direct drill-seeded rice and wheat on beds and 3680 kg CO_2 eq. ha^{-1} in conventional puddled transplanted rice and tilled wheat. Compared to the conventional practice all the RCTs reduced the GWP by 13 to 38%. Yields of rice and wheat in heat and water-stressed environments can also be raised significantly by adopting RCTs, which minimize unfavorable environmental impacts, especially in small and medium-scale farms. Specific impacts of various RCTs on GHG mitigation and climate change adaptation are briefly discussed below.

Zero tillage: Conventional land preparation practices for wheat after rice involve as many as 10-12 tractor passes. This enhances emission of carbon dioxide from soil. In zero tillage combined with residue retention on surface, C is sequestered in soil. Changing to a zero-till system on one hectare of land would save 98 L of diesel and approximately 1 million L of irrigation water; this represents about a quarter ton less emission of carbon dioxide, the principal contributor to global warming. However, impact of zero tillage on methane and N_2O emissions have showed contrasting results with lower, equal and higher compared to the conventional systems depending upon the soil type and water management. Zero-tillage allows rice-wheat farmers to sow wheat sooner after rice harvest, so the crop heads and fills the grain before the onset of pre-monsoon hot weather. As average temperatures in the region rise because of climate change, early sowing will become even more important for wheat.

Laser-aided land leveling: Laser leveling of uneven field reduces water use allowing crop to grow in water-limited condition. It also reduces fuel consumption because of efficient use of tractor and reduces GHG emission, particularly carbon dioxide. Besides, several other benefits such as operational efficiency, weed control efficiency, water use efficiency, nutrient use efficiency, crop productivity and economic returns and environmental benefits are also has been reported due to laser-aided land leveling compared to conventional practice of land leveling.

Direct drill seeding of rice: Direct drill seeding of rice (DSR) could be a potential option for reducing methane emission. Methane is emitted from soil when it is continuously submerged such as in case of conventional puddled transplanted rice. However, DSR crop does not require continuous soil submergence, thereby either reducing or totally eliminating methane emission when it is grown as an aerobic crop. Moreover, deeper root growth of DSR crop provides better tolerance to water and heat stress. Besides, the unpuddled soil in DSR does not crack with moisture stress whereas the puddled soil develops cracks, which reduces yield significantly even after providing irrigation.

Crop diversification: Diversification i.e., growing a range of crops suited to different sowing and harvesting times, assists in achieving sustainable productivity by allowing farmers to employ biological cycles to minimize inputs, maximize yields, conserve the resource base, reduce risk due to both environmental and economic factors. The RCTs such as bed planting and zero tillage expand the windows of crop diversification. The farmers of the rice-wheat belt have taken the initiative to diversify their agriculture by including short duration crops such as potato, soybean, urd, mungbean, cowpea, pea, mustard, and maize into different combinations. Such diversification would not only improve income, employment and soil health but also reduce water use and GHG emission and more adaptability to heat and water stress.

Raised bed planting: In raised bed planting a part of soil surface always remains unsubmerged and aerobic. Thus it not only reduces water use and improves drainage but also reduces methane emission. Crops on beds with residue retained on surface is less prone to lodging and more tolerant to water stress, thereby making it more adaptable to unfavourable climate.

Leaf colour chart: The most efficient management practice to maximize plant N uptake and minimize N losses is to synchronize supply with plant demand. The strategy to achieve this objective is site-specific nutrient management that includes site-specific quantitative knowledge of crop nutrient requirements, indigenous nutrient supply, and recovery efficiency of applied fertilizer N. A practical way of site-specific N management is leaf colour chart (LCC)-based N application. It provides a simple, quick and nondestructive method of N fertilizer application.

Some of the RCTs are being adopted by the farmers of the Indo-Gangetic Plains (IGP) on large scale, which would help farmers in combating climate change to a considerable extent. However, there are uncertainties in assessing the impacts of RCTs on GHG mitigation and climate change adaptation under different agro-climatic and management conditions. These uncertainties need to be reduced by developing mechanistic simulation models using exhaustive data on soil, climate and crop management.

MITIGATING METHANE EMISSION IN RICE WITH RESOURCE CONSERVING TECHNOLOGIES

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KEYWORDS: Resource conserving technologies, Rice, Methane emission.

ABSTRACT:

Rice-wheat system is the main source of food and income for millions of people in south Asia. But evidence is now appearing that productivity of the system is plateauing because of a depleted natural resource base. Recent research efforts have attempted to develop resource conserving technologies (RCTs), which are more efficient, and use fewer inputs compared to the conventional practices. However, not much information is available to quantitatively evaluate the RCTs in terms of greenhouse gas (GHG) emissions. A field study was conducted during summer 2006 at Tilda Riceland in Samana Bahu village of Karnal to evaluate the effect of different RCTs (tillage and crop establishment methods) on methane emission from rice (var. Pusa Basmati-1) fields. Treatments consisted of reduced till direct seeded rice with sesbania (RT-DSR+S) and without sesbania (RT-DSR-S), conventional puddled transplanted rice (CT-TPR) and un-puddled transplanted rice (RT-TPR). Gas samples were collected using the closed chamber technique and methane concentration was measured using a gas chromatograph equipped with a flame ionization detector. Higher rate of methane emission was observed in CT-TPR followed by RT-TPR, RT-DSR-S and RT-DSR+S. The RT-DSR-S and RT-DSR+S were similar in term of methane emission. Methane emission mitigation, compared to conventional practices (CT-TPR), ranged from 18% in RT-TPR to 85% in RT-DSR+S. Lower methane emission in DSR was due to alternate wetting and drying of fields whereas in CT-TPR the field was continuously submerged for the entire period of rice growth. The direct-seeded rice treatment (DSR) used 55% less irrigation water with 22% reduction in grain yield compared to CT-TPR. Irrigation water productivity was 42% less in TPR as compared to DSR. Furthermore, DSR with S*esbania* brown manuring (RT-DSR+S) showed higher water productivity than RT-DSR-S. The study showed that DSR has good potential for methane mitigation and water conservation; however, efforts need to be made for improving its yield.

IMPACT OF CLIMATE CHANGE ON PRODUCTIVITY OF RICE-WHEAT CROPPING SYSTEM IN THE INDO-GANGETIC PLAINS

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KEYWORDS: Indo-gangetic plains, Rice-Wheat cropping system, Long term experiments.

EXTENDED ABSTRACT:

Rice and wheat, the major cereal crops of the Indo-Gangetic plain (IGP) of South Asia, grown in rotation in 13.5 million hectares are the principal source of food, nutrition and livelihood security for several hundred millions of people in the region. The yields of these two cereal crops have shown either declining or stagnating trends. The total factor productivity is declining because of (a) extreme events (b) climate change and its variability, (c) nutrient mining and water depletion, and (d) soil degradation. Inter-and intra-seasonal climatic variability and occurrences of extreme climatic events, such as drought, floods, have increased more recently. The annual mean warming by 2020 is projected to be between 1.0 and 1.4°C, and may rise to 3-4°C towards the end of 21st century. Temperature in the IGP is touching the critical limits observed for major food grain crops (rice and wheat) and further increase in temperature will adversely affect the yields of rice and wheat.

Monitoring the long term effect of climate change can be accessed by identifying the associated factors and their change over the period. Long term experiments (LTE) provide unique opportunity to study the changes in the grain yield in conjunction with changes in soil (OC, P, K and micro nutrient) and climatic parameters. We are analyzing rice-wheat LTE (varying from 25 to 30 years) data collected from 30 locations from the Indo-Gangetic plains of India, Bangladesh and Nepal to assess effect of climatic variability on historical yield trends of rice and wheat.

Long term (35-50 years) district average yields of rice and wheat are collected from IGP for obtaining the yield trends. Downscale futuristic climatic scenarios will be generated using the PRECIS model to identify the vulnerable regions. Tropopheric NO_2, hypersepctral and multi-spectral remote sensing data will be used to estimate crucial climatic parameters to bridge the gap of data availability e.g concentration of troposphere gases (eg.CO_2 / NO_2) and land use/land cover etc. The study is utilizing the Earth observation, GIS techniques and simulation models to integrate bio-physical and socio-economic parameters and thereby providing the site specific solutions to vulnerable regions in terms of climate change.

REMOTE SENSING IN CARBON DYNAMICS OF CROPLAND

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KEYWORDS: NDVI, Biomass, LAI, Carbon sequestration.

ABSTRACT:

The potential of cropland to sequester carbon and mitigate the green house effect have not been recognized by the policy markers yet. Though considerable scientific information has been collated about the potential of agricultural lands to sequester carbon, the available information has not been synthesized in a form that land managers readily can use to mitigate CO_2 emissions. In this paper we briefly bring out the significance of remote sensing technique in assessing the carbon dynamics in croplands of Nandod taluka. This technique cannot directly monitor soil carbon dynamics but it helps in providing information on a number of crucial inputs like biomass, LAI, PAR, etc. Spectral vegetation indices such as the normalized difference vegetation index (NDVI) have been shown to be useful for indirectly obtaining information on such parameters. Simple linear relationships developed between NDVI versus two such parameters viz., Biomass and LAI have shown a high associations varied from 0.6 to 0.9 for the different sites studied in the study area. These parameters contribute to the active soil organic matter of the cropland and have therefore aided in understanding the carbon dynamics of agriculture lands.

ECONOMIC IMPACTS OF CLIMATE VARIABILITY AND RESOURCE MANAGEMENT OPTIONS IN CROP PRODUCTION

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KEYWORDS: Agro meteorological Advisory Service, Economic impact, Extreme weather.

EXTENDED ABSTRACT:

Weather forms an important determinant in crop production, especially in agricultural economies which are more dependent on natural systems. Agro meteorological Advisory Service (AAS) based on weather forecasting is a viable risk management strategy to minimize the shocks due to adverse weather conditions. This paper tries to make estimates of economic impact of extreme weather events in two major crops of Kerala, which are important to the marginal and small farming community viz. coconut and banana. The estimate is made following the method suggested by Fernando et al 2007. Further we attempt to assess the impact of AAS on farm output and income through the analysis of economic efficiency in resource use (Cobb-Douglas Model). The personal and household factors that influence the decision making on the adoption of management practices as per AAS are also identified by adopting statistical analysis(tobit model).The data for the paper is drawn from the project *Economic Impact Assessment of Agrometeorological Advisory service on Different Crops*.The farmers who followed the advisory services could sizably reduce the risk of economic loss due to extreme weather events, and their average additional gains in output were higher by 11-12 % in these crops. The analysis shows significantly better economic efficiency in the farms that follow AAS compared to those who do not. However, the analysis suggests a reallocation of resources for realizing better farm efficiency. The results suggest the prospects of including economic criteria in developing management plans in AAS for improving the allocative efficiency of resources. It also helps in streamlining extension strategies for effective transfer of information.

AN APPROACH TO IDENTIFY FAVORABLE PHENOLOGICAL ZONES IN VELLORE DISTRICT, TAMIL NADU BY INTEGRATION BIOPHYSICAL AND AGRO METEOROLOGICAL VARIABLES

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KEYWORDS: MODIS NDVI, Agrometeorological variables, Phenological zones.

ABSTRACT:

Spectral vegetation indices profusely play a pivotal role on the status of the crop. The aid of MODIS A09 offers 8 day clear-sky composite images of surface reflectance and has been validated extensively for scientific application and using this, vegetation indices product derived such as NDVI might provide the crop condition in a near real time manner. Therefore a well vegetated area of Vellore district, Tamil Nadu with different crop type and agrometeorological variation was selected for this study. The study is aimed at regressing spectral indices to agrometeorological variables in extracting favorable phenological zones from the study area. We developed a methodological approach of integrating biophysical variables extracting the MODIS NDVI product from the website for entire season with agrometeorological variables (Tamx, Tmin, Rainfall) for this study, Gridding the study area as 5km*5km has given a spatial pattern of the crop type vegetation distribution and its variation. Collecting, manipulating and interpolating the agrometerological variables such as Tmax, Tmin, Rainfall of the study area and overlaying with the MODIS NDVI provided an overview of the biophysical and agrometeorological variables. Aggregating NDVI values and agrometeorological variables of each grid provide a common value. Yield of specific crop to spectral and agrometeorological values are regressed and thereby identifying the favourable phenological zones of the study area.

USING REMOTE SENSING TOOLS FOR CLIMATE CHANGE INFORMATION

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KEYWORDS: Mars Crop Yield Forecasting System, Chronos Key Indicators, Crop growth simulation, Yield forecast.

EXTENDED ABSTRACT:

The objective of the Mars Crop Yield Forecasting Systems (MCYFS) is to provide precise, scientific, traceable independent and timely forecasts for the main crops yields at EU level. The forecasts and analysis are used since 2001 as a benchmark by analysts from DG – Agriculture and Rural Development in charge of food balance estimates. The system is supported by the use of Remote Sensing data, namely SPOT-VEGETATION, NOAA-AVHRR, MSG-SEVIRI and MODIS TERRA and in the future METOP AVHRR too. So a broad spectrum from low to medium resolution data at pan-European level is covered and historical time series go back to 1981 for NOAA and 1998 for SPOT VEGETATION. In order to work with the data operationally, processing chains have been set-up to make the data consistent with our requirements concerning near real time delivery (3 days), spatial coverage (pan-Europe), projection and ten day time steps. Moreover tailored indicators like NDVI, fAPAR and DMP are derived. In case of available time-series, difference values of the indicators (e.g. relative or absolute differences) and frequency analysis of the indicators (e.g. position in historical range or distribution) are calculated. The data is explored at full resolution or unmixed related to land cover types and aggregated at administrative NUTS 2 level (profile analysis of time series). Special tools to inspect and distribute the data to external users have been developed as well.

Furthermore, it is the objective to develop a strategy for an optimal use of the different sensors and thus derived indicators at different aggregation levels for the ingestion into the MCYFS. As a first step smoothing algorithms have to be applied to the time series to diminish noise effects and to retrieve continuous information. Thus, an algorithm based on Swets et al. (1999) is employed. Thereafter, so-called Chronos Key Indicators are derived from the smoothed time-series.

With the view towards developing a real-time observation system to provide timely information on ongoing impacts on crop production under ongoing climate change, and suggest effective adaptation response strategies, a study is carried out to establish the link between these indicators and (1) state variables of the crop growth simulation (e.g., development stages), (2) observed real time field vegetation parameters and (3) the forecasted yield/production.

THE EARTH OBSERVATION DATA FOR AGRICULTURAL AND CLIMATE CHANGE RELEVANT MONITORING IN RUSSIA

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KEYWORDS: Agricultural vegetation, Long term, MODIS, SPOT, Russia.

EXTENDED ABSTRACT:

Detection and quantitative description of the global change is one the top challenges for multiple disciplines. There is no doubt that the climate change in many cases is responsible for change in agricultural vegetation, which can affect food security in many countries. Referring to the IPCC Special Report on Emissions Scenarios (Nakicenovic and Swart, 2000; Parry et al., 2004) estimated that regional differences in crop production could grow strongly through time. Regional differences in the response of crop productivity to climate change are also likely to emerge in many countries. Enhanced climate variability may lower mean yields because of a higher incidence of years with adverse conditions (Southworth et al. 2000), but sign and magnitude of the impacts will likely vary from region to region and depend on the crop (Porter & Semenov 2005). As reported by Olesen and Bindi (2002), climate change is expected to have positive impacts only in the northern countries of Europe, implying that areas of crop suitability may expand northwards (Olesen et al., 2007).

Southern areas of Europe, on the other hand, will probably have to face increasing water shortage and incidence of extreme adverse weather events.

Russia embraces agricultural lands which are situated in different geographical conditions (from small and scarce arable land parcels in northern taiga to extra arid lands with irrigated agriculture in the south). These are highly dynamic systems due to both natural and anthropogenic actions. Climate is the predominating and most significant natural factor, which sets the phenological rhythms to the vegetation as the seasonal changes in temperature, light and moisture availability translate into plant growth and differentiation. Agricultural vegetation in Russia is also exposed to various disturbances due to land degradation, insect population explosions and plant disease epidemics. The anthropogenic impact has changed profoundly over the last century too: changes in crop varieties, level of mechanization and fertilization, crop acreage dynamics, overgrazing and other factors.

Moreover Russia is a region of abrupt socio-economic changes and also most significant in the Earth System climatic hot-spots. Over the past two decades Russia has experienced changes in lands usage, which led in particular to vast area of arable lands abandonment. Nowadays all information concerning arable lands, crops area and production is provided by farmers and can't be considered as objective and accurate enough. Since the year 2003 under the treaty with Russian Ministry of Agriculture, the Russian Academy of Sciences' Space Research Institute (IKI RAS) has been developing the agricultural monitoring system based on Earth observation data. The impact of climate change on agricultural lands in Russia is potentially among most important, but not well understood and measured yet factor. The conflicting effects of climate change are expected a northward extension of farmable lands, while there is also warning of possible productivity losses and increased risk of drought. The integration of long time-series of satellite data as well as meteorological records gives an instrumental opportunity to document the climatically induced changes of agricultural lands across entire country. The IKI RAS is working in collaboration with Microsoft Corporation on development of tools relevant for assessment of climate change induced vegetation dynamics based on time-series of satellite data.

At present Earth observing satellites provide us with an opportunity to collect information concerning vegetation dynamics, which, in terms of geographical coverage and temporal resolution, is unattainable by other techniques. The Terra/Aqua-MODIS instrument data, namely the daily MOD09 products, were used as the primary data source for agriculture monitoring in Russia. Mentioned products provide information about surface reflectance, solar illumination and instrument viewing geometry. The red and NIR spectral channels with 250 m resolution have been using for vegetation assessment, while blue and SWIR channels with 500 m resolution are important for cloud and snow detection.

At the first step the mask of pixels which are not suitable for thematic processing is produced. This mask includes cloud cover, snow cover, cloud shadows and pixels with resolution worse than stated. The pre-processing algorithms use data about spectral reflectance for cloud/snow detection, solar illumination and instrument viewing geometry data for detecting of cloud shadows and pixels with insufficient spatial resolution. Using mentioned above mask the 7-day and 4-day composite images are generated for thematic analysis.

The Perpendicular Vegetation Index (PVI) and the Normalised Difference Vegetation Index (NDVI) time-series data provide input for highly automated production of annual thematic products, such as:

Arable area mapping, including abandoned and newly- ploughed-up lands;
Winter crop mapping and status assessment;
Clean fallow fields mapping;
Crop acreage and production assessment.

The feasibility study of sunflower and rice mapping with MODIS data has demonstrated promising results and provide a basis for technological development of new thematic products. Another data source is high-resolution satellite images acquiring by HRV and HRVIR instruments on board of SPOT-2/4 satellites. The SPOT-HRV/HRVIR data provide the information about agricultural fields' limits with high enough geometric accuracy, which is being combined with MODIS derived products are focused at increase of reliability of arable lands and crop area estimates. The climate change impact related studies are extensively exploiting long-term time-series data, in particular acquired by NOAA-AVHRR (GIMMS data set) and SPOT Vegetation instruments. These data have been integrated with land cover maps along with methodological records to estimate correlation with climatic indexes, to detect statistically significant trends of agricultural vegetation dynamics. It was found that climate change is one of main driving forces of the long-term dynamics of the agricultural vegetation in Russia. Such parameters as start, end and duration of the vegetation season, date and value of the seasonal NDVI maximum and seasonal photosynthetic potential are mostly affected by the climate changes. The magnitude and direction of this impact differs from region to region, which creates a complex pattern of the climate induced changes of the agricultural vegetation in Russia.

SEA SURFACE TEMPERATURE OVER TROPICAL INDIAN OCEAN AND SOUTHWEST MONSOON PERFORMANCE

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KEYWORDS: Sea surface temperature, Southwest monsoon.

ABSTRACT:

Sea Surface temperature (SST) over Tropical Indian Ocean (10^{o}S to 15^{o}N; 40^{o}E to 110^{o}E) are considered during March and April from 1985 to 2007. By examining spatial distribution of SST, three sub-domains (WEIO, CIO and SEIO) are identified. It is found that (i) April SST over WEIO and CIO gives indication of overall monsoon performance i.e. if south west monsoon season is weak/drought or not (ii) March SST over SEIO and April SST over WEIO give indication of progress/advancement of southwest monsoon over India. The study is useful for water management and agriculture planning because SST parameter alone seems to be sufficient to determine the southwest monsoon performance of a particular year over Indian region about one month in advance (Early May)

QUANTIFICATION OF THE SPATIAL AND TEMPORAL VARIABILITY OF SAVANNA VEGETATION USING MULTI-SCALE REMOTE SENSING

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KEYWORDS: Kruger National Park, Vegetation Monitoring, SAVI, NDVI.

EXTENDED ABSTRACT:

Vegetation at any given location changes through time (*e.g.,* annual and seasonal changes) and in space (in response to climatic or landscape factors). Knowledge of the change in vegetation, not only how much has changed but also where and when changes have occurred, can help land managers identify sources of ecosystem stress, as well as prioritize management efforts. The present study considers the dynamics of savanna vegetation across spatial and temporal scales in Kruger National Park (KNP) through the use of satellite remote sensing for the time period 1984–2002.

Spatial variability of vegetation is a key characteristic of savanna landscapes and its importance to biodiversity has been demonstrated by field based studies. Being limited in space and time, such studies cannot adequately explain the processes of change that are in operation and their interrelationships across hierarchic levels. Stronger understanding of the nature of change requires information to be obtained at regional scales and over longer periods of time. It is argued that multi-scale remote sensing may be an effective means of obtaining this information. Vegetation dynamics across spatial and temporal scales were analysed using Soil Adjusted Vegetation Index (SAVI) images from medium spatial resolution Landsat sensors and Normalised Difference Vegetation Index (NDVI) images from spatially coarse AVHRR sensors. Variability was assessed using its constituent elements of heterogeneity and diversity. In the case of a remotely sensed image, heterogeneity will characterise the pattern in which the picture elements (pixels) are arranged, whereas diversity will be an indication of how different the pixels are from each other. Variability was assessed based on the assumption that changes in vegetation, while contributing to changes in reflectance properties of pixels will also induce changes in the spatial structure of the image. In accordance with this assumption, variability was defined as the variance in brightness (or colour) of texture elements in the image. It was also assumed that texture measures operating on a pixel by pixel basis will be able to quantify this change in local image variance and thereby spatial variability. Quadrats of size 2 by 2 km were selected from vegetation index images to ensure that vegetation pixels alone were used in the analysis of spatial variability. Texture measures of mean, variance, skewness and kurtosis were calculated for individual quadrats using moving windows of sizes 3*3, 31*31 and 61*61 corresponding to local, patch and landscape scales, in an attempt to mimic the hierarchical arrangement of natural systems. The temporal dimension of vegetation variability was analysed by computing the Standardised Principal Components (SPCA) for the NDVI time-series.

The study has found that climatic variability is the main driving force for the spatio-temporal dynamics of vegetation in KNP. Neither the extensive drought during the early 1990s nor the flood conditions of year 2000 has caused irrevocable changes in vegetation conditions as seen by vegetation activity trends in the study area. Analysis of the coarse resolution NDVI data has showed that ecozones show broadly similar trends for the variability of vegetation in the time period 1984 – 2002, considered for the study. Geology and rainfall act as key determinants of vegetation variability, with their influences more pronounced at the landscape scale compared to local and patch scales. The study supports the ecological zonation of KNP as well as the assertion by previous studies that the spatial variability of vegetation is more pronounced in basaltic ecozones compared to granitic.

ASIA LAND COVER CLASSIFICATION USING MODIS SURFACE REFLECTANCE PRODUCTS

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KEYWORDS: Multi-temporal MODIS, Land cover classification, Asia.

ABSTRACT:

The objective of this study is to develop land cover classification algorithm suited for the eastern Asia by using multi-temporal MODIS land reflectance products. The area covers around 10,000km x 6,700km (90 degree longitude width by 60 degree latitude width). There are two versions, which are Surface Reflectance 8-Day L3 product and Nadir BRDF-Adjusted Reflectance 16-Day L3 product. Both are composed of 7 spectral bands with 500 m ground resolution. The former is the atmospheric corrected surface reflectance, while the latter corrects the BRDF effects in addition to the atmospheric correction. In this study, land cover maps derived from these two kinds of source data products are generated and compared. The land cover generation method using in this study has two stages of non-linear reflectance conversion and multi-temporal land cover categorization. In the non-linear reflectance conversion, reflectance data represented with 16 bits were converted to 8 bits data by compression of high spectral region in order to decrease volume of feature space. In the second stage, 8 bits spectral data composed of 46 scenes produced in one year were classified to land cover categories by using time domain co-occurrence matrix. The classification results of above reflectance products were compared with a MODIS land cover product. As the result, Surface Reflectance 8-Day L3 product and Nadir BRDF-Adjusted Reflectance 16-Day L3 product showed about 90% classification accuracy that is about 20 % greater than that of MODIS land cover product.

EXPLORING THE CONTRIBUTION OF LAI TO IN-SEASON CROP ACREAGE ESTIMATES OVER THE CANADIAN PRAIRIES

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KEYWORDS: Crop mapping, RADARSAT-2, ScanSAR, AWiFS, LAI.

EXTENDED ABSTRACT:

Agriculture plays an important role in the global economy, and the sustainability of agriculture is critical for world food security. With the world's ever increasing population, the demand for food continues to rise. Timely information on crop acreage and growth conditions is of great value for in-season prediction of crop productivity and ultimately, crop yields.

Agriculture is an important sector in Canada. The Canadian Prairie region is an important supplier of grains, legumes and oilseeds to the global market. Annual geospatial information on agricultural land use (crop inventory) would permit more efficient and effective delivery of agricultural programs and enhance the environmental sustainability of the agricultural sector. Agriculture and Agri-Food Canada (AAFC) scientists completed a multi-year (2004-2007) project which defined an EO-based methodology for successful end-of-season crop classification [1, 2]. This project revealed that when available, multi-temporal optical data (Landsat, SPOT) collected at different crop

growth stages can achieve satisfactory classification accuracy (above 85%). When data gaps are present due to cloud cover, the addition of radar data (RADARSAT-1, ASAR) provides complementary information which would assist in crop identification.
To implement this methodology for operational use at a national scale, satellites that acquire data across wide swaths are needed for countries like Canada with substantial land masses. In response, a pilot study was undertaken to investigate the integration of RADARSAT-2 ScanSAR data with AWiFS data for crop mapping over the Canadian Prairies [3]. The Indian Space Resource Organization Satellite Resourcesat-1 (IRS-P6) provides multi-spectral Advanced Wide Field Sensor (AWiFS) data with frequent revisit and a large geographic coverage. Compared with Landsat's 16-day repeat cycle, AWiFS' 5-day repeat cycle and large scene overlap increase the potential for successful acquisition of cloud-free optical data. AWiFS' spatial resolution (56 m at nadir), although coarser than that of Landsat and SPOT, is suitable for field level mapping across Canada's vast Prairie region. An earlier AAFC study compared the use of AWiFS data with data from Landsat-TM and SPOT for crop mapping over three Canadian agriculture sites in Eastern Ontario, Manitoba, and Saskatchewan [4]. The study revealed that accuracies were slightly reduced with the use of the AWiFS data and this reduction was attributed to the coarser spatial resolution of AWiFS. For operational implementation, this small reduction in accuracy is an acceptable trade-off to achieve large area coverage (370 km per quadrant). Piloting of an operational crop inventory using AWiFS began in 2008 for one Canadian province, Manitoba. Multi-temporal AWiFS data were acquired throughout the 2008 growing season. In addition, multi-temporal dual-polarization (VV, VH) RADARSAT-2 ScanSAR Narrow data were also acquired. This RADARSAT-2 beam mode offers comparable spatial resolution (50 m) and swath coverage (300 km) to AWiFS. This pilot study demonstrated that multi-temporal AWiFS data can produce an adequate crop classification, with an overall end-of-season accuracy of 83%. The addition of ScanSAR data increases the overall classification accuracies.

Crop inventories delivered at the end of growing season are valuable. In-season crop acreage estimates, however, add additional value for early forecasting of crop yield and biofuel production. Timely early season information on crop acreage and growth conditions is needed to inform these forecasts. In this study, the modified triangular vegetation index (MTVI2) will be assessed for use with AWiFS data For the 2009 growing season, AWiFS optical data and RADARSAT-2 ScanSAR data (VV, VH) have been programmed for the Prairie region. In addition to *in situ* crop type surveys, multi-temporal LAI (leaf area index) measurements using the LAI 2000 have also been scheduled over an intensive site at Indian Head, Saskatchewan. Ground LAI is used to calibrate the MTVI2 estimates from the AWiFS data. In an AAFC experiment conducted in 2008, MTVI2 derived from multi-temporal SPOT-4 data was strongly correlated with above ground biomass for corn, soybean, and wheat crops [5]. It is anticipated that LAI estimates will assist in reducing confusion in discriminating between crops such as cereals and pasture-forage, and in increasing accuracies associated with early season crop area reporting.

REFERENCES

Champagne, C. M., McNairn, H., Shang, J., and Johnson, D. M. (2007). Evaluation of Resourcesat-1 AWiFS data for producing an agricultural crop inventory for Canada. In *CRSS/ASPRS Specialty Conference: Our Common Borders - Safety, Security and the Environment Through Remote Sensing*. American Society for Photogrammetry and Remote Sensing, Ottawa, ON, Canada.

Liu, J., Pattey, E., Shang, J., Admiral, S., Jégo, D., McNairn, H., Smith, A., Hu, B., Zhang, F., and Freementle, J. (2009). Quantifying crop biomass accumulation using multi-temporal optical remote sensing observations. The 30th Canadian Symposium on Remote Sensing, June 22-25, 2009, Lethbridge, Albert, Canada.

McNairn, H., Champagne, C., Shang, J., Holmstrom, D., and Reichert, G. (2009). Integration of optical and synthetica Aperture radar (SAR) imagery for delivering optional annual crop inventories, Journal of Photogrammetry and Remote Sensing (in press).

Shang, J., Champagne, C., and McNairn, H. (2006). Agriculture land use using multi-sensor and multi-temporal Earth Observation data. *Proceedings of the MAPPS/ASPRS 2006 Fall Specialty conference*, San Antonio, Texas, USA.

Shang, J., McNairn, H., Champagne, C., Jiao, X., Jarvis, I., and Geng, X. (2009). Integration of RADARSAT-2 ScanSAR and AWiFS for operational agricultural land use monitoring over the Canadian Prairies. Submitted to IGARSS 2009, Cape Town, South Africa.

MULTI-FREQUENCY SAR IN SUPPORT OF OPERATIONAL CROP MONITORING

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KEYWORDS: Crop mapping, TerraSAR-X, RADARSAT-2.

EXTENDED ABSTRACT :

The sensitivity of visible and infrared wavelengths to internal leaf structures and pigmentation has led to the successful application of optical satellite data for vegetation discrimination and crop identification. Nevertheless, the exploitation of differences in crop reflectance over time, as crop phenology changes through the growing season, is the most important factor for successful crop discrimination. The accuracy of crop classification hinges on the successful acquisition of satellite data during critical points in the growing season. For crops grown in Canada, this period represents the reproductive and seed development growth stages.

The interference of optical acquisitions by cloud cover and haze means that delivery of operational annual crop surveys can be unreliable if optical sensors are the sole data source. Agriculture and Agri-Food Canada demonstrated that C-Band SAR data can assist with improving crop classification accuracies produced by multi-temporal optical images [1]. As well, these SAR data can be integrated with one or two optical acquisitions to assist with filling gaps in optical data collection. However, C-Band on its own was unable to match the accuracies achieved with well temporally positioned optical acquisitions. A multi-frequency (C- and L-Band) SAR data set did provide an alternate to an optical-only or optical-SAR approach [2]. Using RADARSAT-1, Envisat ASAR and ALOS PALSAR data classification accuracies matched those of a multi-temporal optical data set.

In 2008 and 2009, AAFC began acquiring higher frequency TerraSAR-X data over sites in Canada. Early results from 2008 demonstrated that these X-Band data, on their own, could achieve accuracies of 85% [3]. With a C- and X-Band data set accuracies increased to 88%. These encouraging results were achieved in spite of the fact that acquisition of X-Band data for 2008 began only at mid season. The 2008 test site had a relatively simple cropping mix with only four major crop classes - corn, soybean, wheat and pasture-forage. Consequently, in 2009 AAFC programmed TerraSAR-X and RADARSAT-2 satellites to capture crop development over the entire season, and expanded data collection to a site of more complex cropping system, in western Canada. This paper will present results from the 2009 C- and X-Band crop classification project.

REFERENCES

McNairn, H., Champagne, C., Shang, J., Holmstrom, D., and Reichert, G. (2009). Integration of optical and Synthetic Aperture radar (SAR) imagery for delivering optional annual crop inventories Journal of Photogrammetry and Remote Sensing (in press).

McNairn, H., Shang, J., Champagne, C., and Jiao, X. (2009). TerraSAR-X and RADARSAT-2 for crop classification and acreage estimation. IGARSS 2009, Cape Town, South Africa, 12-17 July 2009.

McNairn, H., Shang, J., Jiao, X., and Champagne, C. (2009). The Contribution of ALOS PALSAR Multi-polarization and Polarimetric Data to Crop Classification, IEEE Transactions on Geoscience and Remote Sensing (in press).

SPATIAL AND TEMPORAL PATTERNS OF CROPPING OVER INDIA USING MULTI-TEMPORAL IRS AWIFS DATA

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KEYWORDS: IRS AWiFS, Cropping pattern, Net sown area, Single and double cropped area.

EXTENDED ABSTRACT:

Historical rainfall data over India revealed significant changes in intensity and distribution patterns across the country and significant changes in rainfall patterns are predicted under different climate change scenarios. The understanding on spatial and temporal patterns of cropping in relation to intra and inter annual variability of rainfall patterns is one of the useful inputs for delineation of vulnerable and resilient zones to climate change. Towards this, the development of long term spatial databases on cropping pattern using satellite remote sensing based data is realized as an important need.

In this context, considering the potential of IRS AWiFS data, a project is taken up as part of Natural Resources Repository (NRR) activity under National Natural Resources Management System(NNRMS) of Department of Space(DOS), Government of India, with an objective to undertake "Rapid assessment of National Level LULC on 1: 250,000 scale using multi-temporal AWiFS starting from 2004-05". National Level LULC mapping for the crop calendar year 2004-05, 2005 –06, 2006-07, 2007-08, 2008-9 was completed. As part of this project, spatial information on Net Sown Area (NSA) depicting single (Kharif, Rabi and Zaid) and Double/triple crop areas was generated along with other Land Use and Land Cover information. The paper presents the intra and inters annual patterns of cropping and its spatial variability over the last 5 years across the entire country.

Monthly AWiFS data of Aug - May time window was chosen covering the spatial variability of crop and phonological calendars of agriculture and forest ecosystems respectively. Towards this minimum of 150 IRS AWiFS full scenes need to be used. However to augment cloud covered areas and address certain local variability's, a total 200 IRS AWiFS full scenes comprising of 800 quadrants were used for each cycle.

The multi-temporal datasets were geo-referenced with LCC projection and WGS 84 datum. Later all the satellite datasets were converted into TOA reflectance data to minimize temporal variability. Optimal no. of quadrant mosaics were prepared keeping in view of the radiometry, differences in date of pass for each state. These mosaiced tiles staggered over the months were used as input for classification. A hybrid approach involving Hierarchical Decision Tree (See 5), Maximum likelihood and Interactive classification techniques were adopted for classification. The legacy datasets on forest cover, type, wastelands and limited ground truth were used as inputs for classification and accuracy assessment. The process based QAS was implemented to regulate the data flows and outputs as per the standards.

The spatial and temporal distribution on NSA was extracted over IMD meteorological subdivisions of Indian Meterological Department (IMD) and was analyzed in conjunction with corresponding rainfall data. Four different scenarios have emerged in terms of NSA response to rainfall change viz Positive response to rainfall change either in terms of increase or decrease in NSA and Negative response to rainfall change either in terms of increase or decrease in NSA. Response of NSA to rainfall changes was found significantly different in command and irrigation intensive regions, hilly/high rainfall regions and arid and semi arid regions. Subdivisions like West Rajasthan, North-interior Karnataka, Saurastra, kutch and Chhattisgarh shown increase in cropped areas in relation rise in rainfall during different years of the study period. On the other hand sub divisions like Telangana, Rayalseema, East Rajasthan and Western MP having low productive lands did not show positive response to increase in rainfall indicating the influence various other factors. In Sub-humid West Bengal and Sikkim, Gangetic West Bengal, Tamilnadu, Southern Karnataka, Punjab, and Coastal A.P etc, there is a trend towards increase in NSA despite the decrease in rainfall. These sub divisions are basically fertile productive lands with intensive irrigation systems and hence cropping systems may not be largely effected due to marginal changes in rainfall conditions.

National and state level spatial information on recurrence of double, single crops areas and current fallows observed over longer times is also of critical importance to understand the cropping patterns. It is found that 28.7%, 24.3%, 10.8% areas are consistently present during all the cycles under double, kharif and rabi single crop areas respectively. Consistent double cropped areas are found in the major river basins and command areas. Monitoring these areas on these lines over long term facilitates to understand the stability of these systems in sustaining the cropping conditions. Consistent fallow areas are present especially in areas having less than 750 mm rainfall and in Jharkhand and Bihar. The temporal databases on these patterns would help to understand the dynamics of change in relation to various physical and biological controls of cropping systems especially in the context of climate change.

MEASURING WINTER WHEAT CULTIVAR (*TRITICUM AESTIVUM L.*) HEALTH STATUS USING HYPERSPECTRAL REFLECTANCE DATA

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KEYWORDS: REIP, Continuum removal, Vegetation indices, Hyperspectral data.

ABSTRACT:

The newly-emerged hyper-spectral remote sensing makes possible acquiring images in many narrow and continuous spectral bands, which are sensitive to specific crop variables, so weak difference in plant parameters could be detected. Hyperspectral Crop reflectance data are useful for determining and defining optimal indices to estimate crop health. The objective of this work is to analyze red edge inflection point (REIP) obtained from first order derived reflectance spectrum and deducing its relation with vegetation health indices. Continuum removal was done for normalizing reflectance spectra to allow comparison of individual absorption features. The indices used for determining crop health were NDVI, SIPI and SAVI. A field study was conducted during the winter growing season of wheat. Field was divided into two plots with equal irrigation treatment in which one plot serve as control with no fertilizer treatment. Field canopy reflectance measurements were acquired at most important stage of wheat life cycle that is first tillering stage. Soil adjustment factor (L) value obtained for SAVI measurement was 0 for fertilizer treated plot and 0.5 for control plot. REIP value for fertilizer treated plot was 737.07 nm and that for control was 735.21 nm which indicate nutrient stress condition in control. NDVI, SIPI and SAVI indicate a better health of crop in fertilizer treated crop as compared to control. NDVI serve as best predictor for REIP estimation in both healthy and stressed condition, whereas SAVI show good response in stress condition opposite to SIPI which is best predictor for healthy condition.

LAND USE / LAND COVER MAPPING OF KEOLADEO NATIONAL PARK, BHARATPUR, RAJASTHAN (INDIA) USING HIGH RESOLUTION SATELLITE DATA

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KEYWORDS: Land use/ land cover mapping, Keoldeo National Park, IRS P6 LISS IV, Cartosat PAN.

EXTENDED ABSTRACT:

Land use and land cover change has become a central component in current strategies for managing natural resources and monitoring environmental changes. The advancement in the concept of vegetation mapping has greatly increased research on land use land cover change thus providing an accurate evaluation of the spread and health of the world's forest, grassland, and agricultural resources has become an important priority. Viewing the Earth from space is now crucial to the understanding of the influence of man's activities on his natural resource base over time.

It is necessary to have accurate information about present land use/ land cover so as to prepare integrated plans for optimal utilization of natural resources in the region. Remote Sensing & GIS are the two most important techniques for studying the Land Use patterns and there changes, based on analysis at time series satellites data. Satellite data provides authentic record of the timely and consistent temporal changes in Land Use patterns over a large area & GIS has an advantage of storing and integrating multi- theme data for desired interpretations and modeling. Satellite data with synoptic view, repetitive coverage and multi spectral viewing etc has brought drastic changes in the land use/ land cover mapping and monitoring. Remote Sensing (RS) and Geographic Information System (GIS) are now providing new tools for advanced ecosystem management. The collection of remotely sensed data facilitates the synoptic analyses of Earth - system function, patterning, and change at local, regional and global scales over time; such data also provide an important link between intensive, localized ecological research and regional, national and international conservation and management of biological diversity.

Vegetation patterns are an integrated reflection of abiotic and biotic factors that shape the environment of a given land area. Vegetation mapping plays a vital role in providing relevant information and therefore becomes a prerequisite for the effective and therefore becomes a prerequisite for the effective management of natural resources, especially for the conservation of biodiversity and is surrogate for ecosystems in conservation evaluations, and thus serves as a staring point of monitoring of the tropical vegetation.

Wildlife habitat analysis requires complete understanding of the total ecosystem coupled with influence of land use practices. The physiography and their spatial distribution are considered to be important parameters (apart from) slope, soil, and topography and water availability of population occupied in place is its habitat and each species requires a particular habitat to supply the their sustenance. Vegetation cover mapping which is an important component of habitat analysis has already been operational in India by using remote sensing data.

Keoladeo National Park (KNP) popularly known as Bharatpur Ghana Bird Sanctuary situated between 27°7'06'' to 27°12'02'' N latitude and 77°29'05'' to 77°33'09'' E longitude with an elevation of 572 m above msl. Keoladeo National Park is named after Keoladeo (Shiva) temple located in the center of the park. The KNP is a part of the great Indo-Gangetic plain of India created by a natural depression. This world heritage site is a unique ecosystem known for various resident and migratory birds. This important wetland was set aside as a bird's sanctuary in 1956 and it was elevated to the status of a national park in 1981. It has distinction of being the only Indian wetland to be included under both the Ramsar and the World Heritage convention. Over 320 birds' species have been recorded in the park. Apart from birds, around 27 mammalian species are also available in the park. The most common are Blue Bull, Chital, Sambar, Wild Boar, Jackal etc.

Land use /Land Cover map of Keoladeo National park (KNP) was prepared using merged (IRS P6 LISS IV & Cartosat PAN data) high resolution satellite data, in ERDAS 8.7 and ARC/GIS 9.1 version software. Preparation of Land use / land cover map is based on Manual of NRSA (2006) with some modification.

In the interpretation of Land use/land cover of the KNP, it was found that the total geographical area is 28.96 sq km. In this classification, 7 and 15 classes were identified in level-1 and level-2 respectively.

In the level-1 classification of LULC, out of the total Park area 43.34 % Under forest, 28.56% under Wetland, 23.15 % under Grassland, 3.83 % area under Mosaic of several types, 0.60 % under Saline land, 0.08% under settlement, and 0.45% under water- bodies.

In the level-2 classification of LULC, out of the total Park area, 26.21% Scrub Woodland, 8.50% Thickets, 8.19% Savanna Woodland, 3.0% Low Grassland, 14.60% Shrub savanna, 5.39% Grass Savanna, 3.81% Mosaic of Several Type, 1.41% Scattered Shrub, 0.08% Settlement, 0.09% Pond, 0.46% Canal, 18.86% Dried Wetland, 9.24% Plantation in Wetland, 0.03% Aquatic Vegetation, 0.14% Open Water.

CHANGE OF LAND SURFACE TEMPERATURE AND EVI IN CHINA FROM 2000 TO 2008

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KEY WORDS: Vegetation Cover Change, LST Change, China, Time Series.

EXTENDED ABSTRACT:

In recent decades the temperature of the earth has obvious increasing. It is important to figure out the situation of the climate change and estimate its impacts. Temperature is a vital parameter in the climate system. The vegetation cover partly shows the impact of the climate change. It is significant to analyze the change of the temperature and the vegetation cover. This is also important for agricultural management. Some research has been done to estimate the LST and VI change in Europe. In this paper we make statistics of the satellite time series data and analyze the change of LST and EVI in China. Figure 1 shows the change of the yearly average air temperature of the whole earth from 1948 to 2008 based on NCEP reanalysis data. It shows the obvious increasing in recent decades. In this paper we use MODIS time series data to analyze the change happening in the recent decade.

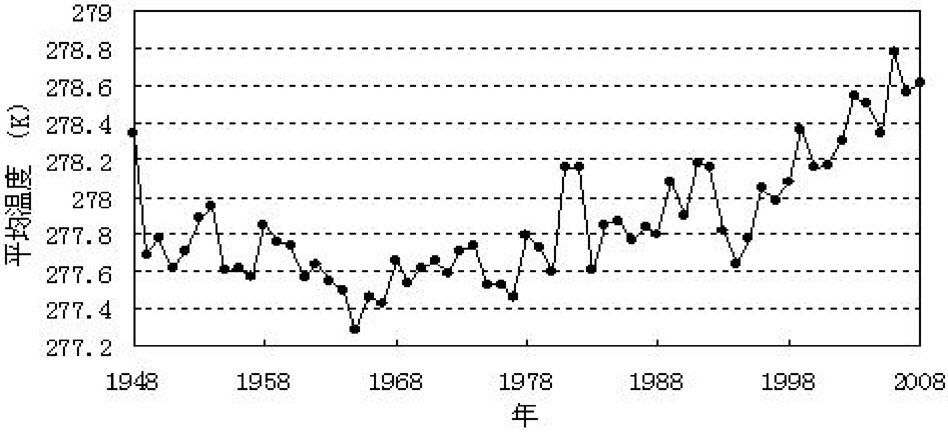

Figure 1. Yearly Average Air Temperature of the Whole Earth from 1948 to 2008 from NCEP Reanalysis Data

The satellite data to analyze is the time series from MODIS LST and VI product. Because of the impact of weather factors, the time series obtained directly from MODIS product is discontinuous. It is required to reconstruct the original time series into the continuous series. We used the modified HANTS algorithm to make time series reconstruction. HANTS (Harmonic ANalysis of Time Series) is developed by Wout Verhoef (Menentiet al., 1993; Roerink et al., 2000; Verhoef et al., 1996). It has been successfully used in some applications of time series analysis. As other algorithms of time series reconstruction, HANTS also has the disadvantage that the accuracy of reconstruction has a tight relationship with the input coefficients. To increase the accuracy of HANTS when applying in large area, we modified HANTS algorithm, and add the a priori knowledge of the original time series into it, and also add a flag to describe the quality of time series reconstruction as the algorithm output.

The modified algorithm is used in MODIS LST and VI product to reconstruct the continuous LST and EVI time series in China. We divide China into arid area, semi-arid area, semi-humid area, and humid area to analyze the LST and EVI change. Because of the sensitive reaction in Tibet Plateau to the climate change, we also analyze it as a special area. We make statistics to get the yearly and the seasonal change of LST and EVI in these areas and also in the whole China, analyze to get the area with increasing LST, with decreasing LST, with increasing EVI, and with decreasing EVI, and finally make a conclusion to the characteristic of the LST and EVI change in China in recent decade

DETERIORATING FOOD SECURITY IN THE SEMI-ARID TROPICS

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KEYWORDS: Semi-arid tropics, Food security NOAA/AVHRR NDVI,

EXTENDED ABSTRACT:

One of the major challenges we face on our planet is increasing agricultural production to meet the dietary requirements of an additional 2.5 billion people by the mid of the century while limiting cropland expansion and other damages to natural resources. This problem is even more so challenging given that nearly all the population growth will take place where the majority of the hungry live today and where ongoing and future climate changes are projected to most negatively impact agricultural production, the semi-arid tropics (SAT). The SAT contain 40% of the global irrigated and rainfed croplands in over 50 developing countries and a growing population of over a billion and half people, many of which live in absolute poverty and strongly depend on agriculture that is constrained by chronic water shortages.

Rates of food grain production in many of the countries of the SAT have progressively increased since the mid 1960s aided by the Green Revolution and relatively favourable climatic conditions. However, aggregated agricultural production statistics indicate that the rate of food grain production has recently stalled or declined in several of the countries in this region, escalating the concerns over matters of food security, that is availability of food and one's access to it, in a region where many people live in extreme poverty, depend on an agrarian economy and are expected to fare increasingly worse climatic conditions in the near future.

In this paper we provide independent evidence of the agricultural deceleration in the SAT and its drivers by analyzing the long term (1982-2006) record of the Normalized Difference Vegetation Index (NDVI) from the National Oceanic and Atmospheric Administration's Advanced Very High Resolution Radiometer (NOAA/AVHRR) together with climate, land use, and aggregated crop production statistics. India, with the world's largest population of hungry people and largest semi-arid croplands, is a leading example of the observed declines. We show geographically matching patterns of enhanced crop production and irrigation expansion with groundwater, initially, but both of which have levelled off in the past decade. Thus, India faces the daunting challenge of needing a 50-100% increase in yields of major crops by the middle to the 21st century to feed its growing population, when its current production rates are decelerating and options to reverse these are limited. Overall, our analysis suggests a deteriorating food security scenario for the SAT countries, given the current deceleration of production trends, unsustainable use of land and water resources, projected climate changes and population growth rates that will require a new green revolution to be reversed.

MONITORING AGRICULTURAL CROPPING PATTERNS IN THE GREAT LAKES BASIN USING MODIS-NDVI TIME SERIES DATA

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KEYWORDS: Great lakes basin, Ecoregion, Crop area, Crop rotation.

EXTENDED ABSTRACT:

This research examined changes in agricultural cropping patterns across the Great Lakes Basin (GLB) using the Moderate Resolution Imaging Spectroradiometer (MODIS) Normalized Difference Vegetation Index (NDVI) data. Specific research objectives were to characterize the distributions of crop types in the GLB for 2005, 2006, and 2007, and quantify any changes in rotation patterns between 2005–2006 and 2006–2007. MODIS 16-day composite NDVI product (MOD13Q) (2005–2007) were obtained from the USGS EROS Data Center and pre-processed using the method developed by Lunetta *et al.* (2006). This created a continuous high quality NDVI dataset for the general cropland and crop-specific (e.g., corn, soybean, wheat) mapping. For each calendar year, the classification of general cropland versus noncropland was conducted first. The training data points for the cropland and noncropland were primarily derived from the 2001 NLCD (National Land Cover Data). The identifications of individual crop types were subsequently conducted within the cropland mask. Three major crop types were considered including corn, soybeans, and wheat. The training pixels were identified using visual interpretation of MODIS NDVI profiles to derive "phenology end-members". We employed an ecoregion stratified classification approach to improve the classification performance by dividing the study area into 12-ecoregions (Omernik, 1987) and conducting independent crop-specific classification within each ecoregion (Figure 1). Both the general cropland classification and crop-specific classification were performed using three-layer **m**ulti**l**ayer **p**erceptron (MLP) classifiers.

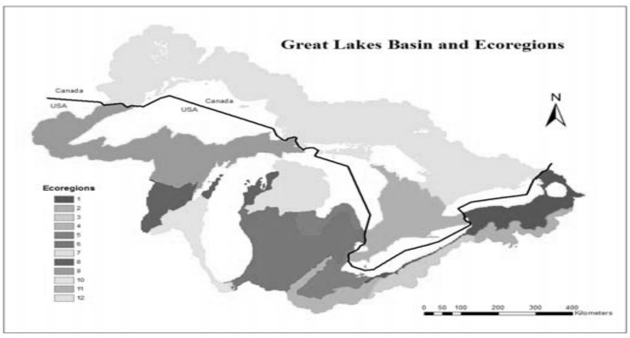

Figure 1. Ecoregion-Based Stratification of the GLB

The accuracy for the 2007 crop-specific classification was assessed using the 2007 Crop Data Layer (CDL) data as reference. The overall accuracy was 84% and Kappa coefficient was 0.73. The user's accuracies for corn, soybeans, and wheat were 87, 82, and 81 percent, respectively. The producer's accuracies for corn, soybeans, and wheat were 85, 81, and 83 percent, respectively. In addition, the estimated crop acreages from MODIS NDVI were found to be close (<10% differences) compared to the state and provincial level agricultural statistics obtained from the National Agricultural Statistics Service (NASS) and the Ontario Ministry of Agricultural, Food and Rural Affairs (OMAFRA).

The total estimated cropland areas in the GLB are 115,590 km^2, 117,973 km^2, and 117,352 km^2 for years 2005, 2006, and 2007, respectively. Over 97% of the croplands are located in the southern half of the GLB. Table 1 shows the distributions of individual crop types for the GLB over the three-year period. The corn acreage decreased (2%) from year 2005–2006, and then increased about 20% from year 2006–2007. The soy acreage decreased slightly (1%) from 2005 to 2006, and then further decreased about 9% from year 2006–2007. Wheat acreage, on the other hand, increased about 18% from year 2005–2006, and decreased 21% from 2006–2007.

	2005		2006		2007	
	Crop Area	% Distribution	Crop Area	% Distribution	Crop Area	% Distribution
Corn	31,462	44.1%	30,766	42.8%	37,318	50.7%
Soybean	31,283	43.8%	30,972	43.1%	28,207	38.3%
Wheat	8,623	12.1%	10,163	14.1%	8,062	11.0%
Total	71,368	100.0%	71,900	100.0%	73,587	100.0%

Table 1: Crop area (km^2) and Percent Distribution Across the GLB

The crop rotations were analyzed by stacking two-year crop maps and conducting a post-classification comparison. We aggregated pixels into 16-categories based on the "from-to" crop change classes. The frequency of crop rotation patterns (i.e., corn-soybean, soybean-wheat) were calculated within the GLB. Table 2a and b summarized the crop rotation patterns of the GLB for 2005–2006 and 2006–2007, respectively. A comparison of the crop patterns suggested that more continuous corn (corn-corn) fields were observed for 2006–2007. There were also increases of wheat-corn rotation and decrease of soybean-wheat rotation from 2005–2006 to 2006–2007.

(a)

		2006				
		corn	soybean	wheat	other	Total
2005	corn	24.7%	41.8%	5.6%	27.8%	100%
	soybean	40.9%	22.9%	13.8%	22.4%	100%
	wheat	25.3%	30.4%	15.9%	28.4%	100%
	other	29.3%	29.4%	9.9%	31.4%	100%

(b)

		2007				
		corn	soybean	wheat	other	Total
2006	corn	32.6%	35.7%	5.4%	26.4%	100%
	soybean	47.9%	24.0%	9.2%	18.8%	100%
	wheat	32.9%	27.4%	9.2%	30.5%	100%
	other	33.9%	26.1%	9.8%	30.1%	100%

Table 2. Crop rotation patterns from 2005–2006 (a) and 2006–2007 (b)

REFERENCES

Lunetta, R.S., J.F. Knight, J. Ediriwickrema, J.G. Lyon, L.D. Worthy, 2006. Landcover change detection using multi-temporal MODIS NDVI data. Remote Sens. Environ., 105, 142–154.

Omernik, J.M., 1987. Ecoregions of the Conterminous United States. Annals of the Association of American Geographers, 77(1), 118−125

LAND COVER AND LAND USE CHANGES AND ITS EFFECTS ON CARBON AND NITROGEN DYNAMICS IN SOUTH AND SOUTH EAST ASIAN REGION

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KEYWORDS: LULUC, MODIS, South and South East Asian Region, Carbon cycle, Nitrogen dynamics.

EXTENDED ABSTRACT:

The distribution of sources and sinks of carbon over land is dominated by land use and land use changes (LULUCs) such as deforestation, reforestation and agricultural management. Despite the importance of LCLUC in determining long-term net terrestrial fluxes of carbon, estimates of carbon fluxes due to LCLUC are uncertain relative to other terms, such as fossil emissions and ocean flux, in the global carbon budget. This is particularly true in tropical regions, due to the lack of spatially explicit and consistent LCLUC data. This study implements satellite based LCLUC data with a geographically explicit terrestrial carbon-nitrogen model ISAM (Integrated Science Assessment Model) to examine the response of vegetation and soil carbon and nitrogen stocks to recent LCLUCs in South and South East Asian Region.

We used spatially explicit satellite derived LCLUCs maps, created using moderate spatial resolution imagery from the MODerate Resolution Imaging Spectroradiometer sensor (MODIS) for the entire globe. Over India, we took advantage of high-resolution forest clearing information derived from IRS AWiFS imagery to estimate forest area change estimates, because its sufficiently high spatial resolution enables the detection of most small scale forest clearing events in India that were undetected by MODIS.

ISAM's terrestrial component cycles consist of fully prognostic carbon and nitrogen dynamics associated with LCLUC, vegetation, litter (above and below ground) decomposition, and soil organic matter. Energy and hydrology processes have been adapted from the Community Land Model (CLM), the land component of Community Climate system of Models (CCSM). ISAM simulates the carbon and nitrogen fluxes to and from different compartments of the terrestrial biosphere with 0.1-by-0.1 degree spatial resolution. The model was calibrated using satellite-based fraction of absorbed Photosynthetically Active Radiation (FPAR), leaf area index (LAI), vegetation cover map and observed meteorological data to estimate plant productivity. The modeled carbon cycle includes feedback processes such as CO_2 fertilization, climate effects on photosynthesis and respiration and increased carbon fixation by nitrogen deposition; whereas the model nitrogen cycle includes all the major processes associated with nitrogen, including immobilization, mineralization, nitrification, denitrification, leaching.

By quantifying the spatial distribution of net carbon and nitrogen sources and sinks, this study will help us more accurately determine how much carbon is being stored or released in south and south east Asian region, particularly in the context of the Kyoto protocol, which allows a country to apply the carbon stored in its forests and other ecosystems toward its budgeted reduction in carbon dioxide and other greenhouse gases.

LAND SURFACE CHARACTERISATION IN ARID AND SEMI-ARID REGIONS OF RAJASTHAN FOR ASSESSING THE LONG-TERM CHANGES IN VEGETATION CONDITION USING EARTH OBSERVATION DATA

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KEYWORDS: Land Surface Parameters, Arid and Semi-arid, Satellite data.

EXTENDED ABSTRACT:

Swift transformations occurring at earth-atmosphere interface has made it imperative to characterise land surface parameters to assess the long-term changes in vegetation amount. Rapid urbanisation, deforestation and subsequent land degradation has impacted the exchange of radiant energy between earth surface and the atmosphere ultimately resulting in substantial changes in the land surface parameters at local, regional and global level. Arid and semi-arid ecosystems play significant role in determining the intricacies of earth-atmosphere interactions and ultimately affecting the global climatic mechanisms. Long term studies to characterise the vegetation condition and

environmental changes taking place at the boundary of earth's surface and the atmosphere in these environments is hence gaining importance world over.

The highly dynamic vegetation of arid and semi-arid regions experiences a phenomenal change in its growth pattern. This change in vegetation canopy density with the change of season greatly impact land surface properties and related interactions. Assessment and monitoring of the vegetation status and seasonal growth characteristics in association with plant diversity in these arid and semi-arid regions is therefore of much importance. Vegetation degradation monitoring in arid and semi-arid regions using satellite data requires long-term observations of vegetation extent. It therefore involves the use of a number of parameters such as NDVI, Evapo-transpiration, LAI, fractional cover, surface emissivity, albedo etc., to corroborate the changes occurring within these marginal ecosystems. Biophysical parameters such as green leaf area index (GLAI) and green fractional cover (*gfc*) have a unique importance owing to their characteristics and their capability to be linked with seasonal changes in vegetation condition.

This paper will present an operational methodology to monitor vegetation condition in arid and semi-arid regions of Rajasthan developed through retrieval of land surface parameters using multi temporal and multi-scale satellite data. Different satellite data used in this study are S-1 and S-10 data from SPOT Vegetation (4 & 5), IRS-WiFS and IRS-LISS-III data. These datasets provide estimates of vegetation amount and condition which can be linked with surface biophysical parameters calculated from ground. These biophysical variables when calculated over a period of time give real-time spatial description of changes in land use and land cover. They can further be incorporated into models to make more realistic assessments of linkages between changes in surface properties and biogeochemical processes (Wessman and Asner 1998).

Land surface parameters coupled with seasonal information provides valuable input to several climate change studies. The phenological information captured from these multitemporal datasets gives an insight into the various processes of energy exchange phenomenon taking place at land surface. It is of significance to regional climate change studies and large scale monitoring of land use and land cover changes. The surface parameters derived from satellite data for the entire study area will serve as a baseline datum to further the studies related to vegetation degradation monitoring and climate change modelling.