"Evaluation of Different Remote Sensing Techniques for Drought Study"

Asia-Pacific Space Cooperation Organization (APSCO)

Directorate of Earth Sciences

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Proposal on "Evaluation of Different Remote Sensing Techniques for Drought Study"

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Introduction

Drought is a period during which rainfall remains lower than average, thus affecting agriculture and ecology of the region. The prolonged absence of rains affect rain fed crops, affecting livestock and community, agro-industries and ultimately economy of country. Besides rains, other parameters like low soil moisture, less availability of ground water, irregular stream flow / canal network and increased evapotranspiration supplement the severity of drought situation. It is a creeping phenomenon that may last long over larger areas.

Pakistan has a diverse climate, ranging from arid and semi arid to hyper arid. Pakistan lies in the western end of summer monsoon belt. It receives least amount of precipitation among the summer monsoon countries of Asia.

There are two major seasons of rainfall in Pakistan; one is monsoon which hits the country during June to September in summer and second is winter that prevails from December to March. The months from April to May and October to November remain transition periods. In any of these seasons, if parts of the country remain dry for more than 50% of the time, it will cause drought in that region. The monsoon rains are brought by south westerly system in Arabian Sea or by south easterly system in Bay of Bengal. It brings rains over the whole country leaving some areas of Southern Punjab, Northwest Sindh and Balochistan on the verge of drought. In winter the westerly winds bring rains to the country during December to March. This westerly system originates in Mediterranean Sea or Atlantic Ocean and travels eastward between 30°N to 60°N, by bringing heavy rains to northern and central regions of Pakistan, leaving South Punjab, central and eastern Sindh dry. In this way Sindh and south Punjab receive least amount of rains during westerly rains. If monsoons fail to generate rains in south in any year, crops are affected by drought as winter does not bring rains to southern regions of the country. Because of this diverse climatic condition southern parts of Pakistan like south Punjab, Sindh and major parts of Khyber Pakhtunkhwa are often affected by drought, affecting the agriculture and consequently influencing the country's economy due to shortage of food.

Pakistan experienced worst recorded droughts during 1998-2000 and 2000-2001. The drought situation caused devastation to 58 districts of the country, specifically hitting Southern Punjab, Khyber Pakhtunkhwa and Sindh. It affected rainfed areas and their ecology to larger extent. Major parts of the Punjab especially the eastern and southern regions are disaster prone and continue to suffer from frequent hazards such as floods and droughts. In 1999-2002, a major drought affected 7,286 villages comprising millions of people in the province. The agricultural crops, livestock and fruit orchards were severely affected resulting in losses to economic assets, environment damage and deterioration of health conditions of people in drought affected districts.

Monitoring impacts on vegetation/agriculture as a result of prevailing drought condition in rainfed areas could be helpful in forecasting yield/production. Satellite Remote sensing has been a potential source of data to provide both spatial and temporal information on vegetation health. Remote sensing data acquired through various satellites can be effectively used to compare different vegetation indices as a means to assessing drought impact on vegetation/agriculture.

Goals and Objectives

1. Exploring HJ-1-A, HJ-1-B and other Chinese Satellite data for drought monitoring in Pakistan
2. Defining and evaluating different indices pertaining to meteorological data and vegetation
3. Impact study of vegetation in rainfed areas as a result of drought
4. Suggest possible strategies towards mitigation of drought related impacts

Project Area

As shown in figure.1 the study area is comprised of rainfed areas i.e. Abbottabad, Attock, Bannu, Bhakkar, Chakwal, DG Khan, Jhelum, Kohat, Lakki Marwat, Layyah, Malakand, Mianwali, Muzaffargarh, Narowal, Rajanpur, Rawalpindi, Swat, Swabi, and Sialkot.

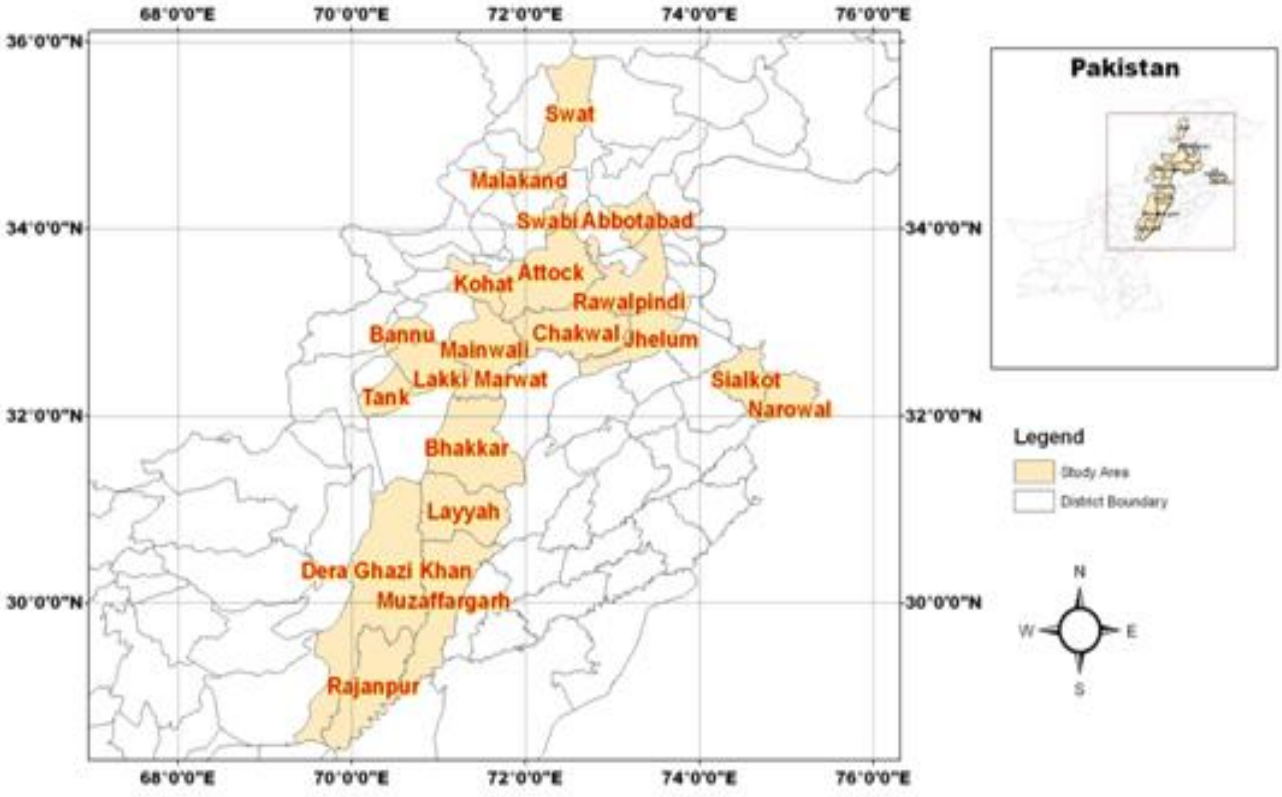

Figure.1

The major crops grown in these areas are Wheat, Chickpeas, Mustard, Peanuts, Jawar, Bajra, and Maize.

Scope of Work

1. Literature review
2. Collection of information on previous drought events in the study area
3. Mapping of the historical drought events in the last two decades using archive MODIS, NOAA, Landsat and Chinese satellite (HJ-1-A,HJ-1-B) data
4. Collection of relevant satellite imageries from APSCO Data Sharing Service Platform
5. Analyzing temporal images of HJ-1-A, HJ-1-B, MODIS (NDVI 250 m) for vegetation indices and land surface temperature data in monitoring water stress level
6. Field surveys

7. Study of relationship between satellite and ground-based parameters including vegetation indices, rainfall, moisture index, etc
8. Analysis of meteorological data (Precipitation, Temperature)
9. Comparison and analysis of results derived from HJ-1-A and HJ-1-B with Landsat, MODIS data for drought monitoring in Pakistan

Schedule

The project will be divided into four phases each of 06 months:

1. First phase: Mapping of severe drought affected areas based on past events
2. Second phase: Calculation of different vegetation indices using HJ-1A, HJ-1B data
3. Third phase: Comparison of vegetation indices derived from Hyperspectral and Multispectral data
4. Fourth phase: Comparison and analysis of Hyperspectral & Spectrometer Data

Detailed Activities, Schedule and Responsibilities

Activity	First Phase 2013						Responsibilities		Output
	Jan	Feb	Mar	Apr	May	Jun	SUPARCO	APSCO	
1. Mapping of severe drought affected areas based on past events									
1.1 Collection of information about past drought events in study area	✓	✓					- Literature Review - Study and analysis of published reports on past drought events in rainfed areas of Pakistan	-	-

	Jan	Feb	Mar	Apr	May	Jun	SUPARCO	APSCO	
1.2 Mapping of previous drought potential hazard area	✓	✓	✓	✓	✓		-Acquisition of archived satellite data of MODIS, Landsat and NOAA -Acquisition of archived meteorological data (precipitation, max min temperature) -Standardized Precipitation Index (SPI) analysis -Processing of satellite imagery to derive vegetation indices - Analysis of parameters derived from satellite images and meteorological data for finding out the reason for drought	-	-Maps showing frequently drought hit rainfed areas of Pakistan
1.3 Training in processing of HJ-1A, HJ-1B data						✓	02 officials will be nominated by SUPARCO	Organization of training course by APSCO	-
Activity	**Second Phase 2013**						**Responsibilities**		**Output**
	Jul	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**SUPARCO**	**APSCO**	
2. Calculation of different vegetation indices using HJ-1A, HJ-1B data									
2.1 Reviewing literature regarding specifications of HJ-1A & HJ-1B	✓						- Literature review regarding processing/analysis of Chinese satellite data	Provision of relevant literature and technical support	-

	Jul	Aug	Sep	Oct	Nov	Dec	SUPARCO	APSCO	
2.2. Study specifications regarding spectral, spatial, temporal and radiometric resolution & development of methodological frame work for impact study of drought on vegetation	✓	✓					- Construct a well defined methodology for drought monitoring using Chinese multispectral satellite data.	Provision of relevant literature and technical support	-
2.3. Acquisition of multi-resolution Chinese satellites data HJ-1A, HJ-1B for rainfed areas for the following periods Jan-Feb (2009,2010,2011,2012,2013) July, August, December (2009,2010,2011,2012,2013)		✓	✓	✓	✓		- Collection of optical and infrared HJ-1A and HJ-1B Chinese Satellite data for required vegetation indices - Acquisition of meteorological data	Provision of multispectral HJ-1A, HJ-1B satellite data(Level-1 and Level-2) Along with metadata information for the mentioned period	-
2.4. Determining different vegetation indices (NDVI, TVDI, MSAVI, EVI, Deviation NDVI, VCI, VHI, etc)	✓	✓	✓				- Processing of HJ-1A and HJ-1B for evaluation of different vegetation indices	-	Processed imagery
2.5. Comparison of results derived from MODIS, NOAA, Landsat with available HJ-1A and HJ-1B data			✓				- Analysis and comparison of results	-	Thematic maps
2.6. Organizing workshop/seminar to present the derived results of phase 1 and phase 2.				✓			- Participation of concerned SUPARCO officials	Organization of workshop for member countries	Presentation of results
2.7. Training on the use of spectrometer					✓	✓	- 02 officials will be nominated by SUPARCO	Training on use of spectrometer	Learning of required techniques

	Jul	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**SUPARCO**	**APSCO**	
2.8. Training in the processing/analysis of hyperspectral data					✓	✓	- 02 officials will be nominated for training	Training on processing of hyperspectral data by SUPARCO	Learning of required techniques
2.9. Training on building spectral libraries					✓	✓	- 02 officials will be nominated by SUPARCO	Training on building spectral libraries	Learning of required techniques
Activity	**Third Phase 2014**						**Responsibilities**		**Output**
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**SUPARCO**	**APSCO**	
3. Comparison of vegetation indices derived from Hyperspectral and Multispectral data									
3.1. Acquisition of Hyperspectral HJ-1A data for "January 2009,2010,2011,2013,2014" of the rainfed areas of Pakistan	✓						- Respective data acquisition and processing	Provision of available HJ-1A hyperspectral data as per data requirement	-
3.2. Field visit for collecting spectral signatures through spectrometer for different crops in rainfed areas	✓	✓					- SUPARCO officials will conduct field visits for collection of field data - processing of field data	-	Processed field data

3.3. Processing of HJ-1A hyperspectral data and building spectral libraries for different crops for "January 2014"		✓					- Respective data processing and analysis	-	Spectral libraries
3.4. Determining vegetation indices based on narrow band widths of hyperspectral HJ-1-A data for "January 2009,2010,2011,2013,2014"		✓	✓	✓	✓	✓	- Determination of vegetation indices using narrow band information HJ-1A hyperspectral data	-	vegetation indices
Activity	**Fourth Phase 2014**						**Responsibilities**		**Output**
	Jul	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**SUPARCO**	**APSCO**	
4. Comparison of Hyperspectral & Spectrometer Data									
4.1. Acquisition of Hyperspectral HJ-1A data for "July-August 2009,2010,2011,2013,2014" of the rainfed areas of Pakistan	✓						- Acquisition of precipitation data	Provision of available HJ-1A hyperspectral data as per data requirement	-
4.2. Field visit for collection of spectral signatures using spectrometer for different crops in rainfed areas for the month of "July-August 2014"		✓					- SUPARCO officials will conduct field visits	-	Processed field data
4.3. Processing of HJ-1A Hyperspectral data and building spectral libraries for different crops for "July-August 2014"		✓					- Respective data processing and analysis	-	Spectral libraries

4.4. Determining vegetation indices based on narrow band widths of hyperspectral (HJ-1-A) data for "July-August 2009,2010,2011,2013,2014		✓	✓	✓	✓		- Processing of HJ-1A Hyperspectral data and building spectral libraries for different crops	-	Vegetation indices
4.5. Compilation of evaluated results based on multispectral and hyperspectral data for drought monitoring				✓	✓		Respective data processing and analysis	-	-
4.6. Final Report					✓		- Integrated analysis	Report	Evaluation
4.7. Workshop on evaluated results based on multispectral and hyperspectral data for drought monitoring						✓	- Participation of SUPARCO officials	Organization of workshop for member countries	Research paper submission and presentation

Hardware Required

Spectrometer specification:

FieldSpec®3 (350-2500nm) / A100590 (TSKAY TECHNOLOGIES)

- ✓ Spectral range: 350nm - 2500nm
- ✓ Spectral resolution: of 3 nm at 700 nm and 10 nm at 1400 nm and 2100 nm
- ✓ Sampling interval: 1.377 nm for 350 - 1000 nm and 2 nm for 1000 - 2500 nm.
- ✓ Spectral resolution: 3 nm at 700 nm and 10 nm at 1400 nm and 2100 nm.
- ✓ Data collection speed: 0.1 seconds single spectrum acquisition, about 1.5 seconds for 10 spectra averaging.
- ✓ Set-up optimization speed: about 8.5 to 14 seconds initial optimization depending upon illumination.
- ✓ Dispersion element & detector: fixed reflective holographic diffraction grating, 512 element silicon photo-diode array with high order blocking filter, 2 X fast scanning reflective holographic diffraction grating and a TE cooled "graded index" InGaAs photo-diode with high order blocking filter, internal shutters, and ASD's proprietary DriftLock® automatic offset correction.
- ✓ Input: 25 deg full conical angle fiberoptic cable 1.5m long (optional screw-on telescopic field-of-view foreoptics and optional fiberoptic jumper cables available at additional cost).
- ✓ Noise equivalent delta radiance (NeDL) for standard 1.5 m fiberoptic cable: 1.1 x 10^-9 W/cm^2/nm/sr @700 nm, 2.4 x 10^-9 W/cm^2/nm/sr @ 1400 nm, and 4.7 x 10^-9 W/cm^2/nm/sr @ 2100 nm.
- ✓ Maximum radiance: well in excess of twice those for a 0 deg solar zenith angle and a 100% reflectance Lambertian surface.
- ✓ Other built-in features: ASD proprietary Fiberchecker system and test optic, accessory auxiliary power jack.

Data Specification

Data required for the project could be processed using SUPARCO's existing facilities. These could be available to stakeholders in Pakistan and APSCO.

The details of data required, are:

1. Medium and coarse spatial resolution satellite data (SPOT-VGT, MODIS)
2. Chinese Satellite data of HJ-1-A, HJ-1-B multispectral (30 m), infrared (150 m / 300 m) and hyperspectral (100 m)
3. Crop calendar, crop statistics (from concerned departments)
4. Other relevant data

Satellite Data Requirement from APSCO Data Sharing Platform

Satellites	Sensors	Period			Scenes	Remarks
		Months	Years			
			From	To		
HJ-1A	CCD Camera	January, February	2009	2014	All the scenes covering study area repetitively every 10 days with minimum cloud cover (<10 %)	Geo-referenced
		July, August, December	2009	2014	All the scenes covering study area repetitively every 10 days with minimum cloud cover (<10 %)	Geo-referenced
HJ-1B	Infrared Sensor	January, February	2009	2014	All the scenes covering study area repetitively every 10 days with minimum cloud cover (<10 %)	Geo-referenced
		July, August, December	2009	2014	All the scenes covering study area repetitively every 10 days with minimum cloud cover (<10 %)	Geo-referenced
HJ-1A	Hyper-Spectrum Image (HSI)	January, February	2009	2014	All the scenes covering study area repetitively every 10 days with minimum cloud cover (<10 %)	Geo-referenced
		July, August	2009	2014	All the scenes covering study area repetitively every 10 days with minimum cloud cover (<10 %)	Geo-referenced

Capacity Building

Trainings**:**

- ✓ HJ-1A multispectral and HJ-1B infrared data processing. Proposed month: May, 2013
- ✓ Spectrometer data handling and processing. Proposed month: November, 2013
- ✓ HJ-1A hyperspectral data processing, analysis, development of spectral libraries and its analysis. Proposed month: December, 2013

Seminars Workshops Arrangement**:**

- ✓ Workshop on phase I and II results will be arranged for member countries. Proposed month: October, 2013
- ✓ Workshop on phase III and IV results will be arranged for member countries. Proposed month: December, 2014

Deliverables

The following deliverables will be provided on hard and soft copies (CD-R/DVD):

1. Copies of drought vulnerability maps
2. Analyzed results such as final generated maps, statistics
3. Final report

Benefits

1. Sustainable agriculture practices and better food security arrangements
2. Mitigating the effects of drought
3. Drought vulnerable maps
4. Scientific publications
5. Capacity building

Licensing

The original data used will be the property of provider. The deliverables will be the property of sponsor. However, arrangements are likely to be made for joint scientific publication (journal articles and reports) of the results for citation in future research studies.

Support from SUPARCO

1. Lab facilities (hardware, software, etc)
2. Relevant manpower
3. Collection of information on past drought events and mapping potential drought prone areas
4. Processing and analysis of satellite and meteorological data
5. Field surveys
6. Preparation of report
7. Presentation of results of the study

Support Requested from APSCO

1. Spectrometer as mentioned on page # 13
2. Satellite data as mentioned on page # 14
3. Organization of workshop / Seminar as mentioned on page # 15
4. Training / capacity building as mentioned on page # 15