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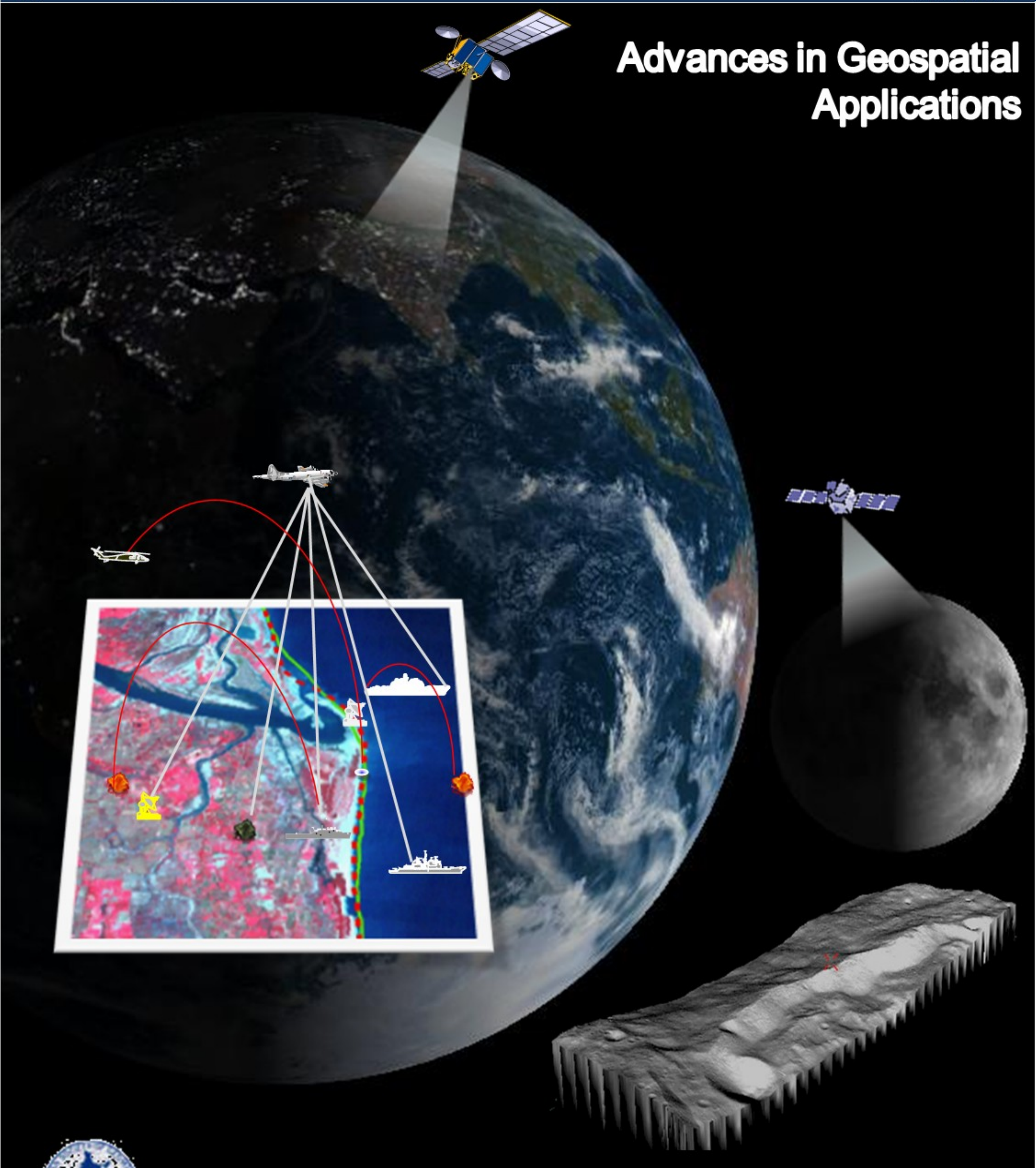
ISG NEWSLETTER

Vol. No. January 2010

Advances in Geospatial Applications



INDIAN SOCIETY OF GEOMATICS

www.isgindia.org
isg@isgindia.org

ISG NEWSLETTER

Volume 15, No. 1 – 4 Advances in Geospatial Applications December, 2009

In this Issue

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Shri R P Dubey, Associate Editor, JoG & Editor, ISG Newsletter — Email: rpdubey@sac.isro.gov,.in

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Send your contributions/comments to the Editor at the above e-mail.

Editorial

During the year 2000, ISG Newsletter underwent a change - from a mere newsletter, it was transformed into a specialized 'magazine', publishing special issues on themes which were considered to be most relevant to the time of publication, apart from important news of interest to Geomatics community.

During the same year, with December 2000 Issue i.e. volume 6, number 4, the Society started publishing ISG Newsletter in a printed form. The tradition of bringing out special thematic issues has been continued. The current special issue on ‘Advances in Geospatial Applications’ is a pertinent topic for today. The issue overall should fit in the backdrop of National Conference Geomatics 2010 being organized by ISG in Space Applications Centre, Ahmedabad due to its thematic relevance. In this issue, you will find very informative articles on planetary geomatics in form of the applications and the mission of India’s first lunar mission Chandrayaan-1 geomatics and some authorative articles related to geological aspects of climate change and sea level rise due to global warming.

The painstaking efforts of Dr Ajai in collection of articles and of Shri C P Singh in compilation of the issue and design of cover needs special mention. The authors have been very supportive of the newsletter by their liberalcontirbutions of articles cast in popular accent.

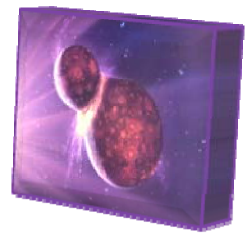
With this issue, the hardcopy circulation of this newsletter will cease to exist – as per the guidelines provided by ISG Executive Council. However, the softcopy version will be continued and circulated through the society’s website (www.isgindia.org).

Members of ISG and other professionals are requested to keep reading the newsletter and sending their articles for upcoming volumes of future issues.

R P Dubey

चन्द्र की सतह सामान्यतया सूखी, धूल और पत्थरों से युक्त और चट्टानों वाली है। भूमि की ओर अभिमुख भाग पर पथरीली सतह लगभग 60 कि.मी .मोटी है और दूसरे भाग पर लगभग 107 कि.मी .है। चट्टानों में केल्शियम, एल्युमिनियम एवं टिटेनियम की मात्रा अधिक है। प्रचुर मात्रा में सिलिकोन और हिलियम भी है। लाखों बरसों से सौर मंडल के हिलियम की चंद्रसतह के साथ टक्करों के कारण वहाँ के खनिजों में फंसकर प्रचुर मात्रा में हिलियम-3 एवं हिलियम-4 उपलब्ध हैं।

चंद्रमा का उद्भव

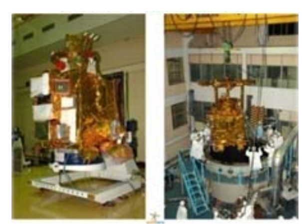


चंद्रमा की उत्तपत्ति अभी तक स्पष्टीकरण के दौर में है और इसके उद्भव के बारे में अनुमान लगाए गए हैं कि ये कैसे बना होगा। रसायनिक खनिजीय समस्थानिक और कालानुक्रम आंकड़ों का उपयोग करते हुए, किए गए अध्ययन से चंद्र के उद्भव के बारे में पाँच प्रमुख सिद्धांतों की अभिधारणा बनी।

- विखंडन सिद्धांत- बहुत समय पहले कभी चंद्रमा पृथ्वी से पृथक हो गया। शायद तब पृथ्वी इतनी गोल नहीं थी जितनी आज है और उस असंतुलन के कारण यह दो हिस्सों में बँट गई।
- प्रग्रहण सिद्धांत- सौर मंडल में कहीं चंद्रमा का उद्भव हुआ, अतः बाद में यह पृथ्वी के गुरूत्वाकर्षण क्षेत्र की परिधि में आया।
- सब-अभिवर्धक सिद्धांत- पृथ्वी और चंद्रमा का सह अभिवर्धन द्वारा सौर नेब्युला से एक ही समय में उद्भव हुआ ।
- टकराने का ग्रहाणु सिद्धांत- सौर प्रणाली के इतिहास में बहुत पहले पृथ्वी का परिक्रमण और सूर्य का परिक्रमण करने वाले ग्रहाणुओं (क्षुद्र ग्रह जैसी चट्टानों का बृहत् भंडार) की अन्योन्यक्रिया के मलवे से उद्भव हुआ।
- विशालकाय (बृहत्) संघट्ट सिद्धांत- प्राचीन काल में मंगल के आकार के ग्रहाणु का पृथ्वी के साथ संघट्ट हुआ, जिससे विकसित होती पृथ्वी से बड़ी मात्रा में पदार्थों का निष्कासन हुआ और इनके मिलन से चंद्रमा का उद्भव हुआ।

पृष्ठभूमि

चन्द्रमा पर वैज्ञानिक मिशन भेजने के संबंध में विचार की शुरूआत भारतीय खगोलयनिकी सोसाइटी द्वारा की गई । ग्रहीय एवं अंतरिक्ष भौतिकी, पृथ्वी विज्ञान, भू-विज्ञान, भौतिकी, खगोलिकी तथा ब्रह्माण्डिकी के विभिन्न संबंध्द क्षेत्रों के लगभग 100 प्रतिष्ठित वैज्ञानिकों के एक दल ने अप्रैल 2003 में इस कार्यदल की अध्ययन रिपोर्ट की समीक्षा की । विस्तृत विचार विमर्श के बाद प्रतिभागियों ने एकमत से भारत को चन्द्रमिशन शुरू करने की सिफारिश की।



तत्पश्चात, भारत सरकार ने इसरो को चन्द्रयान-1 नामक प्रथम भारतीय चन्द्र मिशन के प्रस्ताव को मंजूरी दे दी।

चंद्र मिशन के प्रकार

मुख्य रूप से पाँच प्रकार के चंद्र मिशन होते हैं। पहले प्रकार में यान चंद्र के पास से गुजरता है जिसे फ्लाय वॉच कहते हैं। दूसरे प्रकार में यान वैज्ञानिक उपकरण लेकर चंद्र की निर्धारित कक्षा में परिभ्रमण करता है जिसे ओरबीटर कहते हैं। तीसरे प्रकार में चंद्र की सतह पर अमानव यान को उतारकर वैज्ञानिक परीक्षण किए जाते हैं जिसे लेंडर-रोवर कहते हैं। चौथे प्रकार में यंत्र मानव चंद्र की सतह से नमूने लाता है जिसे सेम्पल-रिटर्न कहते हैं और पाँचवें प्रकार में चंद्र की सतह पर मानव पदार्पण होता है जिसे मेन-मिशन कहते हैं।

भारत का चंद्रयान-1 ओरबीटर प्रकार का मिशन है जिस में अंतरिक्ष यान को चंद्र की सतह से 100 कि.मी. की ऊँचाई पर गोलाकार वृत्तीय कक्षा में परिक्रमित किया गया है।

लक्ष्य

इस मिशन के प्राथमिक उद्देश्य, - चन्द्रमा के उद्भव और विकास के बारे में वैज्ञानिक ज्ञान को बढ़ाना, भारत की प्रौद्योगिकीय क्षमताओं का उन्नयन करना, ग्रहों के अध्ययन जैसे नये और उत्तेजक क्षेत्रों में अनुसंधान करने के लिए भारत के युवा वैज्ञानिकों को चुनौतीपूर्ण अवसर प्रदान करना, चन्द्र का मानचित्र तैयार करना जो इसकी सतह पर वितरित विभिन्न तत्व और खनिजों को दर्शाये तथा चन्द्र की सतह का ऐसा फोटोग्राफ लेना कि चन्द्र के सतही लक्षणों की लम्बाई, चौड़ाई और ऊँचाई को परिशुध्द रूप से पहचाना जा सके आदि हैं।

चन्द्रयान-1 मिशन के माध्यम से प्रकाश भूविज्ञानी, खनिजविज्ञानीय और रसायनिकी मानचित्रण से विभिन्न भू-विज्ञानीय यूनिटों का निर्धारण करना संभव होगा, जोकि चन्द्रमा के प्रारंभिक विकासात्मक इतिहास की जांच करेगा। रसायनिक मानचित्रण चन्द्रमा की भू-पर्पटी की विजातीय प्रकृति और गहराई से स्तरित विज्ञान का निर्धारण करेगी तथा इसके द्वारा मेगमा महासागर की परिकल्पना के कुछ पहलुओं की जाँच करेगी एवं संघटकों के संयोजनों का निर्धारण किया जा सकता है, जोकि पृथ्वी के निर्माण से भी संबंध्द हैं।

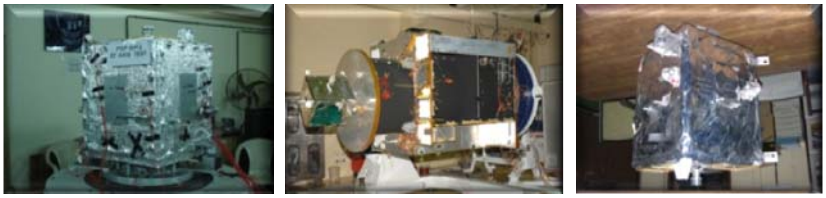
यह मिशन मूलभूत अनुसंधान के अनुसरण के लिए युवाओं हेतु एक महत्वपूर्ण प्रेरक होगा। प्रौद्योगिकीय और वैज्ञानिक लाभों के अलावा चन्द्रयान-1 देश में मूलभूत विज्ञान और इंजीनियरिंग अनुसंधान को प्रवृत्त करेगा। शैक्षिक जगत, विशेष रूप से विश्वविद्यालयों के वैज्ञानिक, चन्द्रयान-1 से अत्यंत लाभान्वित होगें।

चन्द्रयान – 1 के वैज्ञानिक उपकरण

चन्द्रयान- 1 द्वारा इस्तेमाल किये गये पहले पाँच भारतीय वैज्ञानिक उपकरण इस प्रकार हैं–

(i) चन्द्र संघट्ट प्रोब (एम.आई.पी.) – चंद्रयान-1 को निर्धारित कक्षा में स्थापित करने के बाद एम.आई.पी. को यान से अलग करके चंद्र की सतह से टक्कर लगाने हेतु इस उपकरण का निर्माण किया गया। इस उपकरण के तीन मुख्य भाग थे जिसमें (i) वीडियो कैमरा-जो चंद्र सतह पर उतार के दौरान

नजदीक से चित्र ले सके, (ii) रडार तुंगतामापी-जो एम.आई.पी. की चंद्र सतह से ऊँचाई माप सके और (iii) पदार्थ पिंड स्पेक्ट्रामापी-जो चंद्र के पर्यावरण में रहे घटकों के बारे में जानकारी दे सके। इसरो के

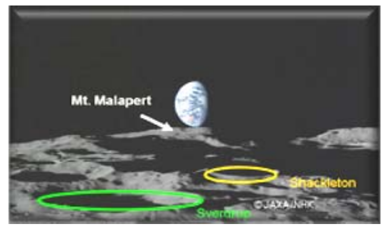


मून इम्पेक्ट प्रोब (एमआईपी)

एमआईएस कैमरा

चेज़

रडार आल्टीमीटर

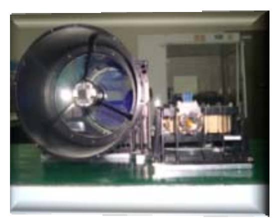


एमआईपी इम्प्केट बिंदु - माउंट मेलापर्ट

विक्रम साराभाई अंतरिक्ष केंद्र द्वारा एम.आई.पी. का निर्माण किया गया।

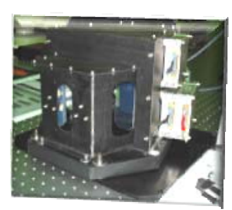
(ii) चन्द्र लेसर रेंजिंग उपकरण (एल.एल.आर.आई.) - यह उपकरण अवरक्त लेसर प्रकाश के स्पंद को चन्द्रमा की सतह की ओर भेजता है और परावर्तित प्रकाश को संवेदित करता है। ऐसा करते हुए यह उपकरण चन्द्र सतह की ऊँचाई के बारे में यथार्थ सूचना उपलब्ध कराता है। बेंगलूर में इसरो की विद्युत-प्रकाशिकी प्रणाली प्रयोगशाला (लियोस) द्वारा एल.एल.आर.आई. का निर्माण हुआ। एल.एल.आर.आई. के विस्तृत विनिर्देशन निम्न प्रकार है:

स्पंदावृत्ती दर	10 Hz
दूरबीन	20 सें.मी. व्यास, परावर्तनशील
लेज़र तरंग स्रोत	1064 नैनो मीटर
सीमा मापनशुद्धता	<5 मीटर

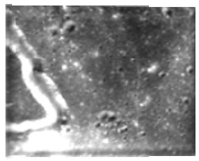


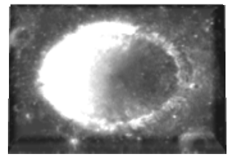
(iii) भूभाग मानचित्रण कैमरा (टी.एम.सी.) - यह एक इलेक्ट्रानिक कैमरा है जो चन्द्र की सतह का श्वेत-श्याम चित्र लेता है। इसका निर्माण इस तरह किया गया है कि चन्द्र की वस्तु की ऊँचाई का, चित्र की जाँच करने से ही पता लगाया जा सकता है। टी.एम.सी. चन्द्र सतह के त्रि परिमाणीय (3 **D**) चित्र लेता है। ऐसे चित्र चन्द्र की सतह पर ऐसे क्षेत्रों, जो वैज्ञानिक रुचि के हैं और अधिक विस्तृत अवलोकन के योग्य हैं, को पहचानने में सहायता करेंगें। इसका निर्माण अहमदाबाद स्थित सैक द्वारा किया गया है। टीएमसी के विस्तृत विनिर्देशन निम्न्न प्रकार हैं-

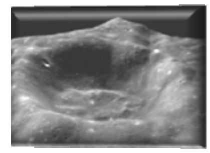
भू विभेदन	5 मीटर *(100 किमी की ऊँचाई से)*
प्रमार्ज	20 किलो मीटर
स्पेक्ट्रमी बैंडों की संख्या	1-पैनक्रोमेटीक बैंड (500-850 नैनो मीटर)
अवलोकन रेखागणित	फोर, नादीर और आफ्ट नाम के तीन कैमरों से



(iv) उच्च ऊर्जा वाले एक्स किरण स्पेक्ट्रममापी (एच.ई.एक्स) - यह उपकरण, एक्स किरण जिसमें शक्ति हो, के उत्सर्जन को संवेदित करता है


अपोलो-15 लैंडिंग साइट

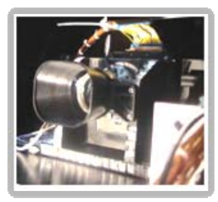

13 जनवरी 09 को देखे गए क्रैटर

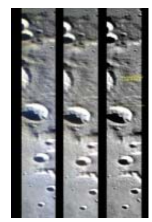

कोलम्ब-सी क्रैटर का 2.5 डी परिदृश्य

जिसे वैज्ञानिकों द्वारा 'उच्च' माना जाता है। ऐसे एक्स किरणों के अभिलेखन व विश्लेषण के द्वारा यूरेनियम तथा थोरियम जैसे भारी घटकों की उपस्थिति का पता अप्रत्यक्ष रूप से लगाया जा सकता है। इस उपकरण को पी.आर.एल., अहमदाबाद व बेंगलूर के इसरो उपग्रह केन्द्र द्वारा संयुक्त रूप से बनाया गया।

(v) अति स्पेक्ट्रमी प्रतिबिंबित्र (एच.वाई.एस.आई.) - यह कैमरा, चन्द्र से प्रत्यावर्तित दृशीय और अवरक्त प्रकाश का रिकार्ड करते हुए चन्द्र के सतह का रंगीन चित्र लेता है। यह चन्द्र की सतह से प्रकाश को 64 अत्यंत पतले बैंडों में विभाजित करता है जिससे कुछ निर्दिष्ट वस्तु या परिघटना प्रकट होती है। हैसी (एच.वाई.एस.आई.) से लिये गये चित्र चंद्र सतह पर वितरित खनिजों का तरीका जानने में सहायता करते हैं। हैसी सैक, अहमदाबाद द्वारा निर्मित है। HySI के विस्तृत विनिर्देशन निम्न प्रकार है:

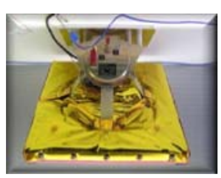
भू-विभेदन	80 मीटर *(100 किमी की ऊँचाई से)*
प्रमार्ज	20 किलो मीटर
स्पेक्ट्रमी रेंज	400-950 नेनो मीटर
स्पेक्ट्रमी बैंडों की संख्या	64 अविरल
स्पेक्ट्रमी विभेदन	<15 नेनो मीटर

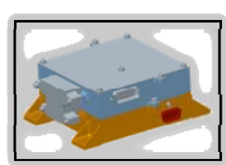

एच.वाई.एस.आई.

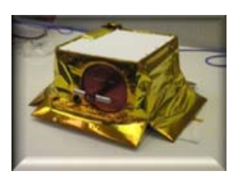

3-विभिन्न स्पेक्ट्रमी बैंडों में प्रतिबिंब

भारत के पाँच भारतीय वैज्ञानिक यंत्रों के अलावा चन्द्रयान-1 अन्य देशों द्वारा बनाये गये छ :उपकरणों को भी ले गया। इसरो ने ब्रिटेन, जर्मनी, स्वीडन, बुल्गेरिया तथा संयुक्त राज्य अमरीका के कुल छ : वैज्ञानिक उपकरणों का चयन किया। वे इस प्रकार हैं –

(i) चतुर निकट अवरक्त स्पेक्ट्रममापी (एस.आई.आर.-2) – यह उपकरण ऐसी किरणों का पता लगा सकता है और रिकार्ड कर सकता है तथा यह पता लगाने में भी सहायता करता है कि चन्द्र सतह पर खनिज कहाँ और कितनी मात्रा में उपस्थित हैं। इसके अलावा इस उपकरण से चन्द्र सतह पर उपस्थित पदार्थ वहाँ के अत्यधिक गरम व ठंड की स्थिति के अनुसार कुछ कालावधि के बाद, कैसे बदलते हैं इसका भी पता लग सकता है। इस यंत्र का निर्माण जर्मनी के मेक्स प्लेंक संस्थान द्वारा किया गया।



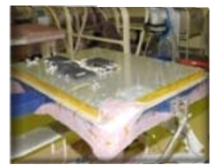


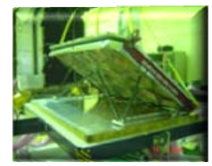


एसआईआर-2 (जर्मनी से)- उद्देशात्मक मिनिरल मैपिंग स्पेक्ट्रल सीमा 0.9 से 2.7μमी.

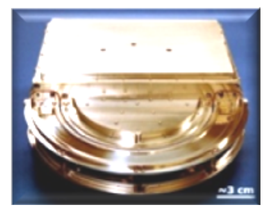
(ii) एक्स-किरण स्पेक्ट्रममापी - (सी.आई.एक्स.एस.) - यह उपकरण सूर्य से उत्सर्जित एक्स किरणों के चन्द्र सतह पर कुछ सामग्रियों से टकराने की प्रतिक्रिया स्वरूप उनसे उत्सर्जित अन्य प्रकार की एक्स-किरणों को मापता है। यह यंत्र मेग्निशियम, कैल्शियम, एल्युमिनियम, टीटानियम, सिलिकॉन तथा लोहे जैसे घटकों के बंटवारे को समझने में सहायक होता है। ब्रिटेन के रुदरफोर्ड एपेलटोन प्रयोगशाला तथा इसरो उपग्रह केन्द्र, बेंगलूर के द्वारा संयुक्त रूप से इस उपकरण का निर्माण किया गया।

(iii) मिनी संश्लेषी द्वारक राडार (मिनी-एस.ए.आर.) - चन्द्रमा के ध्रुवीय क्षेत्र में यदि कोई जल बर्फ उपस्थित हो तो उसका पता लगाने के लिए मिनी एस.ए.आर .का निर्माण किया गया। इस यंत्र के द्वारा मृदा में कुछ मीटर तक की गहराई तक जल बर्फ की उपस्थिति का पता लगा सकते हैं। इस उपकरण का विकास संयुक्त रूप से जॉन-हॉकिन्स विश्वविद्यालय की प्रायोगिक भौतिकी प्रयोगशाला और संयुक्त राज्य अमरीका के नौ वायु युक्त केन्द्र द्वारा किया गया और नासा द्वारा मान्यता दी गई।





(iv) उपकिलो वोल्ट परमाणु परावर्तन विश्लेषित्र (एस.ए.आर.ए.) - यह चन्द्रमा के विगत चुम्बकीय क्षेत्र के बारे में जानने के लिए सुराग उपलब्ध करा सकता है। साथ ही साथ अंतरिक्ष में स्थित पदार्थ कुछ कालावधि के बाद कैसे धीरे-धीरे बदलते हैं, उस पर भी प्रकाश डालता है। स्वीडन के अंतरिक्ष भौतिकी संस्थान के द्वारा एस.ए.आर.ए .(सारा) का निर्माण किया गया।



(v) चन्द्र खनिज विज्ञानीय मानचित्रक (एमथ्री) - जैसा कि नाम से ही पता चलता है एम-3 चन्द्रमा पर उपस्थित खनिजों के प्रकार तथा साथ ही साथ उसके स्थान का पता लगाने में सहायता करता है। एम3 का विकास संयुक्त रूप से ब्राउन विश्वविद्यालय तथा नासा के जेट नोदन प्रयोगशाला द्वारा किया गया।

(vi) विकिरण मात्रा मॉनीटर (आर.ए.डी.ओ.एम.) - बुल्गेरियन विज्ञान अकादमी द्वारा निर्मित यह यंत्र चन्द्रमा के चारों ओर आच्छादित उच्च शक्ति वाले उपपरमाणु कणों के बारे में समझने में सहायक है। यह अत्यंत महत्वपूर्ण है क्योंकि ऐसे कण मानव के लिए खतरनाक है। आर.ए.डी.ओ.एम. चन्द्रमा के चारों ओर विकिरण का बंटवारा और उसकी मात्रा के बारे में जानकारी उपलब्ध कराता है।

भू - सुविधाएं

चंद्रयान-1 की भू सुविधाओं के तीन भाग हैं-

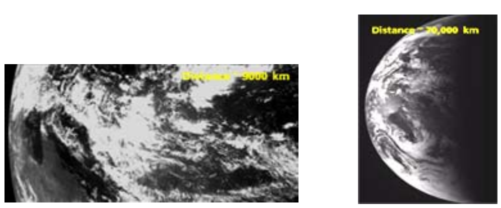
- ***भारतीय गहन अंतरिक्ष नेटवर्क (आई.डी.एस.एन.)-*** यह वह सुविधा है जो दूरस्थ चंद्रयान-1 की अंतरिक्ष द्वारा रेडियो तरंगों के जरिए भेजी गई विविध प्रकार की सूचना का अभिग्रहण करती है। यह बेंगलूर से 35 कि.मी. दूर बायलालु में स्थित है। आई.डी.एस.एन. में दो विशाल ऐंटेना हैं- 18 मी. व्यास का एक ऐन्टेना और 32 मी. व्यास का दूसरा ऐन्टना। 32 मी. के डिश ऐन्टेना को इसरो दूरमिति, अनुवर्तन तथा आदेश नेटवर्क, बेंगलूर के नेतृत्व में कई भारतीय संस्थानों और कंपनियों के द्वारा इसके डिज़ाइन, विकास एवं निर्माण की जाँच की गई थी। यह ऐन्टेना 20,000 वाट के पावर पर अंतरिक्ष यान के लिए अनुदेश के सूक्ष्मतरंगों का विकिरण भी कर सकता है।

- ***अंतरिक्ष नियंत्रण केंद्र (एस.सी.सी.)-*** यह केंद्र बेंगलूर के उपनगर पीण्या में स्थापित है। एस.सी.सी. अंतरिक्ष यान के प्रमोचन के बाद चंद्रयान-1 मिशन का मुख्य केंद्र बना। चंद्रयान-1 को विभिन्न कार्य के निष्पादन करने हेतु अनुदेश देते हुए रेडियो आदेश एस.सी.सी. से ही भेजे जाते थे। चंद्रयान-1 से आने वाली “शून्य” और “एक” संज्ञाओं की धारा का मानव द्वारा समझने योग्य के रूप में अर्थ निर्वाचन करने में सक्षम साफ्टवेयर से युक्त अत्याधुनिक कंप्यूटर भी एस.सी.सी. का भाग है।

- ***भारतीय अंतरिक्ष विज्ञान आंकड़ा केंद्र (आई.एस.एस.डी.सी.)-*** यह भी बायलालु में ही स्थित है अतः अंतरिक्ष यान से भेजी गई और आई.डी.एस.एन. ऐन्टेनाओं के अलावा देश से बाहर के ऐन्टेनाओं से संग्रहित मूल्यवान वैज्ञानिक सूचनाओं को स्वीकार करता है, इसका संसाधन करता है और एक क्रमबद्ध तरीके से संग्रह करता है। इस आंकड़े को लेकर इसके लिए अनुरोध किए गए लोगों को भेजने की सुविधा भी इस केंद्र में है। अत्याधुनिक आंकड़ा भंडारण और कंप्यूटर युक्तियाँ इस केंद्र के भाग हैं।

प्रमोचक रॉकेट तथा अंतरिक्षयान

भारतीय अंतरिक्ष अनुसंधान संगठन (इसरो) का ध्रुवीय उपग्रह प्रमोचक रॉकेट (पी.एस.एल.वी.), जिसे पहले भी सात बार सफलतापूर्वक प्रमोचित किया जा चुका है और जिसने ध्रुवीय कक्षा में भारतीय सुदूर संवेदन उपग्रहों को तथा भू-तुल्यकाली अन्तरण कक्षा में मौसमविज्ञानीय उपग्रह, कल्पना-1 को भी स्थापित किया है, उसको चन्द्रयान-1 मिशन के लिए उपयोग में लाया गया।



29 अक्तूबर 2008 को टीएमसी द्वारा लिया गया पृथ्वी का प्रतिबिंब

चंद्रयान-1 को पी.एस.एल.वी. 11 द्वारा प्रमोचित किया गया जो, पहले अनेक उपग्रहों को प्रमोचित करने वाले मानक पी.एस.एल.वी. की तुलना में अधिक शक्तिशाली था।

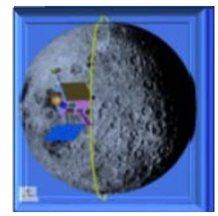
पी.एस.एल.वी. का निर्माण एक के ऊपर एक चार स्वतंत्र राकेट चरणों को रखकर बनाया गया। पी.एस.एल.वी. के प्रथम तथा तीसरे चरण में तथा स्टैप-ऑन में ठोस-नोदन का उपयोग किया गया।

चन्द्रयान-1 – भारत का प्रथम चन्द्र मिशन

ए.एस. किरणकुमार, डॉ. पुनीत स्वरूप एवं सुबोध पी. काछेला

सैक, अहमदाबाद

भारत ने 14 नवम्बर, 2008 को चन्द्रमा की सतह पर पहली बार अपना राष्ट्रीय ध्वज स्थापित कर एक नया इतिहास रचा है। चन्द्रयान-1 पृथ्वी से परे अन्वेषण करने की भारत की खोज का प्रारंभिक कदम है। अब चन्द्रमा की सतह पर कोई वैज्ञानिक यंत्र-उपकरण आदि उतारने वाला भारत तीसरा देश और चौथी अंतरिक्ष शक्ति बन गया है। इससे पूर्व अमरिका, भूतपूर्व सोवियत संघ और यूरोपिय अंतरिक्ष एजेंसी यह कार्य कर चुके हैं।



चन्द्रमा के बारे में

अब पड़ोसी चाँद हमारे लिए अनजाना नहीं रह गया है। चांद, पृथ्वी से औसतन 3,84,400 किलोमीटर दूर है लेकिन पृथ्वी के चारों ओर उसका परिक्रमापथ बिल्कुल गोलाकार नहीं है इसलिए वह कभी 4,06,000 किलोमीटर दूर होता है तो कभी केवल 3,56,000 किलोमीटर। वह हमारी पृथ्वी का प्राकृतिक उपग्रह है। कई वैज्ञानिकों का अनुमान है कि सौर सामग्री से हमारी पृथ्वी और चांद का जन्म एक साथ ही हुआ लेकिन कुछ अन्य वैज्ञानिकों का विचार है कि वह पृथ्वी से टूट कर बना। चन्द्रमा रात्रि में आकाश में सबसे अधिक चमकदार पिण्ड है और सूर्य के बाद यह दूसरा सबसे प्रकाशमान पिण्ड है। पृथ्वी और चंद्र के भौतिक प्रचालनों की तुलना निम्न प्रकार है :-

प्राचल	पृथ्वी	चंद्र
गोलाकार में चपटापन *(Oblateness)*	**0.003353**	**0.00**
त्रिज्या *(Radius)*	**6378** कि.मी.	**1738** कि.मी.
घनत्व *(Density)*	**5.52** (ग्राम/सेमी^{3})	**3.344**(ग्राम/सेमी^{3})
द्रव्यमान *(Mass)*	**5.95×10^{27}** (ग्रा.)	**0.0123** (ग्रा)
गुरूत्वाकर्षण *(Gravity)*	**9.8** (मी/से.^{2})	**1.7** (मी/से.^{2})
निकास गति *(Escape velocity)*	**11.18** (किमी/से)	**2.3** (किमी/से)
औसतन तापमान *(Average Temp)*	**17 ˚ से**	**-170 ˚ से / +130 ˚ से**

चांद का वायुमंडल नहीं है, उसका गुरुत्वाकर्षण इतना कम है कि गैसें उसकी पकड़ में नहीं रह सकती इसलिए वहाँ सूर्योदय और सूर्यास्त का वह नजारा नहीं दिखाई देता जो हमें पृथ्वी पर दिखाई देता है। एक रोचक तथ्य यह है कि चन्द्रमा पृथ्वी की परिक्रमा लगभग एक माह में करता है । एक अमावस्या से दूसरी अमावस्या तक का समय लगभग 29 दिन है।

जबकि इसके दूसरे और चौथे चरण में द्रव नोदकों का उपयोग किया गया। पी.एस.एल.वी .का ठोस नोदक (चरणों तथा स्टैप-ऑन) एल्युमीनियम पाउडर ईंधन के रूप में प्रयोग किया गया, अमोनियम परक्लोरेट को एक ऑक्सीकारक के रूप में और एक रबड़ के कार्बनिक मिश्रण को एक ईंधन के बन्धक के रूप में उपयोग किया गया। पी.एस.एल.वी. में एक विद्युत इलेक्ट्रानिकी मस्तिष्क है जो बिना किसी बाहरी सहायता के अपनी उड़ान को नियंत्रण में रखता है। इस मस्तिष्क का निर्माण छः सूक्ष्म कम्प्यूटरों का उपयोग करते हुए किया गया है। पी.एस.एल.वी. का डिजाइन, विक्रम साराभाई अंतरिक्ष केन्द्र (वी.एस.एस.सी.) द्वारा किया गया। चन्द्रयान-1 मिशन में, अन्तरिक्षयान को चन्द्रमा की सतह के ऊपर लगभग 100 किमी की ऊँचाई पर ध्रुवीय कक्षा में स्थापित किया गया। इसका आकार एक धनाभ की तरह था। इसका सौर पैनल, इसके एक पार्श्व से पंख की तरह दिखाई देता है। अंतरिक्षयान के ऊपरी भाग में तथा इसके बगल में वैज्ञानिक यंत्र जुड़े थे।

प्रमोचन के समय अन्तरिक्षयान का वजन 1380 किग्रा था। इसमें आधे से ज्यादा नोदन (ईंधन व ऑक्सीकारक) का वजन था। चन्द्रमा के चारों ओर की एक कक्षा में अन्तरिक्षयान को स्थापित करने के लिए तथा उचित रूप से इसे बनाये रखने हेतु भी उनकी आवश्यकता थी। अंतरिक्ष यान को 240 किमी की उपभू और 36000 किलोमीटर की अपभू कक्षा, जोकि उस भू-तुल्यकाली अन्तरण कक्षा (जी.टी.ओ.) जिसमें कल्पना-1 उपग्रह को स्थापित किया गया था, की दीर्घवृत्तीय पार्किंग कक्षा (ई.पी.ओ.) में पी.एस.एल.वी. द्वारा प्रमोचित किया गया। पी.एस.एल.वी. के भू-कक्षा में पहुँचने के बाद चन्द्रयान-1 अन्तरिक्षयान ने चन्द्रमा तक पहुँचने के लिए अपने ही रॉकेट इंजन का उपयोग किया तथा उसके बाद उस आकाशीय पिण्ड का एक कृत्रिम उपग्रह बन गया। उस राकेट इंजन को द्रव अपभू मोटर (एल.ए.एम.) कहते हैं क्योंकि यह द्रव नोदन का उपयोग करती है। अन्तरिक्षयान को अपनी चन्द्रकक्षा में पहुँचने के लिए लगभग साढ़े पाँच दिनों का समय लगा। वैज्ञानिक आंकड़े भेजने के लिए इसमें गिम्बलड संचालनीय उच्चलब्धि एंटेना प्रणाली थी।

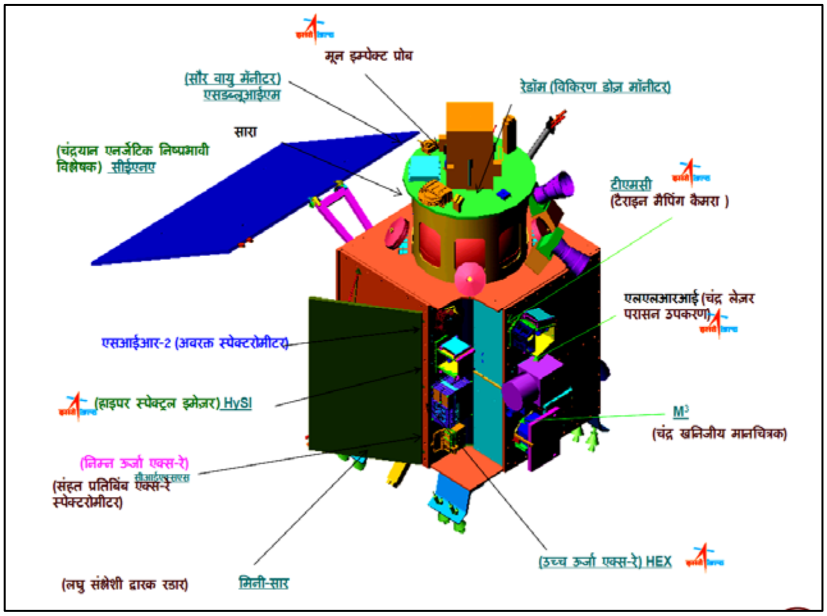
सारांश

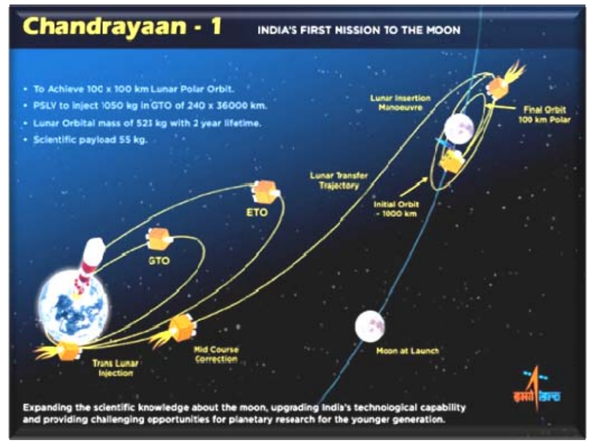
अंतरिक्षयान को बेंगलूर के इसरो उपग्रह केन्द्र (आईज़ैक) में अंतिम रूप दिया गया। इसके अलावा तिरुवनन्तपुरम के विक्रम साराभाई अंतरिक्ष केन्द्र (वी.एस.एस.सी.), द्रव नोदन प्रणाली केन्द्र (एल.पी.एस.सी.), इसरो जड़त्वीय प्रणाली यूनिट (आई.आई.एस.यू.), अहमदाबाद के अंतरिक्ष उपयोग केन्द्र (सैक) व भौतिक अनुसंधान प्रयोगशाला (पी.आर.एल) तथा बेंगलूर की विद्युत प्रकाशिकी प्रणाली प्रयोगशाला (लियोस) ने चन्द्रयान-1 अन्तरिक्षयान के लिए महत्वपूर्ण योगदान दिया।

अत्यधिक नवीन होने के बावजूद अतंरिक्ष तकनीक ने हमारे जीवन में महान परिवर्तन ला दिए हैं। मानव सभ्यता ने केवल एक मानव को चंद्रमा पर उतारकर अपना सपना ही पूरा नहीं किया, बल्कि हम सभी लोग अंतरिक्ष तकनीकी के गौण उपयोगों से अत्याधिक लाभान्वित हुए हैं। अंतरिक्ष अंवेषण मिशनों ने मानव को ग्रहों, पर्यावरण, सौर तंत्र और बह्मांड के विषय में अभूतपूर्वक जानकारी प्रदान की है, जो शायद हमें न मालूम हो पाती, यदि अंतरिक्ष कार्यक्रम न होता। इस सूचना ने हमें पृथ्वी के इतिहास के प्रति

समुचित रूप से अवगत करा दिया है तथा हमें इस क्षमता का भी एहसास करा दिया है कि हम जीवन के आवश्यक निर्णय किस प्रकार लें। अंतरिक्ष कार्यक्रम के उपयोगों ने हमारे जीवन को एक अद्भुत एहसास और अनुभव से भर दिया है।

भारत के अंतरिक्ष वैज्ञानिक मंगल और क्षुद्रग्रहों पर भी रोबोटिक अंतरिक्ष यान भेजने की संभावनाओं का अध्ययन कर रहे हैं। हमें गर्व है कि इसरो देश के विकास के लिए, अन्तरिक्ष प्रौद्योगिकी का उपयोग करके, अपने मूल उद्देश्य पर बिना कोई प्रतिकूल प्रभाव डाले हमारी सौर प्रणाली के बारे में विस्तृत जानकारी देने के लिए मूल्यवान योगदान दे रहा है, चन्द्रयान-1 तो केवल शुरूआत है...





चंद्रयान – 1 सार	
वैज्ञानिक उद्देश्य	पूरे चंद्रमा का उच्च आकाशीय विभेदन सहित दृशीय, निकट अवरक्त निम्न तथा उच्च ऊर्जा एक्स किरणों में एक साथ रसायनिक खनिज विज्ञानीय और फोटो भू वैज्ञानिक मानचित्रण
वैज्ञानिक नीतभार	▪ भू-भाग मानचित्रण कैमरा –टीएमसी ▪ उच्च स्पेक्ट्रमी प्रतिबिंबन- एचवाईएसआई ▪ चंद्र लेज़र रेंजिंग उपकरण- एलएलआरआई ▪ सौर ऊर्जा एक्स किरण/वाय किरण स्पेक्ट्रोमापी-एचईएक्स
नीतभार का वजन	55 कि.ग्रा. (इसरो तथा स्वीकृत विदेशी नीतभार)
प्रमोचित्र	ध्रुवीय उपग्रह प्रमोचन राकेट – पीएसएलवी-11
मिशन नीति	दीर्घवृत्तीय पार्किंग कक्षा – ट्रान्स चंद्र अंतःक्षेपण- चंद्र कक्षा में प्रवेश
चंद्र कक्षा	100 x 100 कि.मी. गोलाकार वृत्तीय
प्रचालनात्मक कालाविधि	2 वर्ष
अंतरिक्षयान	आयतन आकार, 1.5 मी. पार्श्व, त्रिअक्षीय स्थिरीकृत
अंतरिक्षयान का द्रव्यमान	शुष्क भार440 कि.ग्रा. प्रारंभिक चंद्र कक्षा का नोदन सहित द्रव्यमान – 524 कि.ग्रा.
संचार प्रणाली	दूरादेश के लिए एस-बैंड अपलिंक दूरमिति के लिए एस-बैंड डाउनलिंक नीतभार आंकडा अभिग्रहण के लिए एक्स-बैंड
गहन अंतरिक्ष नेटवर्क (डी.एन.एस) केंद्र	स्थान- बयलालु पूरा घूमने वाले द्वय भरण 32 मी. व्यास का एन्टेना
मिशन नियंत्रण केंद्र	स्थानः बेंगलूर- सभी अंतरिक्षयान प्रचालनों के लिए जिम्मेदार, भू-अवसंरचना का संचालन
राष्ट्रीय विज्ञान आंकडा केंद्र (एन.एस.डी.सी)	चंद्रयान -1 पर स्थित नीतभारों से प्राप्त वैज्ञानिक आंकडों के भंडार के रूप में कार्य करता है ।

Moon & the Chandryaan -1 TMC Application

A.S Arya, R P Rajsekhar & Dr. Ajai
Space Applications Centre, ISRO, Ahmedabad
(e-mail: arya_as@sac.dos.gov.in)

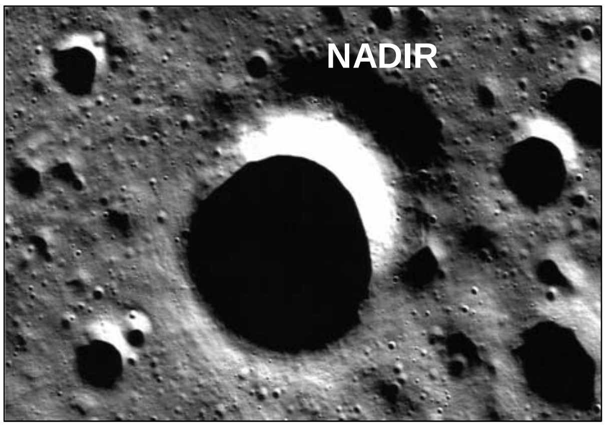
For a long time, the fundamental question regarding the history of the Moon was about its origin. Early hypotheses included *fission* from the Earth, *capture*, and *co-accretion*. Today, the *giant impact hypothesis, postulated* by Reginald Aldworth Daly in 1940's, and which became popular in 1984, is widely accepted by the scientific community. Accordingly the origin of the Moon involves a collision of two protoplanetary bodies during the early accretional period of Solar System evolution. Moon came into existance about 4.5 billion years ago and after solidification of its crust a significant percentage of the lunar impact basins formed within a very short period of time between about 4 and 3.85 Ga ago (lunar cataclysm hypothesis). Many big and huge craters came into existance, which formed enormous basins. The heavy and continuous impacting resulted in volcanism on Moon which filled these basins with dark colored basaltic lava. This is why when we see the Moon from earth with naked eyes, we see two distinct colors on the Moon, the dark patches are called MARE (younger rocks) and the bright areas are HIGHLANDS (older rocks.). It is interesting to note that only one side of the Moon is visible from Earth all the time and thus it is called the NEAR-SIDE and the opposite one is the FAR-SIDE.

The Moon has no atmosphere, so no typical forms of erosion/ degradation, known on earth *viz*. water-erosion, wind-erosion, frost-shattering etc. is applicable on the Moon. However, the Moon experiences space weathering due to high energy particles, solar wind implantation, and micrometeorite impacts.

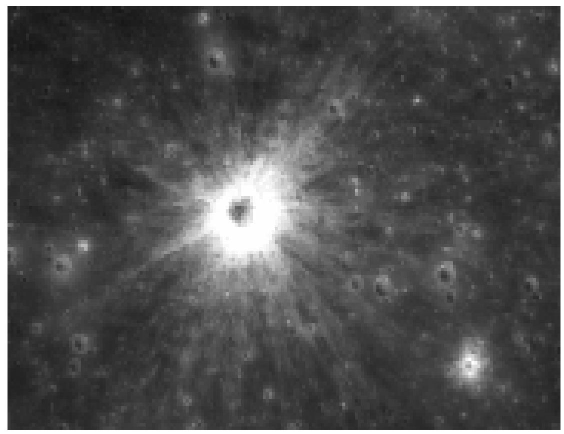
The lunar landscape is characterized by impact craters, their ejecta, hills, lava flows and depressions filled by magma etc. A lot of these features vary in size from several kms. to few cms, or even less. Thus the Lunar surface furnishes an excellent opportunity to study and map all these features to re-construct the hostory of the Moon, and satellite remote sensing is the best and fastest way to do this.

The TMC camera images the Lunar surface in the panchromatic spectral region of 0.5 to 0.85 µm with a spatial/ ground resolution of 5m, 10 bit quantization and swath coverage of 20 Km. The camera has been configured for imaging in the push broom mode with three linear 4K element detectors in the image plane for fore, nadir and aft views in the along track direction of satellite movement. The strength of this camera lies in its high resolution and 3D imaging capabilities providing unique opportunity to study the Lunar terrain in unprecedented way. The primary aim of TMC is to map topography in both near and far side of the Moon and prepare a 3-dimensional atlas with high spatial and altitude resolution. However, for geological purpose the TMC data is used primarily to map the morphology, structural features and crater studies, in order to answer the science questions related to the origin & evolution of the Moon as well as the Earth-Moon system. The digital elevation model available from TMC along with the Lunar Laser Ranging Instrument (LLRI) on Chandrayaan-1 will also improve the Moon gravity model. Parts of the near and far side of the Moon has been covered in strip (swath of 20kms) mode and some of these strips have been processed and interpreted for identification of various features on the Moon, especially the morphological features, faults, grabens, lava-flows, crater types etc.

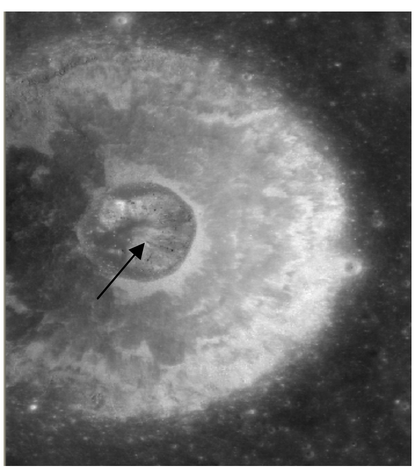
Some of the Lunar features viz. types of craters, rilles etc, as viewed by the TMC camera, are given below:



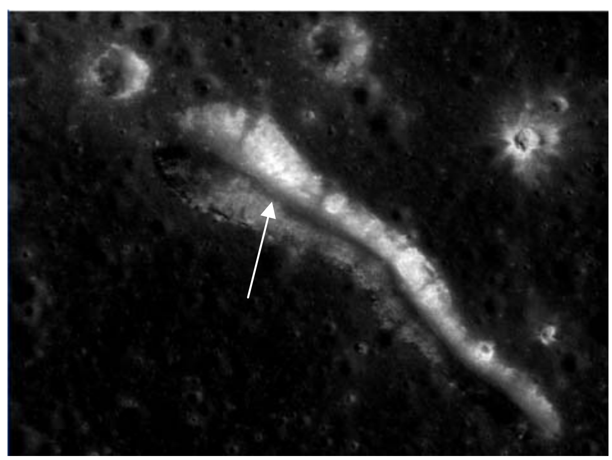
Simple/Conical Crater :Nearside (16.11.2008)



Ray Crater : Far-side (24 .11.08)

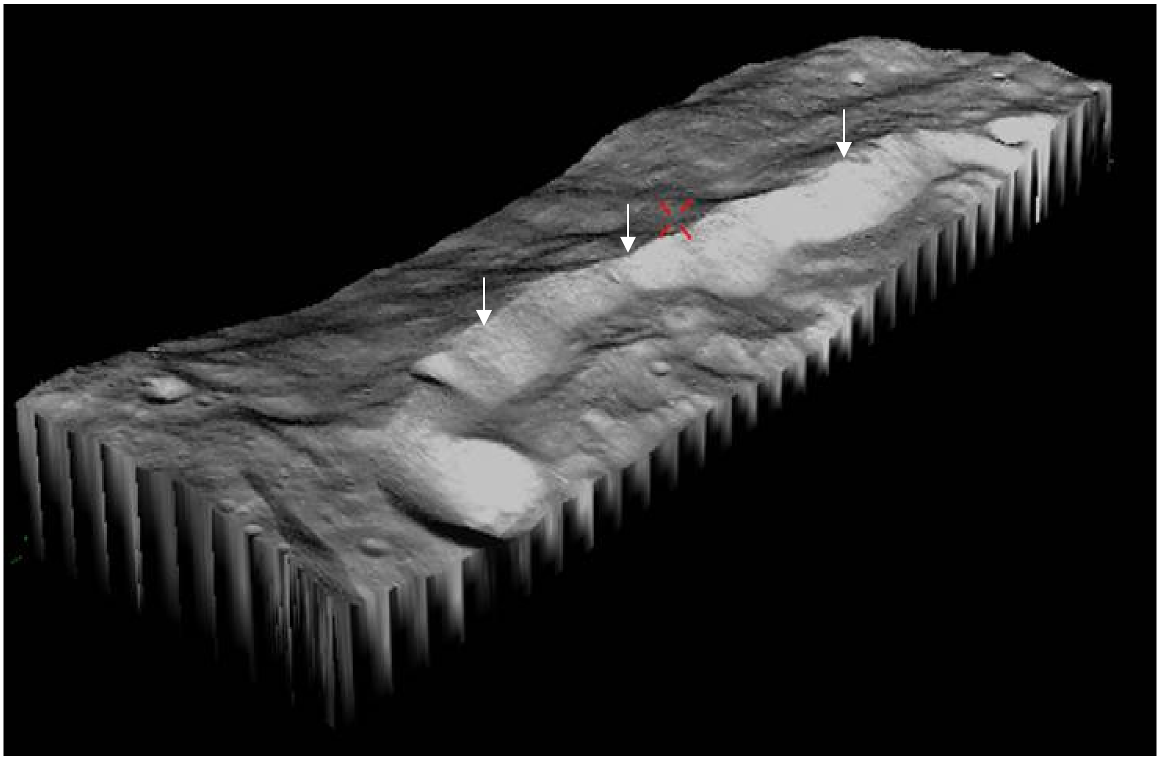


Complex Crater with a Central dome (see arrow) : Far-side (13 Jan 2009)



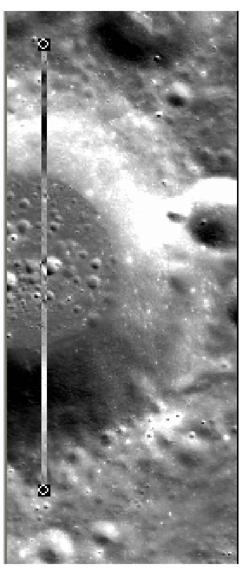
A typical `Sinuous Rille' indicating a collapsed lava tube, tapering away from the crater.

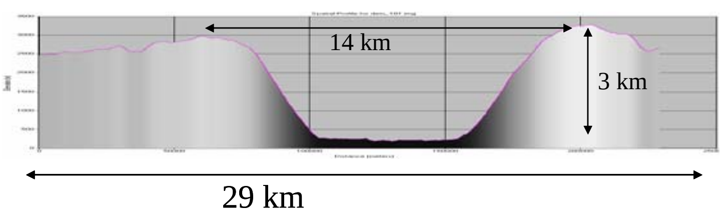
The following image shows a major break in the Lunar surface showing part of a faulted rim of Moretus crater near the south pole.



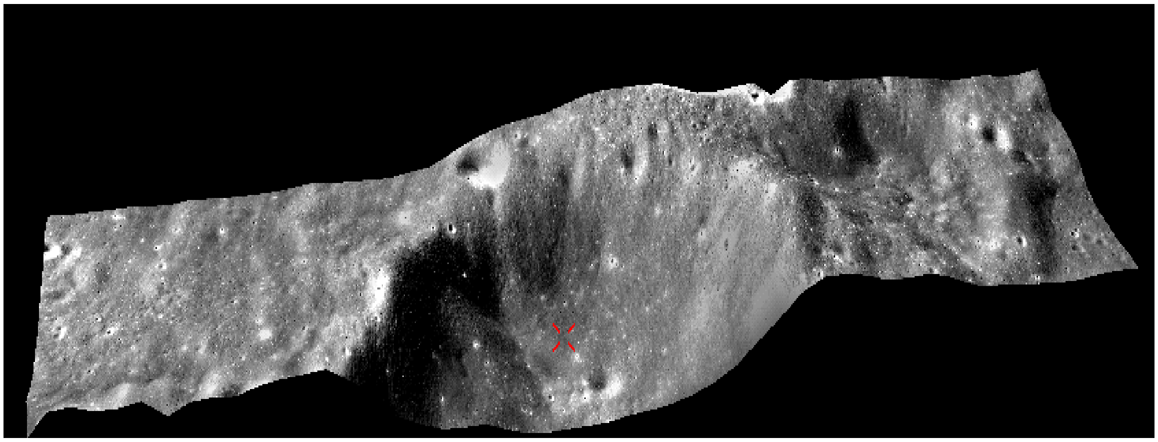
3D view of part of step faulted-rim of Moretus Crater (see arrow) :
Near-side , 15 Nov 2008, TMC Image)

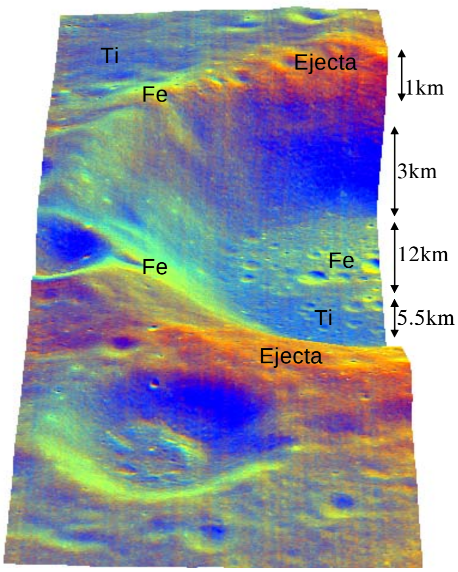
The multi-viewing capability of TMC (Fore- Aft- Nadir-) enables to estimate the depth and height of craters as shown in following profile cross-section of a crater.





Consequentially the 3D view of TMC is used to generate DEM (Digital Elevation Model) of desired area or feature and a perspective view of the same is possible to generate as follows, which is useful in understanding the chronological ordering of the features and classifying them accordingly.





The TMC DEM is also very useful as the` rider-data' for other CHANDRYAAN-1 sensors, e.g. HySI data can be draped on the TMC DEM and thus a perspective view can be generated to understand the three dimensional sptial distribution of the mineral assemblages, and their relative proportions , in and around a crater, as shown below

Thus a wealth of data set from TMC is available which could be mosaiced for entire Moon surface to map composition and structure of the Moon inorder to address the scientific issues associated with the origin and evolution of the Moon and Earth-Moon system.

Planetary Geomatics

B Gopala Krishna and Amitabh
Space Applications Centre, ISRO, Ahmedabad
(e-mail: bgk@sac.isro.gov.in)

Introduction

The term *Geomatics* is an acronym formed by "***Geo***" that means the Earth, while the term "***matics***" refers to the information. There are various definitions cited in the literature, viz.,

> *"Geomatics is the science and technology of gathering, analyzing, interpreting, distributing and using geographic information." Source: Natural Resources Canada.*

> *"Geomatics is a field of activities which, using a systemic approach, integrates all the means used to acquire and manage spatial data required as part of scientific, administrative, legal and technical operations involved in the process of the production and management of spatial information." -- quote from the Canadian Institute of Geomatics*

Hence the field of ***Geomatics*** encompasses the acquisition, storage, analysis, dissemination, and management of geographically referenced information for improved decision-making. It embraces the subjects of geodetic reference systems, Global Positioning System (GPS), astronomy, Geographical Information System (GIS), Photogrammetry, Remote Sensing (RS) and Cartography, as well as traditional surveying. It uses tools of Data Base Management Systems (DBMS), Computer Graphics and Artificial Intelligence.

Originally used in Canada, because it is similar in French and English, the term geomatics has been adopted by the International Organization for Standardization, the Royal Institution of Chartered Surveyors, and many other international authorities, although some (especially in the United States) have shown a preference for the term geospatial technology. A number of university departments which were once titled surveying, survey engineering or topographic science have re-titled themselves as geomatics or geomatic engineering.

The rapid progress, and increased visibility, of geomatics since 1990s has been made possible by advances in computer technology, computer science, and software engineering, as well as airborne and space observation remote sensing technologies.

Geomatics applications areas include the environment, land management and reform, urban planning, subdivision planning, infrastructure management, natural resource monitoring and development, coastal zone management and mapping, archaeological excavation and survey for GIS applications, disaster informatics for disaster risk reduction and response, Air Navigation Services.

There are other related fields defined in geomatics.

The new field Hydrogeomatics covers the geomatics area associated with surveying work carried out on, above or below the surface of the sea or other areas of water. The older term of hydrographics was too specific to the preparation of marine charts and failed to include the broader concept of positioning or measurements in all marine environments.

The field **Planetary Geomatics** concerns the spatial information, usually scientific, of terrestrial worlds such as Earth, Moon, Mars and other bodies in the solar system with a solid surface such as asteroids and comets. The allied fields are planetary GIS, Planetary remote sensing, planetary cartography and planetary mapping. GIS procedures offer the planetary scientists a way for data organisation, fast retrieval, storage and analysis of the heterogeneous data from the planetary bodies.

Planetary researchers have only begun to apply rudimentary GIS techniques. Because of its (1) flexibility in data management, (2) time and cost efficient production of large databases (including planetary maps), (3) ability to create multilayered databases for comparison studies, and (4) capacity to readily update and add information obtained from future missions and studies. GIS is becoming an increasingly valuable tool in planetary studies, which continues to grow rapidly in functionality for planetary research. The ability to overlay datasets is becoming increasingly vital, as more diverse databases are created. The influence of online GIS websites will also continue to rapidly grow as the technology matures and the Internet becomes faster.

For the more scientific approach of data viewing, querying and basic analyses, the USGS Astrogeology Branch has been playing a major role in the planetary community by providing not only pre-processed data for download but also by employing a web-based GIS (the USGS Planetary GIS Web Server PIGWAD) to which one can connect either directly via web browser or via WCS/WMS services (T M Hare, et al, 1999; PIGWAD website; T M Hare et.al, 2002). Planetary Interactive GIS-on-the- Web Analyzable Database (PIGWAD) has been an experimental method for planetary analysis, for data distribution over the Internet, and for educating the planetary community in Geographic Information Systems (GIS). The contents of PIGWAD include Polar Image Mosaics, Equatorial Image tiles, 3D topography and Unified Lunar Control Points (ULCN 2005). PIGWAD is built on technologies created by Environmental Systems Research Institute's (ESRI) ArcView Internet Map Server and Arc Internet Map Server (ArcIMS).This system is continuously updated with the upcoming technologies. By supporting OpenGIS standards and makes the datasets available to the widest possible audience.

Terrestrial GIS technology is predominantly used for data organization, data revision, data modelling and data analysis in all sorts of scientific and public branches and it forms a well-established platform for planning purposes. Consequently, such possibilities can easily be transferred to other planning requirements, such as planetary landing site selection, planning of orbital imaging, or for data organization by means of large-scaled database systems. The fundament for such goals is the consistent and coherent storage of data within a proper geospatial context. Use of GIS procedures for study of terrestrial planets and their satellites is provided in detail with good examples of Mars data (A. Frigeri, et al, 2007).

Very few references could be found on the use of GIS on lunar observation. The Lunar mapping and Modeling Project (LMMP) (Cohen, et al, 2008) is a NASA led initiative with the aim to create a single, consistent, uniform, intuitive, and easy to use NASA portal that accesses lunar mapping and modeling products, tools and media.

A lunar Information System is being developed (J. Schulz, et al. 2009) within the commercial ArcGIS framework by ESRI for (a) building a consistent database of lunar mission data and file management infrastructure by means of geo databases and by incorporating additional tools and routines for performing sophisticated analyses making use of different data types and a variety of scales, i.e. global scales for orbiting spacecraft to local scales for manned missions and experiments during the Apollo program.

A geotechnical GIS is proposed (L Croukamp, et al, 2009) to contribute substantially to building the base of relevant data required to enhance and support the future missions, target generation for mining of materials for the purpose of propellants, oxygen, construction material and planning of excursions as well as the construction of permanent moon base. Envisaged data layers to be collected include but not limited to Geology, Slope angle, Topography, Slope aspect, surface roughness, excavatibility, bearing capacity, soil density etc., Good results are available in this reference.

Apart from GIS, Planetary cartography (Wikis.gis.com) & planetary mapping (http://grass.osgeo.org/grass62/screenshots/images), which are used to produce Albedo maps, Atlas, Geochemical, Geologic, Geomorphologic, Geomorphic, Geophysical, Hypsometric, landing site, tectonic, thematic, synoptic, outline, physical properties, terrain maps and Planetary mapping play an important role in Planetary Geomatics.

Indian Scenario

Planetary Geomatics is a new field and just coming up in India with the launch of Chandrayaan-1; the first mission to moon. Considerable amount of data was collected from the onboard instruments, especially from Terrain Mapping Camera (TMC), Hyper Spectral Imager (HySI) and M3 which are mainly used for terrain and mineralogy mapping of the moon. The organisation of the data is carried out in the global standards called Planetary Data System (PDS) and the data is planned to be distributed through a web portal after querying and ordering the user requested area from Indian Space Science Data Centre (ISSDC). This system (data dissemination for

TMC and HySI) also caters to the visualisation of the available data including its meta data (label) information.

Lunar Mapping and the Atlas generation are the prime objectives of the above data for which the concepts are defined and the software is being developed at Space Applications Centre (ISRO). Towards this, Digital Elevation Model (DEMs) and orthoimages for the acquired data (B Gopala Krishna, et al, 2009) are the prime layers, which are being generated with the help of third party packages along with the indigenous software development. The overall (mapping) system caters to visualisation and data base management aspects of generated maps along with the corresponding layers of information like elevation contours, annotation, images etc. With the upcoming ISRO planetary missions in future, this field is likely to grow in a multi-fold.

Tools

Some of the tools available in literature for Planetary Geomatics are :

1. ArcMap 8.x (http://moon/ArcMap 8_x and Planetary Projection Tutorial.htm) is one of the tools used in the planetary geomatics for data analysis and manipulation of the geospatial data now updated to the new version 9.x with solar systems definitions package giving provision for many projection parameters..
2. ArcGIS, GRASS (Saiger Peter et. Al, 2005, http://grass.osgeo.org/grass62/screenshots/images), while the regular standard GIS Systems are developed for terrestrial reference systems, additional efforts are required for the integration of planetary datasets into a GIS, to related them to a common reference system before analyzing them. ESRI`s commercial ArcGIS 9 and the open source project GRASS 5.3 (Geographic Resources Analysis Support System) address these issues.
3. Geodesic Tools (Jeff Jenness, 2008), this is a package of the tools for calculating surface measures (coordinates, distances, areas) on a variety of spheres or spheroids, with specialized functions optimized to assist planetary researchers with planetocentric / planetographic conversions. All tools are available at the ArcView license level. This also includes a tool to wrap existing geographic datasets around longitude ranges of -180° to 180° or 0° to 360°. Several tools produce point, multipoint, polyline or polygon shape files. Some geometry tools produce new shape files while others add new fields to attribute tables. This package requires ArcGIS 9.1 or better This tool has only been tested on Windows 2000 and XP.

Some of the issues and solutions (T M Hare, et al 2005)

a. Planetary mapprojections: Practical understanding of map projections is required, in order to successfully use planetary imagery in a cartographic package. This usually means that the data must be translated to the same map projection using a matching coordinate reference system (CRS). While planetary CRSs are well defined, when mixing different map projections, datasets, and software packages, there are many potential pitfalls. Accurate documentation of the dataset's CRS and map projection is even more vital with the advent of on-line or streamed databases. Fortunately for planetary mappers, many of the datasets are eventually map-projected and released in PDS. However, many parameters needed to accurately define the map projection may be missing from the dataset label, like the particularsof the projection's equation or the latitude type.

b. Ographic and Ocentric Martian Issues: In dealing with Martian datasets ther is a confusion of existance of two competing coordinate systems for Mars viz, International Astronomical Union (IAU), where one combines longitude measured positive east with latititude measured from the equatorial plane to a point through the center of the planet, so-called planetocentric (areocentric for Mars, geocentric for Earth) latitude. This is simply a right-handed spherical-polar coordinate system. The other system uses longitude measured in such a direction that the sub-Earth longitude increases with time; for Mars, this means positive west. The maximum difference between the two types of latitude on Mars is about 0.3 degree or 20 km, at 45 degrees In fact IAU has approved these two systems for all bodies, but Mars has been more difficult because there has been extensive use of both systems and the fact that Mars is defined on an ellipse.north and south. As with the projection, researchers must recognize the details of the coordinate system and whether or not their software system can handle the defined system
c. Cartographic package: With respect to the above issues, major consideration is the compatibility of software with the projection type and, for Mars, the two types of coordinate systems. The two main planetary cartographic packages, ISIS and VICAR have already incorporated modifications with respect to the elliptical references; however most of the other GIS and photogrammetry systems (i.e. ESRI's ArcGIS, Generic Mapping Tools, BAE's SOCET SET) use a mixed east/planetographic system not approved for Mars by the IAU/IAG. Thus, one must convert data for use with these packages in either case.

Some solutions are suggested (T M Hare, et al. 2005) to the above issues by making CRS standard as part of PDS as well as usage of OGC (Open Geospatial Consortium) standards and encoding the CRS information in Geography Mark Language (GML) (T Hare, et al, 2006), which is quickly becoming a standard for Geospatial data to not only hold the CRS and the transformation, but also the data itself.

Technology

The development of online mapping makes 'web mapping or cartography' one of the most important growth areas for cartography, geomatics and 3D visualisation. Prototype is being implemented (E. Dobinson, et al, 2006) at JPL using open gepspatial standards viz.,Web Mapping Services (WMS) and Web Coverage Services (WCS) to present high level products derived from NASA's Mars and Lunar datasets to produce scientific composites of the knowledge of the planet. These techniques of data distribution will be a significant addition to the method currently used by the Planetary Data System (PDS) (T M Hare et al, 2007, T M Hare et al, 2008).

In Indian context, these are upcoming technologies to be used in the field of Planetary Geomatics, starting with the Chandrayaan-1 data, towards user access and data dissemination.

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Technological Trends in Geo-informatics

Ajai and P M Udani
Space Applications Centre, ISRO, Ahmedabad
(e-mail : ajai@sac.isro.gov.in)

Information has always been the corner stone of effective decisions, be it on managing the resources, planning the infrastructure or managing/mitigating the disasters. In the context of disaster management, efficient decision, accurate planning and organized response are the key functions which highly depend upon the readily available easily interpretable and highly reliable information, both spatial and non-spatial. Spatial information is particularly complex as it requires two descriptors 'where is what'. For thousands of years the link between the two descriptors has been traditional, the manually drafted maps. More recently, analysis of mapped data has become an important part of understanding and managing geographic space thus the decision making. This new perspective marks a turning point in the use of maps from just emphasizing physical description of geographic space, to interpreting mapped data, combining map layers and finally, to spatially characterising and communicating complex spatial relationships. The movement from "Where is what" (descriptive) to "So what and why" has set the stage for entirely new concepts and tools i.e. today's 'geoinformatics' or geomatics'.

Geo-informatics is a broad term and encompasses a gamet of technologies such as remote sensing, GIS, GPS, Photogrammetry, image processing, cartography, networking technologies etc. Geo-informatics has evolved over a period of time but made rapid progress during the past three and a half decades. There have been many issues and challenges in each of the technologies which have converged to define 'geoinformatics'. Needless to say that the spatial data and the above mentioned technologies have proven to be crucial in management of natural resources, monitoring environment and disaster mitigation.

Recent advances in the space based data capturing techniques (imaging), during the past three decades, have revolutionized the field of cartography and mapping. High resolution images acquired by satellites, high precision measurements from global positioning systems (GPS) as well as the sophisticated image processing and GIS techniques, developed during the last three decades, have further augmented the pace of mapping and its updation manyfolds. The use of satellite images for mapping started way back in 1972 with the launch of ERTS satellite (later known as LANDSAT), the first one in the series of earth resources satellites. The period of past three decades has witnessed a dramatic improvement in spatial resolution from 80m to less than a meter, monoscopic data capturing to stereoscopic imaging, broad band to hyper spectral bands and moderate to high radiometry in the earth observation systems. All these improvements in satellite imaging has led to availability of better quality images for mapping applications. There have been rapid strides in the imaging/data capturing capability from space platform in our country as well. The improvement in indigenous space imaging quality, in terms of spatial resolutions from 1 km in 1979 (from Bhaskara) to as high as 1m in 2001 (TES), as well as the stereoscopic capabilities from IRS 1C and 1D have given tremendous boost to the field of mapping the country. The Cartosat-1 having 2.5 spatial resolution with along track stereo helps to generate high resolution DEM required for many applications. Cartosat-2 with 0.8m spatial resolution offers the potential of large scale mapping required for urban and rural planning. These recent developments in the imaging capability will go a long way in empowering and strengthening the discipline of mapping and surveying in the country by offering mapping potential to a scale of 10,000 scale for topographic and to 4,000 scale for thematic mapping. The recent developments in satellite remote sensing, ranging from high resolution DEM/topography (using digital Photogrammetry, SAR interferometry & LIDAR) to hyperspectral (available from MODIS, ASTER, IMS, Hyperion) and active microwave imaging have transformed the discipline of earth observation and earth system sciences.

Coming to GIS considerable changes in both expectations and capabilities have taken place since the introduction of GIS in late sixties/early seventies. Increased demands for mapped data focussed attention on data availability, accuracy and standards as well as data structure issues. Regional, national and international organizations began addressing the necessary standards for digital maps to insure compatibility among systems.

As GIS continued its evolution, the emphasis turned from descriptive query to prescriptive analysis of maps and thus the spatial analysis involving many layers operation such as effective distance, optimal path routing, visual exposure density and landscape diversity became possible. These new tools and modelling approach to spatial information combine models into effective decision support systems.

In the early years, GIS was considered the domain of relatively few cloistered techno-geeks. Today, it is on everyone's desk, PDA and even cell phones. In just three decades it has evolved from an emerging science to a fabric of society that depends on its products from getting driving directions to sharing interactive maps of the family vacation.

Societal acceptance of this technology is due to the new map forms and processing environments available in recent times. Flagship GIS systems, once heralded as "tool boxes" are giving way to web services and tailored application solutions. There is growing number of websites with extensive sets of map layers that enables users to mix and match their own custom views. Data exchange and interoperability standards are taking hold to extend this flexibility to multiple nodes. On the web, with some data from here, analytical tools from there and the available display capabilities results in to high level applications that speak in a user idiom and hide the complexity of data manipulation and obscure command sequences.

Another characteristic of new processing environment is the full integration of GPS and remote sensing with GIS and the digital map bring geographic positioning to the palm of your hand.

In addition to the changes in the processing environment, contemporary maps have radical new forms of display beyond the historical 2D paper maps i.e. draping spatial information on a 3D view of the terrain. 4D GIS (X, Y, Z and time) is the next major frontier. Currently, time is handled as a series of stored maps layers that can be animated to view changes on the landscape.

As mentioned earlier, the data exchange and interoperability are the key words today. There have been paradigm shift from proprietary data models to open source data models. Open Geospatial Consortium (OGC) which is a group of 333 partners all over the world has brought out the open standards for geospatial services which are being accepted by more and more geomatics professionals and many companies have initiated development of OGC compliant GIS software. In OGC model types of objects/features and storage structure is well defined and user end modification or enhancement is not possible as been practised in case of GIS data model. This allows easier data exchange and do not pause any interoperability problems. At, Space

Applications Centre (ISRO), Dept. of Space, OGC compliant IGIS software has been developed with combined functionalities of GIS and image processing. GIS Database storage is also moving from file based system to RDBMS system and network accessed based storage architecture. Open source PostGRE relational data management system combined with open source PostGIS software is increasingly used for OGC compliant GIS database organisation, access, processing and providing web services for distribution of maps and data. This approach not only helps in data storage but also allows to associate rule and relationship with data so that business data and business logic can be seamlessly applied for applications like customer relation management, emergency response for utilities services, market and sales forecasting. Thus GIS is getting integrated to main stream IT.

In context of GIS software development, many industries prefer customisable .NET or JAVA components library development compared to out of the box solutions. Growing trend is observed in utilisation of GIS in utilities services, enterprise asset management and this would lead to development of industry specific GIS data models and software modules. The development of client side third party plug-ins is another area of development where researchers are defining solutions for appropriate partitioning of client-server GIS processing for the purpose of network load balancing and quality of web GIS services. In web GIS architecture multiple clients are provided services from the single web interface/gateway. For distributed resources such implementation is not suitable and many enterprise GIS implementation have been following distributed GIS architecture where client and server role are interchangeable and solutions are built using distributed servers where GIS data , software and applications are residing at different locations.

The recent technology development and unification pertaining to GPS, GIS, mobile computing and wireless communication has lead to development of mobile GIS system for extending GIS data collection and maintenance services from office environment to in-situ field access. Mobile GIS system with GPS interface provides tools for real time GPS data collection and integration with the existing GIS databases. Most of the mobile GIS systems have been used for mapping purpose and required limited GIS capabilities. The proliferation of wireless internet GIS, Pocket PC devices and cell phones has created greater demand for GIS data dispatch and collection services and requires to embed few more GIS functions like simple and complex attributes query, direct theme table access, object/feature level symbolisation, simple attributes based classification. The GPS functions for configuration settings, filtering and NMEA data access and decoding have become essential. Versatile GPS-GIS interface software for mobile GIS services is required for enabling access of RS-GPS-GIS technologies for emergency support services like disaster damage assessment. Space Applications Centre (ISRO) has developed a low cost reconfigurable mobile GIS system comprising of indigenous QPad GPS-GIS software, CF GPS and Windows CE Pocket PC for showcasing technology integration and applications for in-situ GIS database creation and manipulation. Cell phone based similar systems are increasingly used for consumer centric allocations like on route navigation and location based services.

Satellite navigation systems are among the top 10 emerging technologies. The notable satellite navigation systems in the world are GPS of USA, GLONASS of Russia, GALILEO of European Union. Two upcoming navigation systems are Indian Regional Navigation Satellite System (IRNSS) of India and COMPASS of China. Indian IRNSS would comprise of 4 GSO satellites and 3 GEO satellites for providing navigation and timing information over Indian Territory and for 1500 kms around India. The GPS of USA is getting augmented and more civilian signals are incorporated for enhance and more accurate standard positioning services. Almost all GPS programs are designed to provided inter operable services at RF front level based on common frequency slot of L-band with choice of different code structure and messages formats. This has lead to increasing demand and development of GPS receivers with interoperable unified RF front-end platforms. The unified RF front end with subsequent signal processing based on software approach would be the one of the major area of design and development in context of next generation satellite navigation receivers. This facilitates designing of reconfigurable receiver with choice of appropriate acquisition and tracking mechanism and offers multiple choice of selection of IF, correlation time interval, messages structure etc. Such software defined GPS receiver uses same positioning techniques after decoding of ephemeris and almanac data. The miniaturization of GPS receivers and development of new SiRF chipsets has made possible to embed GPS in more and more consumer electronics devices such as cell phone, digital camera, wrist watch, PDA etc. This has lead to development of consumer centric applications such as car navigation, fleet monitoring, search and rescue etc. The growing geospatial technologies have made significant contributions in the growth of two peripheral technologies namely, scanning and plotting technology.

In today's era of web GIS, distributed GIS and wireless mobile GIS, the inter operability is of big concern and most of the time heterogeneity problems are solved limited to GIS data only. The GIS interoperability encompasses from lower most network protocol level to highest level of applications. In most of the GIS implementation, attention is paid to interoperability at data level which needs to address three issues i.e. syntax, structure and semantic. The syntactic heterogeneity is related to data format and it can be overcome by adopting common data format like GML. The structure interoperability, relevant to attributes schema, enforces common data model like NNRMS. The critical among the above three issue is semantic interoperability and is still considered to be the area of research. It requires development of semantic translator (SOI DGN to NNRMS conversion) and adherence to common domain specific vocabulary. The GIS interoperability also needs to address the issues related to remote procedure calls, search and access of databases and file system (OS).

In the context of geospatial information system, which normally comprises of a data bases, query/analysis tools and a spatial data interface (SDI)/search engine. The key issues are the standardizations of data bases, open source data model, the cost effective or freely available software tools as well as the easy accessibility of data bases. Towards, this department of space & NNRMS have made good beginning. These are:

i) NNRMS Standards for geospatial thematic data has been evolved.

ii) OGC compliant indigenous software IGIS has been developed. This integrated GIS and image processing software (IGIS) is the only available high end software having both GIS and image processing functions in one package. IGIS is based on a fully OGC compliant data model. As the preparation of development plan, infrastructure development and disaster management requires both image processing tools as well as the analysis of multi layer spatial data for decision support, IGIS will be ideally suited for the purpose.

iii) Development of a indigenous Mobile GIS "Q Pad". This mobile GIS system, comprising of a pocket PC, GIS software and GPS, is ideally suited as mobile mapping system for data collection attribute based querying, direct access to thematic tables, classification, analysis and display. This mobile mapping system is highly useful in data collection and damage assessment during the disaster.

Data Constraints in Precisely Quantifying the Indicators and Impacts of Climate Change *(With special reference to snow, glaciers, hydrometeorology and wetlands)*

Shakil A Romshoo
Professor, Department of Geology and Geophysics,
University of Kashmir, Srinagar Kashmir
(e-mail: shakilrom@yahoo.com)

Introduction: With climate change, as with ozone depletion, the human footprint on earth is apparent. The earth's climate is now clearly out of balance and is warming. Evidence from most oceans and all continents except Antarctica shows warming attributable to human activities (Alley et al., 2003, IPCC, 2001a, IPCC, 2007). Many components of the climate system--including the temperatures of the atmosphere, land and ocean, the extent of sea ice and mountain glaciers, the sea level, the distribution of precipitation, and the length of seasons--are now changing at rates and in patterns that are not natural and are best explained by the increased atmospheric abundances of greenhouse gases and aerosols generated by human activity during the 20th century (AGU, 2008). Therefore, the argument that Climate Change is natural and has nothing to do with the humans is simply not tenable in light of the plethora of research that has been conducted in every nock and corner of the globe over the last few decades. So, whilst we cannot exclude natural variability as the cause of global warming over the past few decades, and it has definitely played some role, but it is very unlikely that this will have been the sole reason. The changes in the average global temperature during the last century are larger than can be explained by the natural changes alone, As of 2006, eleven of the previous twelve years were warmer than any others since 1850. Global average surface temperatures increased on average by about 0.6°C over the period 1956—2006 (AGU, 2008). Looking at the ice cores, the levels of Co2 have been 35% greater than they have been for at least last 0.65 Million years. From the chemical composition of these gases, we know that this is mainly due to the burning of fossil fuels, production of cement and the widespread burning of forests in the tropics (Barnett et al., 1999, Claussen, 2001, Stevens, 1999). These results enabled International Panel on Climate Change (IPCC) to pronounce that "...... most of the observed warming over the past 50 years is likely to have been due to the increase in greenhouse gas concentrations". IPCC thus concluded that most recent warming, observed globally, is due to man's activities (IPCC, 1996, IPCC, 2001a, IPCC, 2007).

The potential consequences of the Climate Change have been established beyond any doubt at the global level (Rosenzweig and Solecki, 2001) Though, there is absolutely no uncertainty about the causes of climate change, however, there are various kinds of uncertainties involved in the climate change science (Forest et al., 2000, Forest et al., 2002, Reilly et al., 2001). The experts disagree about how climate might change in future but they generally agree that climate change shall have impacts, not only on environment, but on every sphere of the human activity (NAS, 2001, Prinn et al., 1999, Reilly, 2002). However, we have to move from the use of qualitative language (likely or unlikely) while describing the likelihood of climate change scenarios. We need to talk of uncertainties in quantitative terms by describing exactly what we mean by the specific uncertainty. At least, describing the likelihood more precisely could reduce the uncertainty about the occurrence of various climate change scenarios. Therefore, there is an urgent need to accurately characterize, understand and predict various climatological processes so that the uncertainty could be narrowed down to the minimum possible level in order to predict the impacts of climate change on various sectors (Allen, 2000, Webster, 2003)

In this article, I shall be, in the first part, briefly discussing the uncertainties associated with the climate change predictions and in the second part, I shall be discussing the data constraints encountered while quantifying the various indicators and impacts of climate change.

I) Uncertainties with the Climate Change predictions:

The earth system is so complex—and our time series of good observations so short relative to the time scale on which the system operates—that our ability to know the behaviour of this system may be quite limited. This means that possible responses are not captured in a distribution created with a model that includes only what we now know about the earth system's behaviour. We have the modelling techniques available that help us to calculate how much a given emissions-reduction policy will likely reduce the odds of serious impacts from global climate change (Berliner et al., 2000, McGuffie and Henderson, 1997, Wigley and Raper, 2001). These analytical models take uncertain inputs that affect economic activities, GHG emissions, and the climate system's response and calculate the probability of specific outcomes (Fig. 1). Thus, these models forecast possible temperature increases in future and the probability that each will occur. Subsequent runs using lower emissions show how emissions-control policies could change the probabilities. Though, there is no uncertainty about the impact of greenhouse gases on global warming but there is uncertainty about how fast and by how much shall the emissions be reduced to achieve a specific stable concentration of GHG. One of the pressing challenges is to understand the processes that have led to the previous relatively abrupt change of several degrees Celsius within a decade or so found

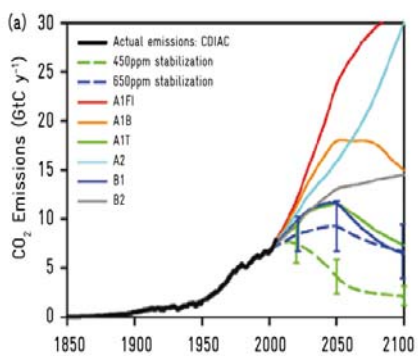
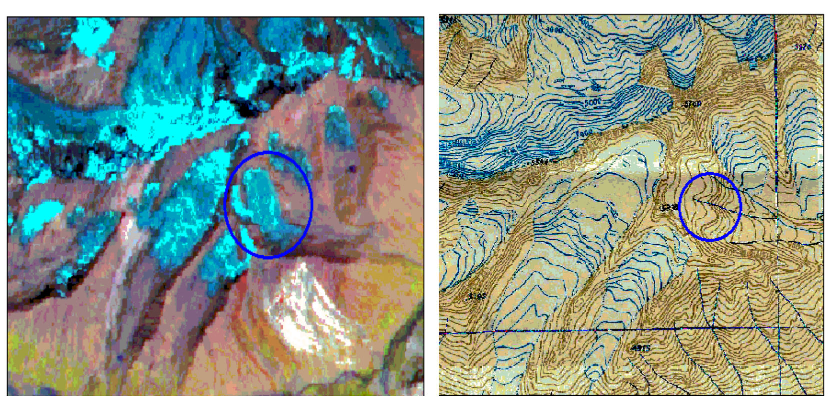


Fig.1 Showing different simulated
Co2 emission scenarios
(Source: IPCC report)



(a) (b)

Fig.2: Showing the inaccuracies in the baseline data where the glacier seen on the image(a) is not shown on the map(b)

in the paleo record of earth (Kaplan et al., 1998, Webster et al., 2002). Current models do not provide an explanation for such changes (Jones et al., 1998, Jones et al., 1999).

The IPCC in its first report in 1990 predicted that temperatures would warm by 0.5 degree Fahrenheit (0.3 degree Celsius) per decade if no efforts were made to restrain greenhouse gas emissions. But the panel of scientists and other experts was wrong: By 2001, the group estimated that average temperatures would increase by 2.7 to 8.1 degrees F (1.5 to 4.5 degrees C) in the 21st century, and they raised the lower end to 3.6 degrees F (2 degrees C) this year in their most recent report. In essence, neither this international team of experts nor any other can say with any certainty just how bad global warming may get. Scientists have projected that simply doubling carbon dioxide in the atmosphere from pre-Industrial Revolution levels would increase global mean temperature by about 2.2 degrees Fahrenheit. However, that projection does not take into account climate feedbacks -- physical processes in the climate system that amplify or subdue the response. Those feedbacks would raise temperature even more, as much as another 5 degrees F according to the most likely projection. One example of a feedback is that a warmer atmosphere holds more water vapour, which in itself is a greenhouse gas. The increased water vapour then amplifies the effect on temperature caused by the original increase in carbon dioxide. Some of these feedback processes are poorly understood—like how climate change affects clouds—and many are difficult to model, therefore the climate's propensity to amplify any small change makes predicting how much and how fast the climate will change inherently difficult. Uncertainty and sensitivity are inextricably linked and some warming is a virtual certainty, but the amount of that warming is much less certain (UW, 2007)

A vigorous scientific research program will undoubtedly improve our understanding of the climate system and may reduce the uncertainties (Allen, 2000, Stainforth et al., 2005, Webster, 2003,). But some of the uncertainty we face in projecting decades into the future is irreducible (Risbey and Kandikar, 2002), no matter what kind of improvements are made in understanding physical processes or the timescale of observations. Even as the necessary research and measurements proceed, we need to decide how much we should begin deflecting the world's economy from a path that would likely more than double the concentration of greenhouse gases (GHGs) by the end of this century. As new data become available, we will need to revise our estimate of uncertainty, and that, in turn, may involve a midcourse correction of policies designed to address climate change.

II. Difficulties in assessing the Climate Change indicators and Impacts:

a) **Snow and Glaciers:** Information about the snow and glaciers is important for understanding and modelling several hydrologic, climatologic and vegetation processes. The glaciers have been recognized as important and sensitive indicators of the climate change and often help us to understand the climate dynamics (Haeberli and Hoelzle, 1995, Paul, 2002, Schoner et al, 2000, Solomon et al., 2007). There has been continuous recession of glaciers all over the world and the Himalayan region is no exception. The Himalayan region, because of presence of largest glacierized areas outside the polar region, need to be monitored for glacier dynamics and other glacial processes to better understand and characterize the climate change science. Further, the snow and glacier resources in the Himalayan region have tremendous social, economic and ecological importance. Besides being a main source of drinking water and irrigation, the snow and glaciers form the backbone of several industrial sectors in the Trans-Himalayan region like hydropower generation, horticulture, tourism and inland fisheries. Though a number of glacier studies have been conducted in the Himalayas in general (Bahuguna et al., 2004, Kulkarni et al., 2002, Saraf et al., 1999, Singh and Kumar, 1996, Wagnon et al., 2007) but only a few studies have been conducted in the Kashmir Himalayas (Romshoo et al., 2007) and Korakaram regions (Ahmad and Hashimi, 1974, Nijampurkar et al, 1982). It is therefore imperative that the glaciers changes and other associated processes are studied, using geological, climatological, and remote sensing techniques, to understand their role in regional and global land surface processes. The role of remote sensing, both optical and microwave, has been well recognized for mapping and monitoring the glacier dynamics and glacial processes in different regions of the world (Bayr et al., 1994, Hall et al., 2003, Mastuoka et al., 2007, Paul, 2002, Williams et al., 1991). However, there are various methodological challenges encountered while using these methods for assessing the changes in the snow and glacier resources. These are briefly discussed here under:

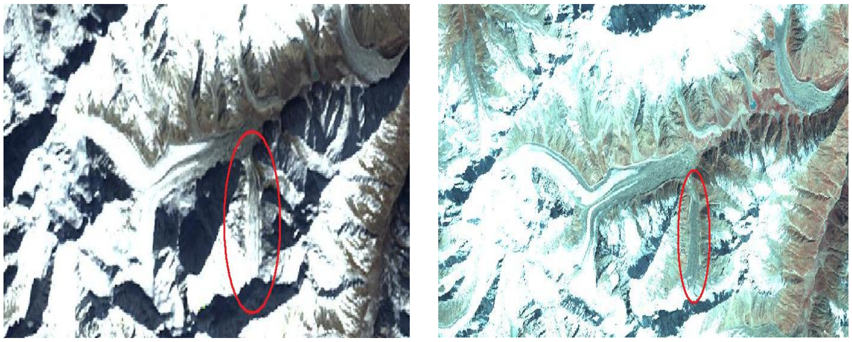
i) Availability of credible Baseline data:

In order to assess the changes in the glacier extent over a period of time, it is important to have credible baseline data available so that the changes could be precisely quantified using the time series of satellite and field observations. However, it is often possible that the baseline data has been generated using coarse resolution or sometimes, the glacier boundaries and extents may not have been properly surveyed or measured. In the worst case, sometimes it has been found that the glaciers in a region have been completely left out of the inventory (Fig. 2). With faulty baseline data, it is not possible to precisely determine the changes in glacier geometry and dynamics using imperfect base data. Under such circumstances, it would be more appropriate to determine the changes in the glacier geometry and dynamics using multi-temporal satellite data. However, we have the satellite data mostly available from 1972 and in few cases from 1960's as well. The use of satellite data for determining the changes in the glacier geometry, extent and dynamics shall overcome the drawbacks inherent in the baseline data generated through human resources and instrumentation.

ii) Satellite data selection:

Assuming that one has the access to the repository of cloud free satellite data over the desired region, the selection of the appropriate images for glacier mapping is one of the major challenges for glacier mapping. Proper scene selection is always a time consuming process. Most of the satellite data lacks continuity and even LANDSAT series of satellites that are in the orbit since the year 1972, vary in spatial and spectral resolutions. Therefore, for change detection analysis of glaciers over longer time periods, there is often no choice but to use data from two different satellite systems with varied spatial and spectral resolutions and that adds certain errors in the mapping accuracy that may sometimes be difficult to resolve (Paul and Anderson, 2009). Fig. 3

shows the glacier snapped from two images with different spatial and spectral resolutions.



(a) (b)

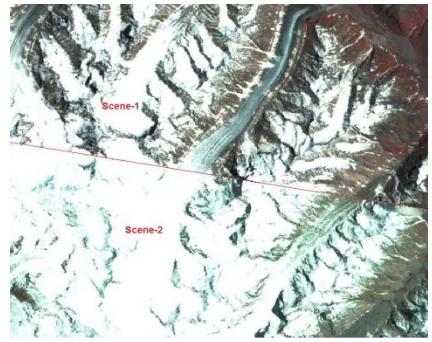
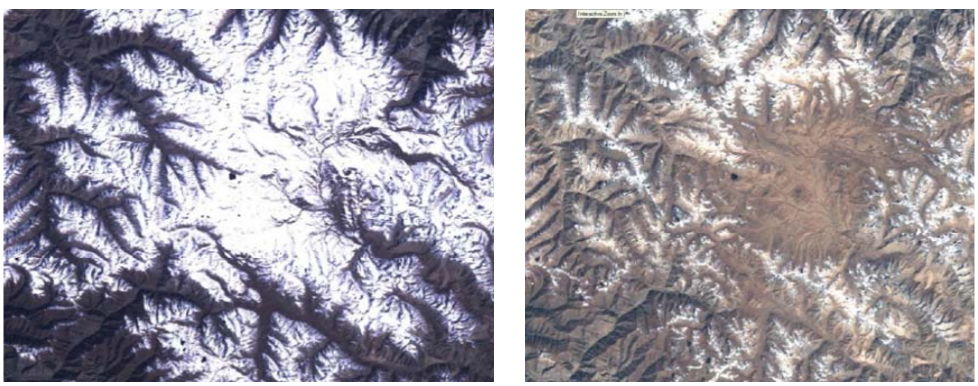


Fig.4: Showing the glacier on 2 scenes taken a few weeks apart

Fig.3: Showing the impact of spatial and spectral resolution on glacier sensing a) 1972 MSS data b) 2005 LISS III

Some a region or even a glacier is not covered by a single scene and it is necessary to stitch a mosaic from two or more scenes taken at different points in time. This makes making and analysis difficult because of the variation in the scene radiometry. Fig. 4 shows the glacier extent spread over two scenes taken at different point in time.



(a) (b)

Fig.5: Showing the seasonal snowcover at the end of the ablation period a) Sept., 1992 b) Sept., 2001

The seasonal snow cover in the images also poses a difficult challenge in glacier inventory. Effectively, one is left with a very little choice on the best possible snow conditions that may be appropriate for glacier mapping. Normally, the images acquired in the ablation session are appropriate for the glacier mapping but from the Fig. 5, it is evident that the sometimes the images acquired by the end of ablation period may have appreciable snow cover that may hinder the mapping of glaciers.

The debris cover on the glaciers poses challenges for the accurate snout mapping and determining the rates of glacier recession. Fig. 6 shows the debris and non-debris covered glaciers as seen from the satellite images.

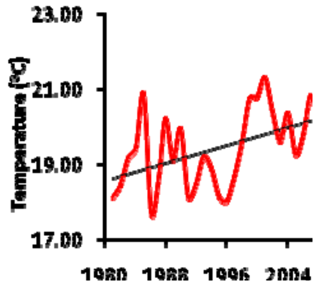
(a) (b)

Fig.6: Showing the debris free (a) and debris covered (b) glacier snouts

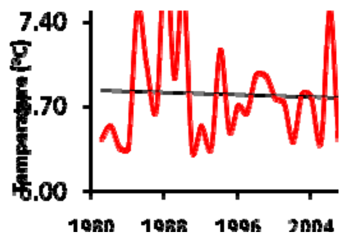
b) Hydrometeorological indicators

Long term instrumental records show a systematic increase in global mean temperature with global mean at a rate of 0.07^{o} C decade $^{-1}$ over the last century. However, the warming has not been globally uniform with high northern latitudes particularly adversely affected (Mann et al., 1999, Mann and Jones, 2003). Due to scanty network and short records of observation stations, particularly in mountainous regions, it is difficult to get statistically significant trends of the hydro-meteorological indicators of the climate change. For example, in the entire valley of Kashmir, we have only five meteorological stations manned by the Indian Meteorological Department. Similar, is the scenario for most of the mountainous regions in the country where the existing network of weather stations falls short by more than an order of magnitude of the minimum requirement recommended by the World Meteorological Organization (WMO, 1970). Mountainous regions are said to require a much greater density of climate stations than the neighbouring flatlands to achieve the same reliability for the estimation of climate change indicators.

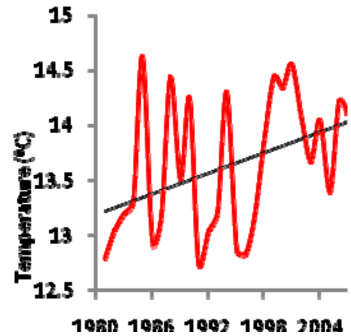
Strong contrasts are found between the winter and summer temperatures over the Himalayan regions and between maximum and minimum temperatures. Winter mean and maximum temperature shows significant increase but mean and minimum summer temperatures show consistent decline (Fowler and archer, 2006). This divergence is not unique to the Kashmir Himalayan region but has been observed in Karakoram range and over much of the Indian subcontinent (Kumar and Pant, 1994, Yadav et al., 2004). However, the analysis is based on the inadequate observed data. Fig. 7 shows the contrasting trends in winter temperatures in the two stations, one hilly and other on flatland.



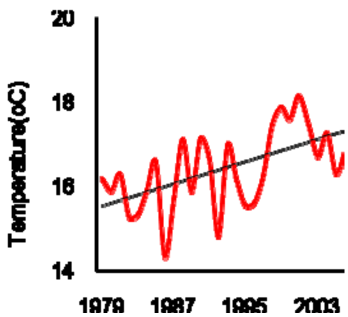
Average yearly Max. Temperature (1980-2008) at Srinagar station



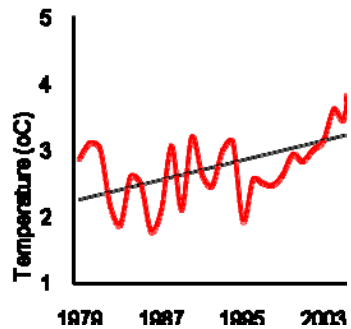
Average Yearly Minimum Temperature (1980-2008) at Srinagar station



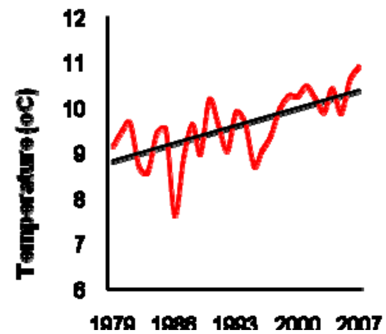
Average Yearly Temperature (1980-2008) at Srinagar station



Average Yearly Maximum Temperature (1949-2007) at Pahagam station



Average Yearly Minimum Temperature (1979-2007) at Pahagam station



Average Yearly Temperature (1979-2007) at Pahalgam station

Fig.7: Showing the divergent trends of the average minimum temperature at hillstation (Pahalgam and the flatland (Srinagar)

For assessing the impacts of climate change on glacier mass balance and hydrological regime, we require the credible data about both the precipitation and the temperature. How far the temperature and precipitation measurements at weather stations in the valleys and flatlands are suitable indicators of these parameters at higher altitude where most of our glaciers are located, is a debatable question. Fig. 8 shows the mismatch between the observed and simulated hydrograph from a glacierized basin in Kashmir valley (Romshoo and Dar, 2009). Most of the disagreement is due to the empirical lapse rate used in absence of the actual observed temperature and precipitation data in mountainous parts of the watershed.

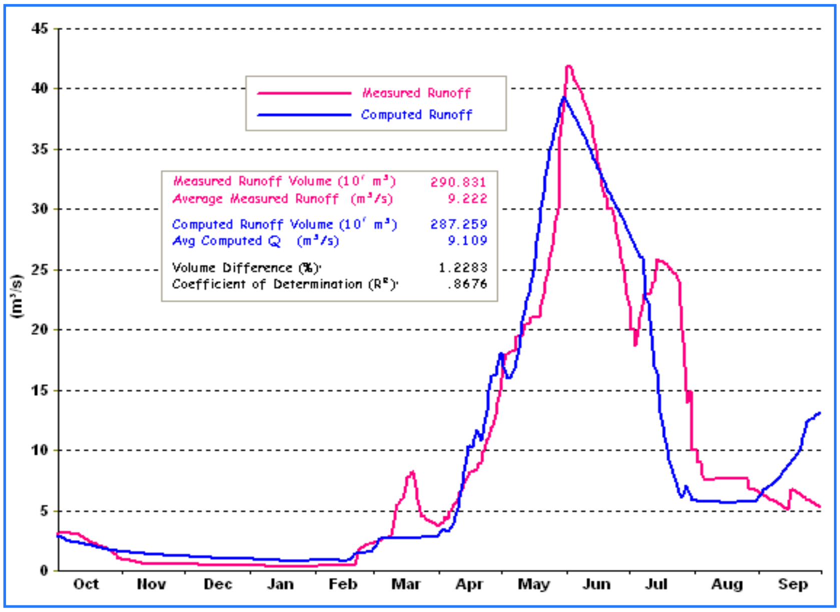


Fig.8: Showing the disagreement between the observed and simulation hydrograph due to the inaccurate temperature lapse rate

Another very important hydrometeorological parameter that is used as a credible indicator of climate change is the changes in the stream discharge. Again, we have neither adequate network of stream discharge observation stations nor a long time series of the data, particularly, in the upstream mountains basins in the country that could provide us a precise and robust estimate of the climate change impacts. More sophisticated modelling techniques such as physically based hydrological models or artificial neural network models could be used for estimating the temporal change in the discharge in unguaged streams. In view of the impending water shortage in the region due to climate change, the forecasting of seasonal flows may become a fundamental requirement for the successful management of the depleting water resources in the region.

The rugged terrain in the Himalayas is a serious obstacle for ground based observations of snow cover, snow depth, snow water equivalence and other snow physical parameters at higher elevations. Satellite observations of the snow physical parameters suffers from the perpetual cloud cover during most part of the winter over the Himalayan region (Fig. 9) Microwave remote sensing data, having cloud penetrating capability, could be used for estimating most of the snow physical parameters. However, compared to the optical data, microwave data is still not so popular and freely available in the country.

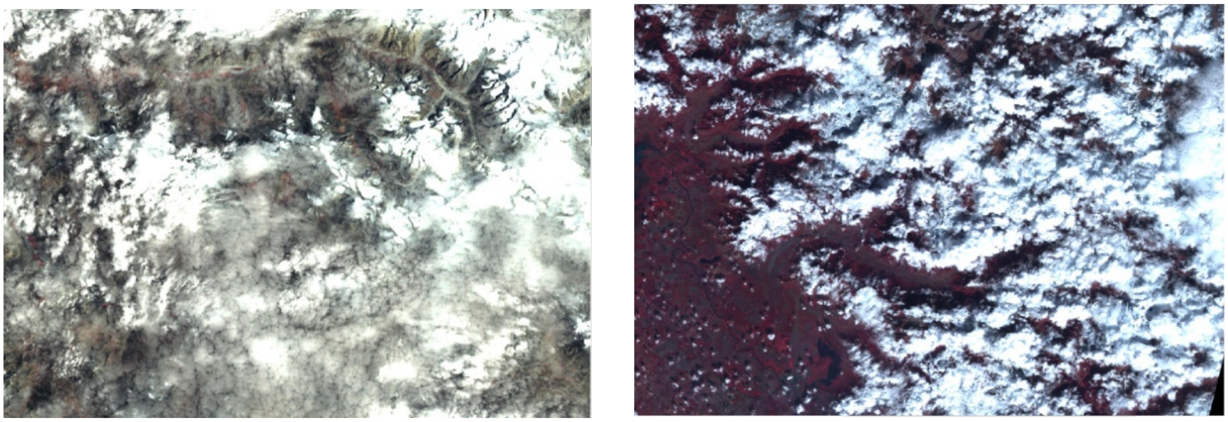


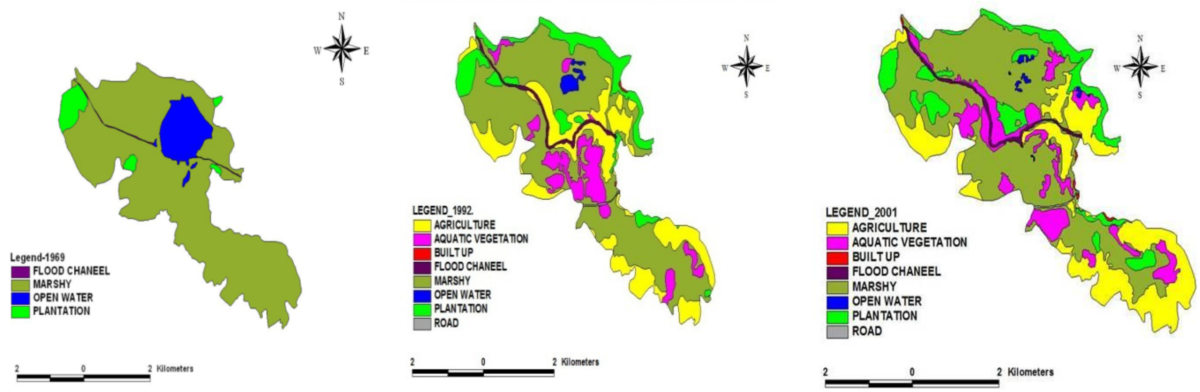
Fig.9: Showing the difficulties in glacier mapping due to cloud cover

C. Wetlands

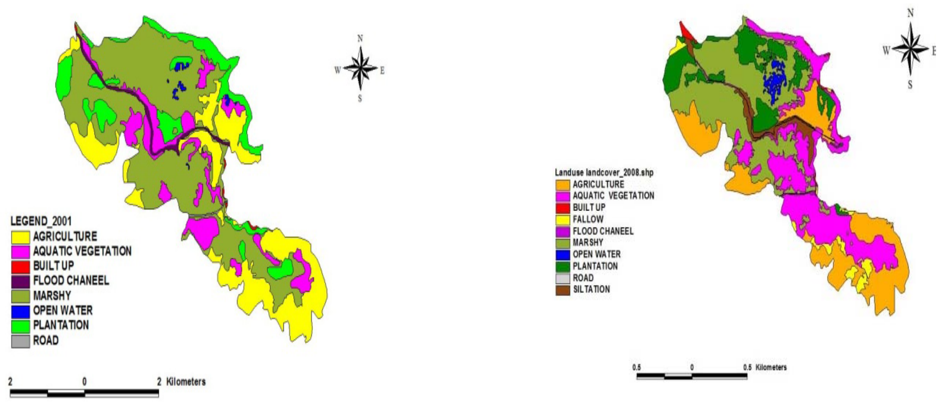
Climate Change predictions, with increase or decrease in precipitation, will have important implications for all ecosystems, particularly, wetlands, whose ecological character is very much dependent on its hydrological regime (Anderson *et al.,* 2008, Winter, 2000). The potential impacts of climate change on wetland hydrology are of interest to a wide-range of stakeholders from wetland managers to international policy makers. With the snow and glaciers resources receding at a fast pace due to increasing temperatures, together with decrease in the precipitation, many rivers, fed by snow and glacier melt, are showing, on an average, decreasing trends in discharge and therefore will have an impact wetland hydrology and aquatic life (Finlayson, 1996, Gregory and Oerlemans, 1998, IPCC, 2001b, Johnson *et al.,* 2005). Despite the benefits of increased precipitation for some freshwater wetlands, the climate change projected by the IPCC are likely to have pronounced harmful impacts on many wetland ecosystem (MEA, 2005) The loss of wetlands can result in wetlands becoming a net source of carbon dioxide serving as positive feedback to global warming (Burkett and Kusler, 2000, Clement and Aidoud, 2007).

Wetland responses to climate change are still not fully understood In order to quantify the impacts of climate change on the wetlands (Clair, 1997). However, we usually assess the relationship between the wetlands and the climate change through the changes in the ecological parameters like vegetation, wetland hydrology and hydric soils over a period of time. Remotely sensed data is regarded as a primary source data for determining the changes in these parameters as a result of climate change.

Climate change is projected to severely effect regions where precipitation is mainly in the form of winter snowfall and spring and summer snow- and ice-melt. In these areas, a temperature increase is likely to induce an increased winter runoff and a reduced spring and summer flow (Kwadijk and middlekoop, 1994, Sealthun et al., 1998). The decline in the precipitation and river discharge will adversely affect the water spread of the wetlands and lakes. Several wetlands are showing depletion in the water spread over a period of time attributed to the climate change. Remotely sensed data is used detect the changes in the water spread of the wetlands. However the use of multi-temporal satellite data introduced some complexities in the data analysis as can be seen from the Fig. 10. The use of high resolution IKonos data in 2009 shows higher water spread compared to 2005. So in order to resolve this conflict, the impact of spatial resolution on wetland mapping has to be worked out. Further, the changes in the wetland extent could be a result of both the climate



1969 1992 2001

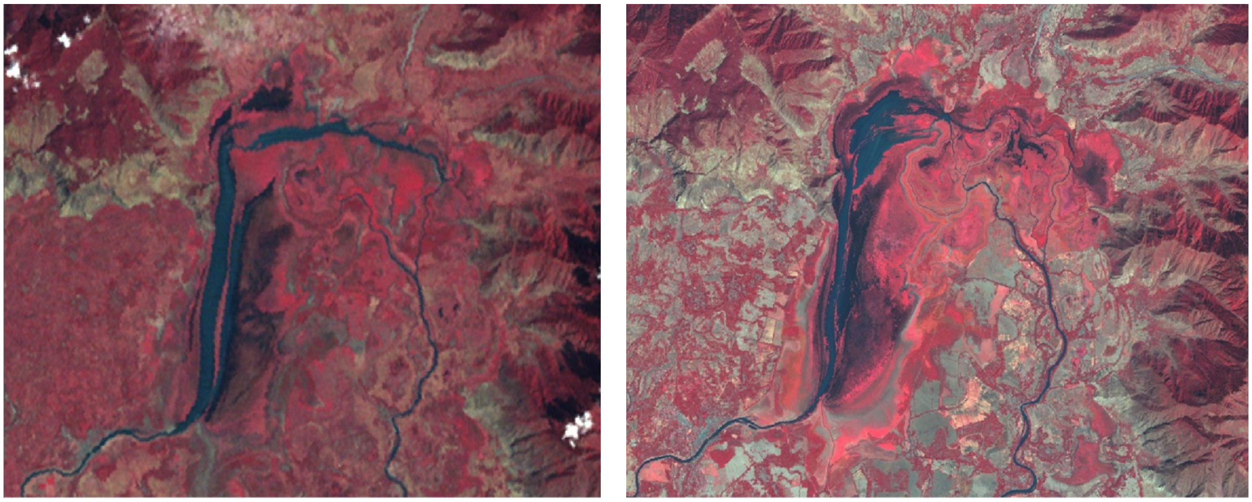


2005 2008

Fig.10: Showing the impact of resolution on mapping the water spread; 2008 water spread is mapped from the high resolution IKONOS data

change and anthropogenic factors. Urbanization, deforestation and the conversion of wetlands to agriculture also leads to major changes in the hydrology, vegetation and soil characteristics and sediment and nutrient loads. Sometimes, these changes may dwarf some of the expected changes associated with the climate change.

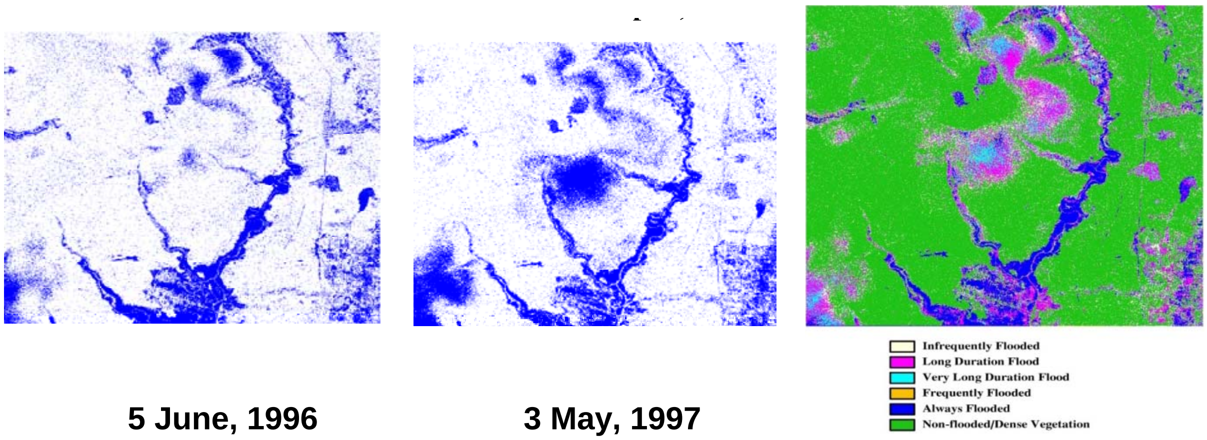
Wetland flora responds to small and permanent changes in the water levels and water temperature. A number of new species and extinction of some other species has been reported in various wetlands during the last few decades and is attributed to the climate change (Kaul and Zutshi, 1967, Khan, 2002, Pandit and Kumar, 2006). However, the use of remotely sensed data for determining the changes in the aquatic flora over a longer period of time suffers from the inadequacy of appropriate satellite data. Though the use of hyperspectral remote sensing data for discrimination between vascular and non-vascular plants, trees and shrubs and mosses is possible because of the variation in their structural, biochemical and function attributes but the high cost and the difficulty in procuring the hyperspectral data makes this source of data limited for determining the changes in the composition and distribution of aquatic vegetation for most of the wetlands. Fig. 11 shows the distribution of vegetation at two different points in time and no distinction can be made about the vegetation composition and patterns from these two images.



(a) (b)

Fig.11: Showing the multispectral data over wetland a) Sept., 1972; b) Sept., 2005. The data is not suitable for mapping the changes in the species composition observed in the lake

Wetlands and rice fields are two of the largest sources of methane to the atmosphere, making up about 40% of the methane input to the atmosphere, due to the anoxic conditions occurring in their flooded soils and their high primary production (Bartlett and Harriss, 1993, Mathews, 1993). Important factors controlling methane production from wetlands include water level (Roulet et al., 1992) and soil properties (Sas et al., 1994), Optical remote sensing data has limited applicability for mapping the inundation and soil moisture patterns in the wetlands because they reflect off the top of the aquatic vegetation. Because of their ability to penetrate beneath the canopy, active microwave data has a potential for inundation mapping and for determining the hydric status of the soils (Romshoo, 2003). Fig. 12 shows the inundation patterns mapped at various points in time using the L-band SAR in Kalimanthan peatlands. Satellite radar altimetry can be used to measure the surface water height changes in wetlands. This information is very important to estimate the emissions of carbon dioxide and methane from the wetlands.



5 June, 1996 **3 May, 1997**

Fig. 12: Showing the capability of L-band SAR to map the inundation patterns in the tropical peat lands (Source: Romshoo et al., 2001)

The most effective approach for observing various wetland parameters and processes should combine optical multispectral remote sensing data Synthetic Aperture Radar (SAR)and microwave altimetry data.

Conclusion: Uncertainty in climate change predictions and data constraints for quantifying the indicators and climate change impacts is no argument for doing nothing. The belief that uncertainty and constraints must mean that things can only be less bad than predicted is purely wishful thinking, not science. There is utterly no case to be made for inaction and a strong case to be made for developing and improving robust and holistic scientific mechanisms to characterize, understand and predict the climate change processes and impacts. As we reduce the uncertainty of the science and data constraints, we will find catastrophic warming becoming more likely.

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Driving Force in Climate Change Dynamics

V K Verma

Professor (Rtd) of Geology, University of Delhi

B-3/1 Janak Puri New Delhi 110058

(e-mail: profvk_verma@yahoo.com)

The climate of the Earth has varied through past many geologic times. Climate change is, essentially, a significant meteorological deviation in the mean or in its variability through space and time,- often used for anthropogenically driven temperature led radiation imbalance or global warming a process that triggers climatic change, a product may (or may not) be always related to global warming.

Indicators of Climate Change:

Following are some of the indicators of climate change, as observed in different regions of the world:

I) ***Arctic region***

- Polar sea-ice melting and shrinking from approximately 7.0 to 5.0 million square km between 1978 to 2005;
- Snow-pack visco-elastic avalanches and huge ice block(s) structural dismembering to form ice island (as on August 13, 2005)
- Giant crack development in the major and massive Northern Greenland (Petermann glacier) haemorrhaging 29 sq. km chunk off between July 10 and 24, 2008 (Box, Jason 2008);

II) ***Antarctic region***

- Higher CO_2 and methane concentrations in frozen cylindrical ice cores of EPICA and Japanese projects and
- Emergence of large grass growths earlier under frozen ice-cloak, hundreds of kilometer away from the Abbott Ice Shelf

III) ***Europe*** **:** advancing wild cherry blossoming comparatively earlier

IV) ***South America*** **:** Peruvian Broggi glacier disappearance

V) ***Asia region*** **:** Retreat in Himalayan glaciers. Himalaya glaciers retreated in the past three decades, Its ice cover during the Quaternary Ice Age 15,000 to 17,000 years is believed to have been at least three times what it is today. In Gangotri group of glaciers;

the trunk is receding at a slower rate than the tributaries. 30 km long, the impressive Gangotri glacier never extended beyond 10-15 km odd from the present snout is said to be erratically receding in different time windows at varying rates now believed to be natural and need no corrective measure. Recent studies (Kumar et. al. 2008) on estimation of retreat of Gangotri glacier is 6 meters/yr indicate a general rapidly declining recessional trend; the slow down attributed to high and frequent snow-fall during 2004 winter. Kolahal glacier encompassing a little over 11 km^2 has shrunk down to 2.63 km^2 on the last three decades at an alarming rate of 0.08 km^2/year attributed due to temperature rise of 1.1^0C in the past 100 years. On the other hand; Siachen and some other glaciers are reported to be advancing.

Impact of Climate Change:

Some of the obvious consequences of global warming are

- Glacier melting and consequent land shrinkage due to sea level rise
- saltwater ingress in coastal areas and land salinity increase
- change in rainfall pattern, frequent drought and floods
- adverse effect on (i) drinking water supply (like saline enriched ground water in Haryana, Fluorine + Arsenic rich waters contamination in UP and Bengal) (ii) agricultural productivity [land becoming infertile and lack of fresh sediment (soil) supply compounding problems of droughts] and (iii) hydro-power generation
- climate and landuse pattern changes as the drought ravaged the Great Sahara Desert at least in 2400 stretch around Sahel, Chad and Western-Sudan on a satellite imagery study shows huge vegetation increase signaling the return of 1200 years ago Savaana lush revitalized by glacier melt rains (TOI, 2009 d)
- propagation in vector-borne diseases like malaria and dengue
- change in floral and faunal patterns
- bio-diversity and migration, loss of life as Invasive Allien Species (IAS) may wipe off the local species leading to bio-extinction

Global warming may have more impact in the tropics. Cook (2009) critically examined 70 peer-reviewed papers related to long term satellite measurements, balloon data, climatic models and sea temperature studies to conclude that the traditional Tropic of Cancer and the Tropic of Capricorn widened apart upto 50 kms in the past 25 years pushing the subtropical arid zone bordering the heavily populated temperature areas-southern Australia, Africa, Europe (Mediterranean), Middle East, Southern Western United States, Northern Mexico, southern South America predicted to encounter devastating severely drying out water resources crunch already visible in wind and, consequently, rain pattern changes.

Is Climate Change Anthropogenic or Natural

The period much before the incept of Phenerozoic era (5 million years ago), when the complex life arose amid volcanic eruptions, has CO_2 concentrations 18 times of the present levels substantiating that the gas level fluctuations are fall out of step of the planet's hot and cold cycles (Ghosh 1976). The above time period show three major glacial periods *viz.* **700 *m.y,* 300 *m.y*** and **200 *m.y.*** The earliest glaciations are recorded through the Pre-Cambrian Vindhyan Supergroup. The Gondwana Ice-age and subsequent at least 16 large and small Pleistocene glaciation cycles each lasting for about 1.25 lakh years, of which the glacial phase varying from about 5 decades upto 1.00 lakh year duration may have prevailed with brief intervals of 1 to 20000 years when the temperature rose, are rather well documented in geo-records. The Earth seesawed a series of varying duration glacial- interglacial cycles. It's temperature is estimated ~22^{0}C about 65 million years ago, much before the alleged CO_2 problem was in the picture in contrast to present 12^{0}C. The Earth has passed through several periods of warming and cooling during the past 15000 years (Holocene) prior to large scale industrial growth or even much before human appearance. Pollen studies indicate ongoing climate change during the past 10,000 years in temperate regions. It also witnessed in general climate change during historic times.

It is further observed that there was warming since 1850s on temperature rise by ~0.5 °C between 1900 and 1945, when industrial CO_2 input in the atmosphere was rather low and precedes the anthropogenic contribution beginning of sharp atmospheric CO_2 rise. Cooling on temperature lowering between 1945 to 1977 when severe winters were considered as on-setting of Big Ice Age, and again a steep rise attributable to atmospheric CO_2 increase the most recent decade 1999 to 2008 was indeed the warmest in the last 2000 years of least in the Arctic (TOI, 2009i). Earlier it was cooling for nearly two million because of changes in Earth's orbit causing direct sunlight reduction availability.

The warming trend over India is estimated at 0.57^o C/ 100 years (Rupkumar *et al.* 1994). The prolonged Late Quaternary dry period including Last Glacial Maximum (20,000 – 16,000 years BP) continued until about 11000 years BP where after progressively wetter and warmer climate dawned (Valdiya, 1999) with SW monsoon intensification prompted by strong unveiling of the oceanic currents commencing about 10,500 – 10,000 years BP.

In fact, the "Earth has been traveling a well-defined roller-coaster temperature path cycle of 900,000 years an solar intensity variations…" There appears to be ongoing 25-30 years global warming/cooling cycle matching well with that of similar solar irradiance (Easterbrock 2009) cycles.

Alternate postulates

A great condition is observed between solar intensity and Earth's temperature. Weakened solar activity by fluctuations in sun's magnetic field causes global cooling. It (sunspot activity) was at its peak in 1990's. Based on 150 years of climate data, Danish Space Research Center DSRC (2008) opined that Greenhouse Gas Emission may be one of the many factors in global warming and evinced exceptionally high varying solar activity in the 20th century compared to 400 to 800 years ago when the flux of the galactic atmosphere cosmic rays ionizing in atmosphere with condensable gases such as sulphuric acid and water vapours that control aerosols production cloud droplet formation precursors, is reduced due to increased solar magnetic shielding influencing climate through low lying clouds causing more warmth near the Earth surface. The sun is the biggest contributor in global warming.

Milankovich identified 3 cyclical movements to display the complex space-time scale climate spectra seeking significant available valuable data decoding due to changes in

(i) eccentricity from circular to elliptical of which the periodicity is ~ 1 lakh years
(ii) obliquity or tilt of the Earth's axis with ~ 22.1 degrees to 24.5 degrees and back again on a 41,000-year cycle periodicity and on Hercynian like Earth movements and
(iii) orbital precision on gravitational attraction inducing equinoxes that lead to changes in the Earth receipt of solar redirections.

Slight change in earth's obliquity or eccentricity can play in

(a) mega scale mass displacement and/or
(b) change in it's magnetic field.

Recent researcher's view that the Earth's spin-axis is tilted some 23.5^0 implying shift in dates of equinoxes, solstices and monsoon along with temperature change. The planet-spin axis would deviate on mass distribution displacement as eventually indicated by 3 microseconds centre ward~ 1" shift on recent 2004 December tsunami, developing earth's and rock's magnetic fields anomalous alignments impinging on the global environment. Subtle effect is being expected over the century to cause the spin-axis northern pole to shift by ~1.5cm /year westwards (TOI, 2009g).

A study indicates dearth of terrestrial volcanoes during the Archaean but later in Palaeo-proterozoic associated with profound global change scenario including the break up into two super count after tectonic episode terrestrial volcanoes dramatically surfaced and dominated whence oxygen levels increased in the atmosphere in control to submarine volcanic eruptions at lower temperature more efficient at reducing oxygen. Volcanic eruptions as also meteoric impacts throw dust into the atmosphere causing cooling by reflection. The Holocene temperature/climatic vicissitudes coupled with the ongoing neotectonic Himalaya uplift on India crashing down underside of Asia initiated by lithospheric plate dynamism perhaps about 40 to 50 million years ago causing 1 to 4 Richter scale around 250 seismic shocks a year and also changing the climate controller land and sea distribution to slide northward at a geologically quick pace of 2" (5 to 6cm) a year displaces low pressure areas and consequently monsoon spells too, impacting on climate. Volcanism worldwide is on decline, both in terms of (i) frequency and (ii) intensity. P/T and K/T boundaries mass extinction on oxygen deficiency on gigantic scale volcanic CO_2 release (Singh 2007) is no match and incompatible to fossil fuels human use CO_2 release.

These natural disequilibria may be surmised as plausible response showing a definite climate change and dispels off the British economist Sir Nicolas Stern's concept on impact of climate change and is altogether insensitive to CO_2 concentration enhancement supremacy on fossil fuel use global warming postulate. Impressive 100-150 years climate change data generated on various meteorological variables mostly computed through instrumental climatology with more reliability limited to only 20-25 years are inadequate to infer the passage through which the planet Earth and the Indian subcontinent in particular traveled through its long journey of several billion years though the weather pattern fluctuations over a few decades are rather visible and calls for earlier or even palaeoclimatic record documentation in natural archives for sensitive proxies particularly for the tropics. They could as well reverse "the change in terms of temperature and rainfall are not free from uncertainties" (De, 2001) as also "possibilities of surprises" in correctness are not ruled out.

Admittedly it is rather hard to strike unique signature(s) to unravel the changing nonlinear multifactorial interactive climate complex, but it attracts to strive compatible convergence of various exogenic and endogenic processes related climate data with geo-match records to relate and reconcile the meteorological deviations scientific quest.

Perhaps it may be worthwhile to generate, accumulate and integrate more data obtainable from climate change related driving force viz.

(a) Plate dynamics and consequential unrest, isostism and volcanism and
(b) Sunspot activity

and then interwoven with the bio-related driven data component to arrive at reasonably reconciled inferences to work out more meaningful mitigation/management measures.

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Status of Tamil Nadu Coast in the Context of Global Warming and Related Sea Level Rise

C.J. Kumanan[1], SM.Ramasamy[2], J.Saravanavel[1], and A.S. Rajawat[3]

[1]Centre of Excellence in Remote Sensing, Bharathidasan University
Tiruchirappalli – 620 023, Tamil Nadu, India
[2]Gandhigram Rural University, Gandhigram, Dindigul – 624302, Tamil Nadu, India
[3]Marine and Earth Sciences Group (MESG), Remote Sensing Applications Area (RESA)
Space Applications Centre (SAC), Ahmedabad-38 0015, India

(E-mail: cersbard@yahoo.co.in)

1.0 INTRODUCTION

The coastal zones generally remain dynamically active due to multivariate tectonic and geomorphic processes viz: tectonic, fluvial, fluvio-marine, marine and aeolian processes, which act in varying degrees and duration independently and conjunctively and thus construct and destroy various landforms / geosystems. Further, the coastal zones always remain vulnerably exposed to various natural disasters viz: tsunamis, storm surges, cyclones, floods, tectonic movements and related seismicities, etc.

In addition to such hierarchy of natural disasters, global warming and the much apprehended Sea Level Rise (SLR) has driven the scientists from all over the world to look into this phenomenon critically, as coastal zones are thickly populated along with infrastructural developments and the considerable percent of these are likely to get submerged and also expected to face many related environmental problems.

Hence realizing these, a lot of international studies for assessing vulnerability of a coast to climate change have developed from the IPCC Common Methodology for vulnerability assessment developed in 1991. For example, the coastal vulnerability index (CVI) developed by the United States Geological Survey (Gornitz and Kanciruk 1989, Gornitz 1991, Thieler and Hammer-Klose 2000) is based on the geomorphology, coastal slope, relative sea-level rise, shoreline erosion/accretion, mean tidal range and mean wave height. A social vulnerability index (SoVI) developed by Boruff et al. (2005)

for USA is based on the socio-economic variables. The Sensitivity index (SI) for Canada developed by Shaw et al. (1998) used various physical parameters like relief, rock type, landform, sea-level change, shoreline displacement, tidal range and maximum wave height. A risk matrix model for assessing vulnerability of the South African coast lines by Hughes and Brundrit (1992) used location, infrastructure (economic value) and hazard as variables. Yamada et al (1995) developed a sustainable capacity index (SCI) for South Pacific coast by analyzing vulnerability and resilience of natural, cultural, institutional, infrastructural, economic and human factors. Recently, Nageswara Rao et al (2008) have brought out the coastal vulnerability mapping for Andra Pradesh coast lines using various physical variables like geomorphology, slopes, shoreline changes, mean spring tide range and wave height.

With the above studies and literatures review in the background and the credentials of Geomatics technology (comprising satellite borne multi spectral and altimeter data, GIS, GPS and digital cartography) in visualizing and mapping the various coastal vulnerability parameters, the present research study was taken up to evaluate the status of the Tamil Nadu coastal regions in the context of global warming and related sea level rise.

2.0 APPROACH

For this present study of evaluating the status of Tamil Nadu coast with special reference to global warming and related sea level rise, the following methodology was adopted

- ❖ Preparation of geomorphology map using high resolution IRS P6 LISS IV satellite data for entire Tamil Nadu coastal segments
- ❖ Preparation of coastal slopes using digitally processed SRTM data
- ❖ By analyzing the multi-dated satellite data and brought out the shoreline changes (i.e.) erosion and accretion coasts of Tamil Nadu
- ❖ Mean spring tidal range of the Tamil Nadu coastal segments were from National hydrographic chart
- ❖ Finally the ranks and weightages were assigned to each geosystem parameters according to its vulnerability to sea level rise and related impacts

- ❖ Integrating the ranked and weighted various physical coastal variables and brought out the coastal vulnerability index for Tamil Nadu coast

3.0 COASTAL VULNERABILITY OF TAMIL NADU COAST

3.1 Geomorphology

The geomorphology map for entire Tamil Nadu coastal region was prepared by interpreting raw and digitally processed IRS P6 LISS 3 and AWIFS and LANDSAT satellite data. While interpreting the geomorphology, wherever necessary, the satellite data was subjected to various image processing techniques using ENVI image processing software. At places, satellite data was wrapped over the SRTM based DEM and geomorphic features were interpreted in 3D visualization. The geomorphology of the Tamil Nadu coastal sectors is represented by a package of landforms of tectonic origin, viz: dissected and undissected uplands and pediments; fluvial origin viz. flood plains, palaeo channels, river beds, sand bars etc and fluvio marine and marine origin like deltaic plains, beach ridges and swales, tidal flats, mangroves, creeks, beaches, etc.

Further, the Geomorphology map was critically analyzed and on the basis of its vulnerability to sea level rise and possible inundation, the coast line was divided into five classes (ranks) such as

1 - Very low (Rocky coasts, Cliffed coasts)

2 - Low (uplands, pediments, Medium cliffs, Indented coasts)

3 - Moderate (Low cliffs, alluvial plains, beach ridges)

4 - High (Estuary, lagoon, creeks, backwater)

5 - Very high (Barrier beaches, sand beaches, saltmarsh, mud flats, deltas, mangrove)

3.2 Slope

The slopes % of the Tamil Nadu coastal region was prepared using the digitally processed SRTM data using ENVI image processing software. As per the slope is concerned, 80% Tamil Nadu coastal segments fall in with in 1% slopes. On the basis of slope, according to the coastal vulnerability, the coastline was classified into five classes (ranks) such as 1 - Very low (Slope > 0.81 %), 2 - Low (Slope 0.61 - 0.8 %), 3 - Moderate (Slope 0.41 - 0.6 %), 4 - High (Slope 0.21 - 4 %) and 5 - Very high (Slope < 0.2 %).

3.3 Shoreline changes (erosion and accretion coasts)

By analyzing the multi-dated satellite data of same season (LANDSAT TM 1990, LANDSAT ETM 2000 and IRS P6 LISS 3 satellite data), the shoreline changes (i.e.) erosion and accretion pattern of Tamil Nadu were brought out. According to the erosion and accretion pattern, the coastline was divided into five classes (ranks) such as 1 - Very low (> +2 m/yr), 2 - Low (1 to 2 m/yr), 3 - Moderate (- 1 to +1 m /yr), 4 - High (- 1.1 to - 2.0 m/yr) and 5 - Very high (> -2 m /yr). The Figure 1 shows the erosion and accretion status of Tamil Nadu coast.

3.4 Mean spring tidal range

Mean tidal range elevation data collected from National Hydrographic Chart at 13 locations and extrapolated into entire coastal region of Tamil Nadu. The same shows that the 0.6m to 1.2 m mean tidal range elevation variations was observed along Tamil Nadu coastal sectors. On the basis of mean spring tidal range, according to the vulnerability, the coastal sectors were divided into five classes (ranks).

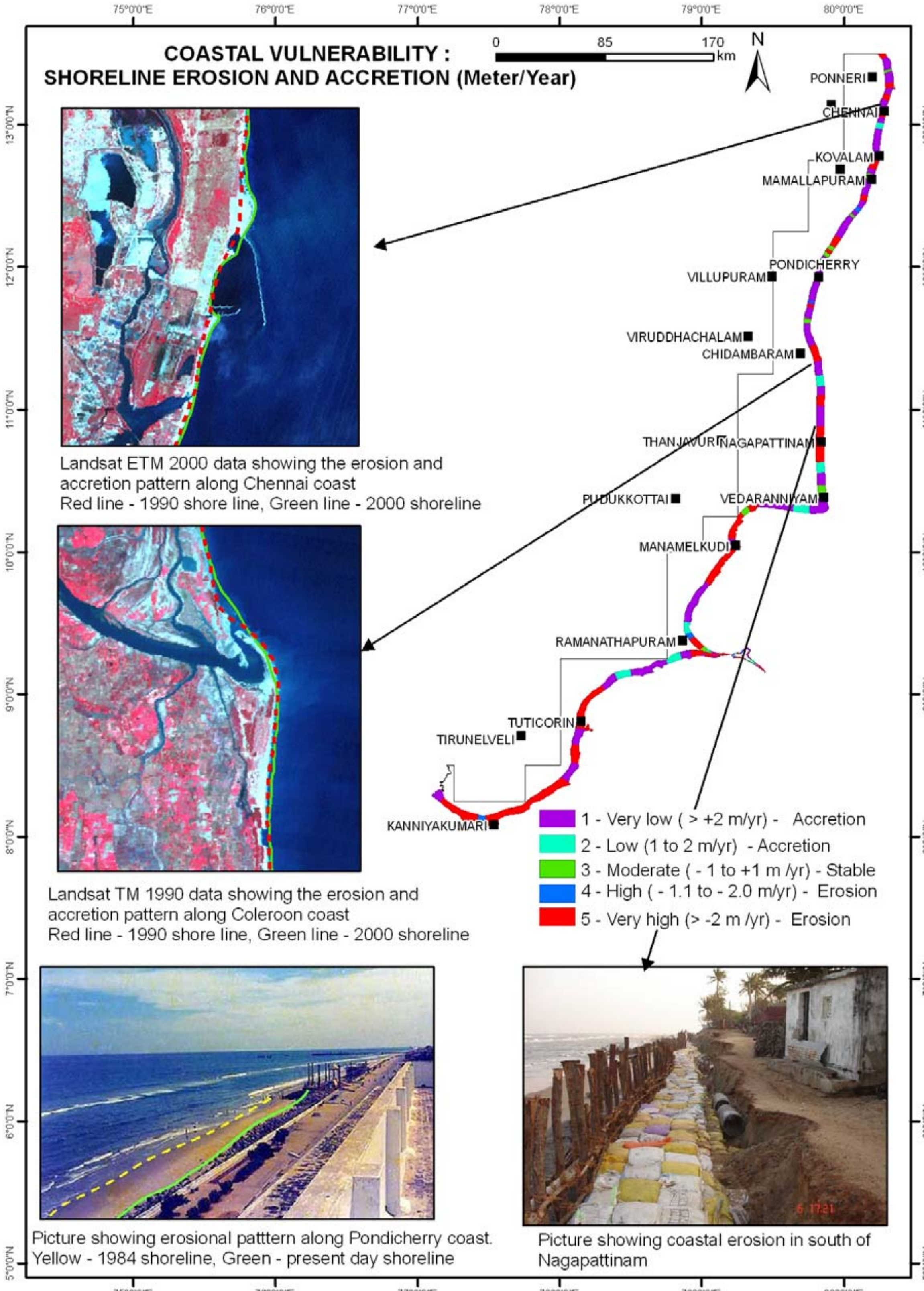

Fig.1 Shoreline changes (erosion and accretion coasts) along Tamil Nadu coast

3.5 Coastal Vulnerability Index

After ranking the each geosystem parameters in to 1-5 according to their coastal vulnerability, coastal vulnerability index was worked out using the above variables and assigning the relative weightages according to their significance in coastal vulnerability with special reference to global warming and related sea level rise using the following formula.

CVI = 4 G + 3 SL+ 2 SC+ 1 TH

CVI - Coastal Vulnerability Index
G - Geomorphology
SL - Slope
SC - Shoreline change
TH - Mean Tidal Height

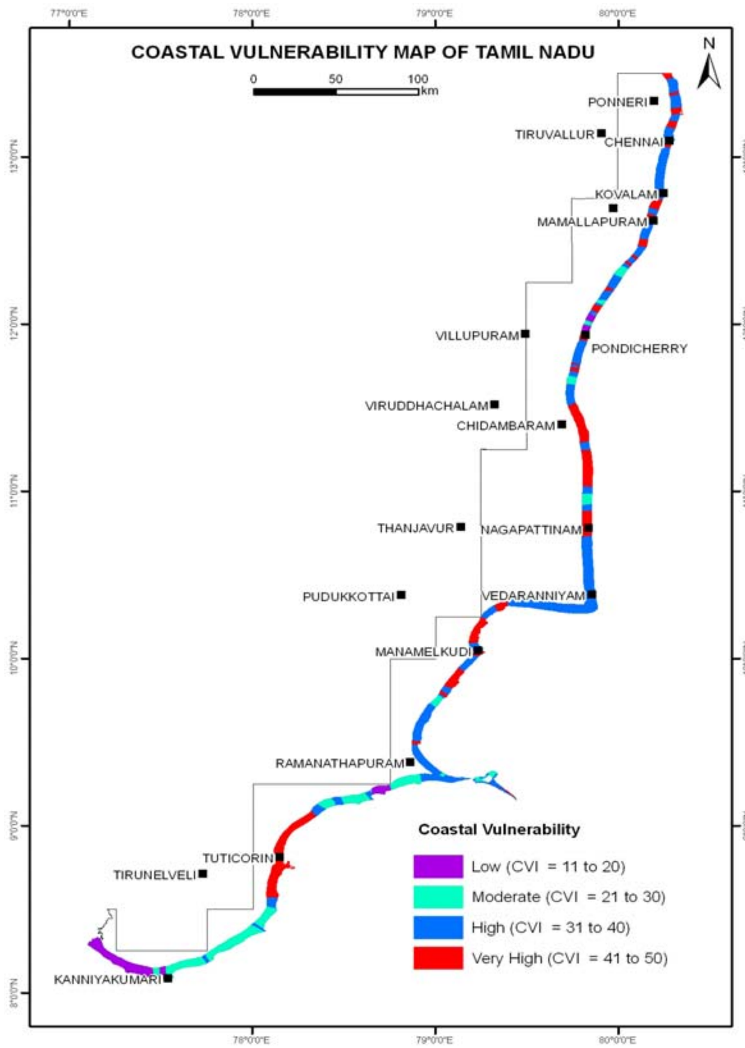

Fig.2 Coastal Vulnerability Index for Tamil Nadu coast

Ramasamy et al (2006) have inferred that the run-up and inundation limit of Tsunami 2004 was greatly controlled by coastal geomorphic units and accordingly they have classified the geomorphic units into facilitators (River mouths, creek mouths, Bay mouth bars and spits, mudflats and saltpans), carriers (Creeks and rivers/streams), accommodators (Estuary, backwaters, mangrove swamp, palaeo mudflat and swale), absorbers (Beaches) and barriers (Beach ridges). Further, many studies have come out on the role of geomorphology in controlling tsunami inundation (Nair et al 2005, Ram Mohan 2005, Chadha et al 2005, Banerjee 2005). The Ramanamurthy et al (2005) have attributed that the gentle slope nature of Nagapattinam coast only lead to tsunami inundation and related hazards.

Using the above formula, CVI (Coastal Vulnerability Index) were worked out entire Tamil Nadu coast. The same shows that the CVI ranging from 11-50 and these CVI were classified Low (CVI = 11 to 20), Moderate (CVI = 21 to 30), High (CVI = 31 to 40) and Very High (CVI = 41 to 50) vulnerable coasts. The GIS map showing the various vulnerability index has been generated (Fig.2).

4.0 DISCUSSION AND CONCLUSION

The coastal vulnerability map so prepared for Tamil Nadu coast by the above model is coinciding with the tsunami inundation, storm surges and coastal erosion scenario of Tamil Nadu coast. Further, during tsunami 2004, Pondicherry, Cuddalore, Colleroon coast and Nagapattinam coastal region faced ferocious tsunami waves and related disasters in greater extent. Now those regions were fall in the high and very high coastal vulnerability index. At the same time, Manamelkudi and Tuticorin region have fallen in higher vulnerability, but they have lesser tsunami impact compare to other coastal pockets because of Srilanka obstructed the tsunami waves. The southern tip of Tamil Nadu coastal region falls in the low vulnerability grade as these region having higher slope and rocky coast. Further, the present study indicates that the 300 km coastal length fall in very high vulnerability, 350 km coastal length fall in the high vulnerability grade. The present research study shows that the Tamil Nadu coast is highly vulnerable to global warming and related sea level rise.

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Address for Correspondence:

Arun Kumar Sharma
4136, ESHD, MESG, Space Applications Centre (ISRO), Ahmedabad – 380 015
T.No. +91-79-26914136, Fax No. +91-79-26915825
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Mr. Yunus Saleem	S/o. Hasan Ali Nr. Idgah, Vill.+Post Soorwal Sawai Madhopur 322027 Rajashtan	ISG-L-1116
Mr. Ghanshyam	New Colony Nimaj Teh. Jaitaran Pali 306303 Rajashtan	ISG-L-1117
Ms. Richa Kaushal	1-A-34, New Housing Board Nr. S.T.C. (Panchwati) Bharatpur 321001 Rajasthan	ISG-L-1118
Mr. Mahadev	V.P.O. 54, L.N.P. Padampur 335061 Rajasthan	ISG-L-1119
Ms. Babita	D-121 - III-A Khelri Nagar, Copper Complex Jhunjhunu 333504 Rajasthan	ISG-L-1120
Mr. Ajay Singh	4/29, Saket Nagar Housing Board Beawar 305901 Rajasthan	ISG-L-1121
Mr. Balveer Singh Rathore	Village-Nokha Chandawata, Via - Gotan Nagour Rajasthan	ISG-L-1122
Mr. Richpal Singh	Ajmer 305009 Rajasthan	ISG-L-1123
Ms. Shikha Jhanwar	82, Rastogi House Street No. 2, Nagina Bagh Ajmer 305001 Rajasthan	ISG-L-1124
Mr. Saurabh Sharma	Ayodhya Kunj Colony Saipau Road Dholpur 382001 Rajasthan	ISG-L-1125
Ms. Khushboo Chouhan	H.No. : 969/29, Chouhano Ka Kua Dhola Bhata Ajmer 305001 Rajasthan	ISG-L-1126
Ms. Khushbu Rawat	H. No. : 427, Adarsh Nagar Railway Station Vigyan Nagar, Street No. 5 Ajmer 305006 Rajasthan	ISG-L-1127
Mr. Suresh Chandra	H. No. : 827A/24, Opp. Vaishnav Hostal Subhash Nagar, Khanpura Road Ajmer 305003 Rajasthan	ISG-L-1128
Mr. Shyo Ratan Pareek	V.P.O. Manderpura Teh.-Nohar Hanumangarh 335523 Rajasthan	ISG-L-1129
Mr. Aakash Saini	Opp. Param Hans Aashram Hospital Road Sawai Madhopur 322021 Rajasthan	ISG-L-1130
Mr. Ram Kishor Kumawat	J.P. Builders & Suppl. Bass Ka Teeba, Post-Niwana, Via-Etawa Bhopji, Teh.-Chom Jaipur 303804 Rajasthan	ISG-L-1131
Mr. Amit Yadav	Kaliya Para Bari Dholpur 328021 Rajasthan	ISG-L-1132
Mr. Sunil Hotchandani	Plot No. 576, Haribhau Upadhayay Nagar (Extension) Pushkar Road Ajmer 305004 Rajasthan	ISG-L-1133
Mr. Kripal Singh	Q.No. F-48 - I.D. Khetri Nagar Jhunjhunu 333504 Rajasthan	ISG-L-1134
Mr. Rajesh Kumar Dhinwa	Village - Sautholi (Dhinwa ki Dhani) Post - Titanwer Jhunjhunu 333012 Rajasthan	ISG-L-1135
Ms. Megha Sharma	24, Gyan Vihar B.K. kaul Nagar, Pushkar Road Ajmer 305004 Rajasthan	ISG-L-1136
Mr. Manoj Kumar Pachar	C/o. Hemkirana and General Store Nr. Subalpura Power House, Fathepur Rd. Sikar 332001 Rajasthan	ISG-L-1137
Mr. Dinesh Chand Saini	VIP. Rashidpur (Rawat Mohalla) Teh.-Mahwa Dausa 321613 Rajasthan	ISG-L-1138
Ms. Sulochana Pareek	V.P.O. Hastera, VIA - Govindgarh Teh.-Chomu Jaipur 303712 Rajasthan	ISG-L-1139
Ms. Sunita	D-121-III A, Khetri Copper Complex Khetri Nagar Jhunjhunu 333504 Rajasthan	ISG-L-1140
Ms. Kirti Yadav	H.No. : 221/A, Nr. Raja Koti Gulab Bari Ajmer 305001 Rajasthan	ISG-L-1141
Dr. Varun Joshi	Sikkim Unit P.B. No. 24 Gangtok 737101 Sikkim	ISG-L-1142

Mr. Anand N. Khobragade	66, Empress Mill Qtrs. Bezon Baug Nagpur 440004 Maharashtra	ISG-L-1143
Dr. Markand P. Oza	CMD/AFEG/RESA (Room No. 4331) Ahmedabad 380015 Gujarat	ISG-L-1144
Dr.(Ms.) Abha Chhabra	AMD/AFEG/RESA (Room No. 4007) Ahmedabad 380015 Gujarat	ISG-L-1145
Dr. K. Nageswara Rao	D.No. 4-51-6 Lawsons's Bay Colony Visakhapatnam 530017 Andhra Pradesh	ISG-L-1146
Mr. Vijay Singh	25/1A, Institutional Area D-Block, Pankha Road, Janakpuri New Delhi 110058 Delhi	ISG-L-1147

Chapter’s Activities

Activities of the Kashmir Chapter

The election for the selection Executive Council and other office bearers of the Chapter was held through open vote. Dr. Shakil A Romshoo was elected as the President of the Kashmir Chapter of the ISG.

The Kashmir Chapter of the ISG was formally inaugurated by the Vice-Chancellor of the Kashmir University, Prof. Reyaz Punjabi on 7 May, 2008 at Gandhi Bhavan, University of Kashmir Srinagar. The Registrar of the University of Kashmir, Dr. K. L. N. Sastry, Scientist SAC, ISRO, and Prof. Shakil Ahmad Romshoo, Chairman of the Kashmir Chapter of the Indian Society of Geomatics also addressed the inaugural. On this occasion, one day symposium on the theme “Geoinformatics for Sustainable Development” and a “Geomatics Exhibition” was also held. The inaugural function, Symposium and the Geomatics Exhibition was attended by the around 350 participants from different University Departments, academia, State Government agencies and the print and electronic media.

The Vice-chancellor of the Kashmir University, Prof. Riyaz Punjabi hoped that, with the launching of the Chapter, the research in the field of Geomatics in the state of Jammu and Kashmir shall get further boast in near future. He emphasized the need for translating the benefits of the advancement in the field of Science and Technology for the common man. He suggested organizing more such workshops in the University so that the scientific achievements could be better utilized for the societal benefits. Prof. S. Fayaz, Registrar of the University implored the participants for optimizing the benefit of the advancements in the field of Geomatics for different sectors in the state. Dr. Sastry deliberated on the utility and importance of the Geomatics for environmental and socio-economic development. He also gave a detailed account of the milestones of the Indian Society of Geomatics. Prof. Shakil Ahmad Romshoo, Chairman Kashmir Chapter of the Indian Society of Geomatics talked about the rationale and urgency for starting the Kashmir Chapter of the ISG. He said that the Chapter has enrolled around 40 life members and 30 student members after its launch in January. He said that the launching of the Chapter shall boost the inter- and intra-departmental collaboration in the field of Geomatics research and education in the state.

In the symposium, the experts delivered keynote speeches on the theme “Geoinformatics for Sustainable Development” with special reference to the state of Jammu and Kashmir. The Geomatics Exhibition hosting more than 30 posters, prepared by the members of the Chapter, on a variety of scientific themes related to different aspects of physical, geological and biological sciences was inaugurated by the Vice-Chancellor. The participants had interactive discussions with the authors of these posters and the research findings were appreciated by one and all.

The Newsletter of the Chapter was also released on the same day. Newsletter highlighted the importance and applications of Geomatics for sustainable eco-friendly economic development. 500 copies of the Newsletter have been distributed to various Departments and agencies in the state.

The Chapter plans to hold the next 1-day symposium in the month of July, 2009 and theme shall be “Geomatics for the Earth Resource Management”. Further the Chapter proposes to hold a few functions/lectures in the Schools and Colleges to popularize the understanding of the Geomatics at the school/college level. The Chapter contemplates to launch a special drive to increase the life membership from the Chapter above 50 members.

Activities of Ahmedabad Chapter

GIS - Day Celebrations

GIS day was celebrated at CEPT University on 22 November 2008, with lectures on "Data Products from Indian Moon Mission" by Dr. B Gopala Krishna and "Indigenous GIS" by Dr. S.K. Pathan, followed by screening of a documentary - Indian Moon Mission. Students participated through Quiz Challenge, GPS based Treasure Hunt, and Face Painting.

ISG AC CSI Workshop: Kadi

One Day Workshop on Applications of Geoinformatics was held on Sept 12, 2009 at S V Institute of Computer Studies, Kadi, Mehsana for students of MCA stream of the isntitute.

ISG AC CSI Workshop: Ahmedabad

The Indian Society of Geomatics – Ahmedabad Chapter organsied a two day workshop during October 30-31, 2009 (Friday / Saturday) at Ahmedabad for college students and faculty. The workshop was jointly organized with Ahmedabad Chapter of Computer Society of India (CSI) and Scanpoint Education and Research Institute (SERI), Ahmedabad.

INDIAN SOCIETY OF GEOMATICS (ISG)

(www.isgindia.org)

MEMBERSHIP APPLICATION FORM

To: The Secretary Indian Society of Geomatics

Building No. 40, Room No. 34,

Space Applications Centre (SAC) Campus

Jodhpur Tekra, Ambawadi PO, AHMEDABAD – 380 015

Sir,

I want to become a Life Member/ Sustaining Member/ Patron Member/Annual Member of the Indian Society of Geomatics, Ahmedabad from ------------Month of --------- year.

Membership fee of Rs./US$ _____ /- is being sent to you by Cash/ DD/ Cheque (In case of DD/ Cheque: No.__________, drawn on Bank ________________________________ payable at Ahmedabad. For outstation cheques add clearing charges Rs 65.00/US$ 10.00). I agree to abide by the constitution of the Society.

Date:

Place: *Signature*

1. Name: (Dr / Mr / Mrs/ Ms) ______________________________________
2. Address: ____________________________________

   ____

   ______________________________________ PIN: _______

   Phone: ___________ Fax: ___________ Email: ____________________
3. Date of Birth: __________
4. Sex (Male/Female): ______
5. Qualification: ___________
6. Specialisation: ___________
7. Designation: _____________
8. Membership in other Societies: _________________________________

   ____
9. Mailing Address: ________________________________

   ____

   ________________________________ PIN: _______

Proposed by:

(Member's Name and No) Signature of Proposer

For Office Use

ISG Membership No: ISG- -

Receipt No.: **Date:**

MEMBERSHIP SUBSCRIPTION				
Sr. No.	Membership Category	Admission Fee Rs. (Indian)	Admission Fee US $ (Foreign)	Annual Subscription Rs. (Indian)
1.	Annual Member	10.00		200.00
2.	Life Member Admitted before 45 years of age b) Admitted after 45 years of age	1000.00 750.00	250.00 200.00	
3.	Sustaining Member	---	----	2000.00
4.	Patron Member	15000.00	2500.00	----
5.	Student Member	10.00	---	50.00

MEMBERSHIP GUIDELINES

1. Subscription for Life Membership is also accepted in two equal instalments payable within duration of three months, if so desired by the applicant. In such a case, please specify that payment will be in instalments and also the probable date for the second instalment (within three months of the first instalment).

2. A Member of the Society should countersign application of membership.

3. Subscription in DD or Cheques should be made out in the name of '**INDIAN SOCIETY OF GEOMATICS'** and payable at Ahmedabad.

4. Outstation cheques must include bank-clearing charges of Rs. 65.00/US$ 10.00.

5. For further details, contact Secretary, Indian Society of Geomatics at the address given above.

6. Financil year of the society is from April 1 to March 31.

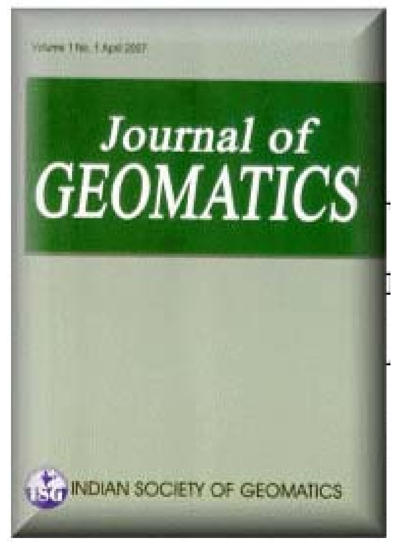
7. ISG has chapters already established at the following places: Ahmedabad, Ajmer, Chennai, Hyderabad, Indore, Mangalore, Mumbai, New Delhi, Pune, Tiruchirappalli and Vadodara. Applicants for membership have the option to contact Secretary/Chairman of the local chapter for enrolment. Details can be found at the website of the society: www.isgindia.org

8. Journal of the society will be sent only to Patron Members, Sustaining Members and Life Members.

“Journal of Geomatics”

Indian Society of Geomatics (ISG), established in 1993, is a premier society of professionals and institutions involved in promoting and popularising Geomatics in India. It has about 1150 life members as on date. ISG regularly brings out a quarterly newsletter (ISSN: 0972-642X) for circulation to its members. We have recently published many special issues on various themes such as Agriculture, Urban Planning, Coastal and Marine Environment, Space-based Cartography, GIS: Education and Training in India, Water Resources, Location-based Services, Geomatics in India: Retrospect and Prospects, Impact of Climate Change etc.

The journal will cover all aspects of Geomatics starting from geodata acquisition, pre-processing, processing, analysis and publishing. It implies inclusion of areas like GIS, GPS, Photogrammetry, Cartography, Remote Sensing, Surveying, Spatial data Infrastructure and Technology including hardware, software, algorithms and modelling. It will endeavour to provide an international forum for rapid publication of developments in the field – both in technology and applications. Each paper will be reviewed by three peers.



The interested scientists are requested to submit their contributed papers on the following email address: ajai@sac.isro.gov.in, ajai_dr@yahoo.com.

Instructions for authors to submit the paper are available on ISG website www.isgindia.org

Reviewers of Journal of Geomatics Volume 3

Editorial Board places on record its sincere gratitude to the following peers for sparing their valuable time to review the papers and provide critical comments for Journal of Geomatics Volume 3.

Dr. Rajkumar
Dr. Ashok Kaushal
Dr. Anirudha Roy
Dr. B. Kartikeyan
Prof. R. Krishnan
Prof. A.K. Singh
Prof. S.K. Katiyar
Prof. P.K. Garg
Prof. K. Nageshwar Rao
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Dr. Rajashree Bothale
Ms. Shweta Sharma

NATIONAL CONFERENCE
on
Climate Change: Coastal Ecosystems
with
A Special Session on Planetary Geomatics
and
Annual Convention of
Indian Society of Geomatics (ISG)

February 04 – 06, 2010
Ahmedabad, India

INDIAN SOCIETY OF GEOMATICS
ISG

Organized by
Indian Society of Geomatics, Ahmedabad

Hosted by
Space Applications Centre (ISRO), Ahmedabad
&
Indian Society of Geomatics-Ahmedabad Chapter

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CEPT UNIVERSITY
ज्ञानं विज्ञानसहितम्

GEOMATICS-2010

Co-hosted by
Centre for Environmental Planning and Technology (CEPT) University, Ahmedabad

Conference Themes:

- *Integrated development for coastal environment*
- *Eco-sensitive marine habitats*
- *Natural resources management*
- *Water resources*
- *Urban and Regional planning*
- *Infrastructure development*
- *Terrain Characteristics & evaluation*
- *Vegetation monitoring*
- *Renewable energy*
- *Technological trends and Geomatics*
- *Planetary Geomatics*
- *Geoinformation for industries and business processes*
- *Archaeology*

Pre-Conference Tutorials (February 02 — 03, 2010)

Following three tutorials are planned :

- *Coastal Ecosystem : Venue - SAC, Ahmedabad*
- *Planetary Geomatics : Venue - SAC, Ahmedabad*
- *Municipal GIS & e-Governance : Venue - CEPT, Ahmedabad*

Participation

Please send us e-mail indicating your interest towards attending the conference and / or pre-conference tutorial. The number of seats are limited for tutorials.

Important Dates

- *Last Date for Submission of Abstracts : November 1, 2009*
- *Intimation of Acceptance of Abstracts : November 30, 2009*
- *Submission of Full papers : December 31, 2009*

E-mail:
geomatics2010@isgindia.org
Web site: www.isgindia.org