GIS & REMOTE SENSING NEWS

FIJI USER GROUP, Number 11 (9502), June 1995

This is the second newsletter for 1995 and apologies are in order for the small number of issues this year. The main excuse is always the lack of contributions and that it is put together in spare time and of course who has spare time! We have a fair cross section of articles this issue touching both GIS and Remote Sensing. MSD has focused on remote sensing for Fiji's forests drawing on more than a years work and MSD also explains data handling which covers geometric correction as well as file format translation. The two user meetings summarised here also addressed this type of data handling and there has been an ongoing discussion image projection and correction. While the MRD articles have also addressed DTM and data translation.

USP has provided an article which covers the human resource development in the GIS sector and while this is the first time we have received reports on this subject it is expected that there will be followup.

There has been a further contribution from Europe which shows first experience with the new MOMS satellite data.

Again we welcome contributions from national, regional and international users. Yes, you can reach us by Internet – see back page for the addresses!

NEWS

There were GIS & Remote Sensing User Meetings in March and April where the March meeting was held at MSD-Forestry in Colo-i-Suva on 7 March 1995 while the April meeting was held at Mineral Resources Department (MRD), 11 April 1995.

During the March meeting:

Osea Tuinivanua (MSD-Forestry) gave a briefing on FAO/RAPA[1] "Expert Consultation on Forest Resources Monitoring Systems" in the Asia/Pacific Regions. The meeting was held on 27/2/1995 - 3/3/1995, in Bangkok, Thailand. The group of experts came from China, India, Bangladesh, Burma, Nepal, Bhutan, Philippines, Malaysia, Laos, Cambodia, Sri Lanka, Thailand, Vietnam and Fiji. It was part of the continuous global effort of FAO/Forestry Sector to standardise the forest type classification, improve accessibility and reliability of information, increase the period of forest resources assessment and enhance country capacity for planners and decision makers in forestry and related development sectors, which includes scientific community, Global Change community of Universities, national as well as international research teams and public at large.

Unlike FAO´s two global developing countries of tropical forest (Africa and Latin America), the Asia/Pacific Region has the least tropical forest cover areas. Fiji forest resources inventory has improved remarkably in recent years using satellite images and adopting some recent technologies to enhance its monitoring capacity. Fiji (PICs[2]) commented the variability of standards used for forest classification and proposed a mobile receiving station for regular satellite data receipt in the Pacific.

The consultation endorsed: the national level classification to be maintained, non-forest land forest products to be monitored, sub-regional and regional levels of classification of forest types to consider the ecofloristic zones, regional scale maps to be standardised at scale 1:250 000, standard terminology and methodology to be adopted, exchange of expertise to be promoted, national planning and funding to be supported, and FAO to promote national biodiversity inventory and monitoring.

Don Forbes (SOPAC) explained the features of GRASS (Geographic Resource Analysis Support System) which is a public domain GIS and image analysis package produced and available from the US Army. It is a UNIX-based commandprocessor that includes capabilities for digital rectification (rubber sheeting or full ortho-rectification) of raster images, extraction and overlay of vector and point data, surface generation and shaded relief visualisation, among others. Applications of GRASS at the Geological Survey of Canada have included analysis of historical shoreline changes from digitised, rectified and geographically referenced aerial photographs and shaded relief seafloor images from swath and sweep bathymetric surveys. GRASS has been installed at SOPAC, where it will be used for coastal process studies, with possible future application to SOPACMAPS and other swath bathymetry in the South Pacific.

Robert Smith (SOPAC) illustrated the advantages of gridding and contouring using QuickSurf under AutoCAD. This software was compared to Surfer for Windows which was demonstrated at a GIS & RS meeting last year. QuickSurf, which is a LISP routine and runs inside both AutoCAD for DOS and Windows, allows the user to contour ASCII data sets right inside working base maps, readily define boundaries, interpolate in areas between surveys and develop digital terrain models of delineated aggregate resource areas in the marine environment. At the same time, the user has the use of AutoCAD's editing and drawing capabilities at his disposal. Cut and fill volumes, beach modelling for accretion or erosion are easily integrated into base maps and can be clearly illustrated and easily interpreted in a pictorial sense yet still retain a true to scale orthogonal mapping projection (eg UTM) which would be lost if imported into a presentation program such as CorelDRAW.

Wolf Forstreuter and **Samuela Uluikadavu (MSD-Forestry)** presented the Forestry Economic Data Base. The results have already been described in an article by Osea Tuinivanua in the last GIS & RS Newsletter. Each village closest to a the current permanent forest sample plots was asked questions about forest usage. In Fiji, the natural forest still plays an important role for food and medicine supply. In addition, forest is used extensively as grazing ground for cattle. Quantitative data is necessary to monitor such types of forest use. A discussion in the GIS & RS User Group started about the need of

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[1] FAO = **F**ood and **A**griculture **O**rganisation of United Nations
RAPA = **R**egional office for **A**sia and **Pa**cific

[2] PICs = **P**acific **I**sland **C**ountries

further data and additional investigations of the interaction between villages and forests. The survey also noted a change in water quality which is related to the amount of forest cover and to the forest density and forest type within a water catchment. There were indications that the quality of water is also influenced by tree species. Suggestions were made by the GIS & RS User Group to link the data base to other department such as PWD or USP which have ongoing investigations in this field.

Discussion

ESCAP Workshop on GIS/Remote Sensing. 13-17 February, 1995, Tradewinds Hotel, Suva

FLIS advised that the final record of proceedings and recommendations from this workshop would be received shortly. Questions were raised as to the value of this workshop and it was concluded that the two reasons for it being held were raising levels of awareness and identification of needs and creation of a "shopping list". This "list" is comprised of possible projects for submission to potential donors. There did not appear to be any avenues for ESCAP themselves to satisfy the beneficiaries by funding such "shopping lists" and the question was raised of the likelihood of donors supporting any such projects as ESCAP may expect to beacting as project managers for which they would need a portion of these funds.

Updates

NLTB announced that the first maps have been produced showing the mataqali boundaries at 1:25 000 scale on FMG (WGS 72) spheroid. This information will now be translated to DXF[3] file format and delivered to FLIS. The data conversion is done by a software called "shift translator". FLIS checked already the first maps. NLTB is buying InfoCAT software which imports information stored in internal Synercom format (NLTB GIS). NLTB has plans to scan photographs taken in the field which is also possible with InfoCAT. This photo documentation of development will be stored in a data base and can be included digitally into reports.

FLIS reported from the last FLIC Meeting that FLIC had requested a written report of the GIS & RS User Meeting. This is because FLIC members are very interested in the development and discussions at the technical level. FLIS will revise its charging policy, there will be an article in the next GIS & RS Newsletter. The stereo plotters at Lands Department have been upgraded and are now able to provide digital data sets. Robin Pickering a short term consultant from New Zealand visited all important institutions related to Remote Sensing and GIS in order to investigate the needs and the format of the digital topographic data base. As mentioned by NLTB, the first maps showing mataqali boundaries are translated to DXF file format and will now be checked by FLIS. As a result of an investigation of and modification to the wide area network, the response time for data access has improved to an acceptable level.

At the **Department of Environment** installation of ARC-INFO (PC) has started. The hardware consists of two PCs, an A0 size plotter and a digitising table of same dimensions. The department bought a portable Pinnacle Micro 3.5" optical drive to be able to store information safely and to import data from MSD-Forestry in a fast and simple way. In-house training will be provided by a consultant from UNEP for two weeks.

MRD provided information on the following projects:

Namosi DEM (Digital Elevation Model)

A DEM concerning the Namosi copper mine prospect area was produced using raw data (profile with elevation with a spacing of approximately 20 m between each profile) provided by Placer and using GDM (Geological Data Management) software at MRD. The DEM is available as a grid (20 x 20 m) and also as a vector file (contours) which has been incorporated into MRD GIS Mapgrafix.

Vanua Levu Geological Map

This project is aimed at producing an up-to-date 1:250 000 digital geological map for the assessment and promotion of mineral resources exploration. This map will be based on a compilation of existing 1:50 000 geological map and others relevant available information including open-file reports, geological notes, unpublished work. 8 out of 14 maps have been digitised so far. Information digitised are the geological units and boundaries, faults, fossils locations, rock samples. The major part of this project is performed by a consultant.

Mines Tenements Database

The development of the database application for the management of mines tenements has progressed. A first version should be available by end of April.

MSD-Forestry has digitised the water catchments from the old LRD[4] forest type maps at 1:50,000 scale. Water catchments (western part of Viti Levu) not covered by LRD maps were digitised from topographical maps from PWD. MSD started to correct Landsat TM and SPOT data geometrically referenced to the new Lands Department map series 1:50 000. Two new hand held GPS instruments arrived for documentation

[3] DXF = **D**ata E**x**change **F**ormat is the file structure of AutoCAD software. It is a very common format which was agreed as standard for exchange of spatial data in Fiji. It is different from **SIF** which is the **S**ystem **I**nterchange **F**ormat.

[4] LRD = **L**and **R**esource **D**ivision

■ *by Dr Bruce Davis, Director, USP GIS Unit, University of the South Pacific*

GIS/RS Human Resource Development in the South Pacific

The topic of Human Resource Development (HRD) was given emphasis at the February ESCAP GIS/RS workshop because it appears to be one of the major elements that is too often overlooked when considering the technology. Several speakers underscored the necessity of viewing the "people" part as a paramount concern in starting and maintaining GIS/RS in the region (herein just GIS for convenience). Understandably, new users are awed by the flash and wonder of hardware and software, and in fact it may be these attributes that provide initial sparks in adopting the technology (actually GIS is considered a technology and a methodology). Sadly, however, the human part of a GIS infrastructure typically is given the weakest attention, before and even after establishment. We hope to avoid this syndrome in the Pacific.

This brief report summarizes a few major points made at the workshop in terms of:

- GIS Human Resource Development
- Needs of the region
- Special considerations
- Current situation
- Development and strategies

GIS Human Resource Development

i) GIS without people has no value; GIS exists for people, not people for GIS: GIS is a tool used for a wide variety of purposes, but it is only a tool and not a solution (despite the hyperbolic terminology of computer vendors). Humans are not only part of the equation of use, they are the core, the central intent. GIS will not operate in any sense of the word without humans and certainly will have no purpose without them. Therefore, it stands to reason that the "people" component should receive primary consideration.

ii) GIS is an enabling technology: The major function of GIS is to "enable" humans to achieve goals that incorporate spatial and associated non-spatial data. It is a technology that helps us to gather and manage data, to analyse and model, and to present information.

iii) Why is HRD typically last, or even absent, in the chain of planning and considerations when beginning or maintaining GIS? This has no convincing answer, but one premise has been that people are taken for granted and can be counted on to achieve whatever is necessary. There are too many contradictions for acceptance of such thinking, however, e.g., certain qualifications are needed for every profession and people are not expected to arrive unprepared; also, continuing training and education are universally appreciated. Obviously, a major message is that indeed, GIS HRD should be *first*, not last.

Regional Needs

In brief, the major needs of the region for HRD are:

i) Dedicated programme: without a designed strategy, specialty training and education become ad-hoc and a disservice. There must be recognition that the GIS user community has grown and evolved out of the initial exploration stage and is in need of structured advancement.

ii) Properly trained professionals should not depend upon the first generation of GIS users. A recent survey mentioned in the March GIS World notes that more than two-thirds of GIS users in natural resources and environmental industries are self-taught (with over half receiving GIS training from short courses and 44.3% from vendor training; only 25% have graduate degrees in GIS). These users deserve accolades and may be idea "mentors" in specific applications, but they are not necessarily the best ones to teach the next generation. In the Pacific, we are still relying upon that first generation, "recycled" professional group to keep GIS moving, but the second generation should have more substantial formal training. The evolution-

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of logged over areas. The logging planning continues and the GPS base station is working without problems. A new EU funded project started to map hardwood plantations using GPS and GIS technique as well as remote sensing data. Wolf Forstreuter will work under this project and will stay in Fiji for another 13 months.

SOPAC announced that: The CD writer or CD recorder (CDR) is now fully utilised creating offshore bathymetry data in MapInfo format from European funded surveys in the region and the recent acquisition of an A3 scanner will enable the collection of aerial photos to be archived and accessible in a digital library.

Bathymetry maps for the region were being produced using Gebco Digital Atlas 5th edition, DMA World Vector Shoreline and official EEZ boundaries provided by Forum Fisheries Agency. The maps will be produced in various sheet sizes using MapInfo for Cook Islands, Federated States of Micronesia, Fiji, Marshall Islands, Niue, Tokelau, Tonga and Solomon Islands at scales ranging from 1:2 000 000 to 1:4 000 000. The maps will be provided in MapInfo data format where requested.

Resource maps of lagoonal aggregate in a digital format have been prepared from recent survey data in Kiribati. This data set can be incorporated into MapInfo and used for coastal management needs. In Fiji nine CTD (Current Temperature and Depth) casts measuring water quality conditions to a depth of 225 metres were obtained offshore Navua using SOPAC's "Seabird CTD". Location of casts was with GPS. Recent hardware and software upgrades have given us depth capabilities to 1.2 kilometres. With the new processing software this data can now be stored in a database in an ASCII format with the data converted to engineering units. This means that from a GIS point of view this data can be retrieved and used for modelling purposes with software other than that provided by the instrument manufacturer. In the earlier version of the seabird software a third party user interested in modelling such data required access to this software.

The Japanese Government sent a mission to the SOPAC Secretariat in Suva, early March to finalise and launch Phase III of the Japan/SOPAC Deepsea Mineral Resources Survey Program. Phases I and II of the program which spanned ten years from 1985 to early 1995, had the Metal Mining Agency of Japan's research vessel Hakurei Maru No. 2 carrying out deepsea surveys in the exclusive economic zones of Cook Islands, Kiribati, Papua New Guinea, Solomon Islands, Tuvalu, Vanuatu and Western Samoa. With strong petitions by the governments of Fiji, Marshall Islands, Federated States of Micronesia and Tonga who want similar work done in their exclusive economic zones and praise from the affected countries on the excellent results of the first two phases of the Program, the Japanese Government agreed to entering a third five-year phase to begin in 1995 and go on until 1999.

During the April GIS And Remote Sensing User Meeting:

Presentations

Hervé Dropsy and **Andre Vial, MRD** gave a briefing on the Namosi DEM (Digital Elevation Model). A DEM (Vector and Raster form) concerning the Namosi copper mine prospect area and associated geographical information were integrated into a single GIS map.

Hervé Dropsy, MRD presented the Vanua Levu Digital Geological Map 1:50 000. These have been scanned and digitised on the monitor screen. The end product will be a 1:250 000 map showing the *geological features* in addition to the existing *soil* 1:127,000 map.

Michel Larue, SOPAC presented some of the new geographical tools of MapInfo 3.0. In particular the capacity to use "cookie cutting of a polygon". This allowed users to split the objects of the Digital Chart of the World and later, with the help of a small MapBasic utility, to realign all the layers of this product between 0 and 360 degrees. Now Fiji is no longer split in two parts and unity prevails!

Michel Larue, SOPAC explained the capabilities of the recently purchased flatbed A3 colour scanner where the resolution can be up to 1200 DPI[5]. When set to the highest resolution, it would generate files as big as 800 MB. A first evaluation its capacities was presented together with its anticipated use, which included making mosaics of aerial photograph as well as digitising maps on the screen. The latter is of particular interest for the Pacific Island Countries which do not presently have any digitising table.

Wolf Forstreuter, MSD-Forestry, explained the activity of geometric correction of satellite data at this division. Satellite images, unlike aerial photographs, have a nearly orthogonal projection. However, they cannot fit onto the FMG orientated maps of the new Lands Department series and therefore a geometric correction is necessary to rubber sheet these images to this map projection. The necessary GCPs[6] are stored in a dBASE file, from which a special program selects the relevant points for the corresponding map sheet. The geometric

...wrapped up on page 6

[5] DPI = Dot Per Inch

[6] GCP = Ground Control Points

ary states of the technology and applications demand it.

iii) Continuing training, education, and support: HRD is both a maintenance and an evolutionary paradigm. Training (specific hardware, software, or applications) and education (broader concepts, integrated coursework) are not one-off processes; each is an on-going strategy that ensures the latest techniques and methodologies, particularly for neophytes. Further, current users need to keep up with advances, learn new "tricks," update software and hardware capabilities, enhance current and new applications, and refresh concepts and operations. Today's GIS specialist has one food in the applications, one in computer science, and one in spatial methods—a three-legged dance is required for proper operations. HRD support is necessary.

iv) Distance learning: The region is composed of 15-20% of the Earth's surface, a small amount of highly fragmented land, low and dispersed populations, usually a primate city, limited technologic resources, and basically it is out of the world informational mainstream. A centralised site such as Suva cannot provide adequate regional service. A system of outreach HRD is essential. Fortunately, there is some infrastructure from which to build a distance learning structure, e.g., USP's Extension Centre services, developments in the USP GIS Unit, and the establishment of the global Internet. There is increasing demand in many Pacific nations for GIS education and only a substantial outreach programme can answer the call.

Special Considerations

Establishment of a GIS HRD programme in the Pacific requires additional considerations from the traditional paradigms of the western world. Lack of space prevents adequate discussion of the more important, but some should be isted. Each is very important and must be considered in a olistic approach to implementing GIS in the region:

- Multiple cultures and various "world perceptions."
- Multiple languages. English as a second language (ESL).
- Diverse educational approaches; combinations of local and etropolitan systems.
- Diverse man-land relationships; different land tenure ystems; variety of cultural landscapes.
- Diverse technology traditions; low computer experience; out of the world technology and informational mainstream (requires extra effort and expense to participate); low technology resource base.
- Low available economic resources; external support required for high-tech programmes.
- Desire for less dependence on outside expertise; pride and capabilities to achieve self-support and regionally appropriate expertise.

> GIS is a growing and very dynamic profession globally as well as in the Pacific. The first generation of self-starters will be unable to sustain the demands; there should be continuous production of "new blood" in the profession!

Current Situation

While the current situation is excellent for some parts of GIS technology, there are concerns for others.

i) There is no regional training strategy at present. SOPAC has a small programme to bring a several regionals for an extended time and USP has significant plans, resources pending. The university now offers an introductory GIS course and a few support activities are under development.

ii) Training is ad-hoc, depending on various one-off programmes. It is almost always externally aided, usually with donor resources. Trainers are visitors, who despite their expertise and altruism, are unavailable for follow-up support. Workshops are closed, limited to aid recipients, and normally not part of a regional scheme for GIS HRD.

iii) The Pacific is maturing rapidly, however, and there are increasing demands for HRD that is more substantial and more regionally appropriate.

Development Strategies

Again, with limited space discussion is restricted to listing items, but it is important to note that various ideas have been discussed, some plans are active and others await developments. At the risk of repetition to some of the above:

i) A dedicated GIS HRD programme has been substantiated by regional users and MUST be instituted in the very near future. Dedicated means that such an approach cannot be a by-product of some other activity nor can it be a substandard part of some other programme, lest it become subservient to other needs. The region cannot afford this type of subordinate development.

ii) It must be a sustained programme to provide specialised and general professional development and education; it must be continuous, work at both low and high GIS technical levels, and should include OJT (On-the-Job training).

iii) There should be specialised training workshops, dealing in such matters as software, introduction to GIS for administrators and managers as well as the technical operators, and professional support of various applications.

iv) A professional certification programme is desired, offering specialised certificates for selected courses and a diploma for a substantial programme. This is under development at USP and awaits human resource enhancement, e.g. an additional GIS faculty person.

v) In the future, there should be dedicated educational courses, such as a full array of GIS technology support classes (remote sensing, applications, programming, etc.), perhaps leading to a specialised bachelor degree and post-graduate specialties.

vi) Substantial distance training and education are required. As has been discussed, there is much to do in this topic, but there is a good infrastructure in place at USP to begin the process.

The last points to be made are summary, but essential:

- GIS HRD has to be accessible by the entire GIS/RS user community, not just the lucky few in Suva.
- HRD should be a continuous process, including periodic enhancement of capabilities; an ad-hoc unsystematic approach is unsatisfactory.
- GIS is a growing and very dynamic profession globally as well as in the Pacific. The first generation of self-starters will be unable to sustain the demands; there should be continuous production of "new blood" in the profession.
- There are various levels of HRD needed: technician, manager, administrator, and users for the many and diverse applications. Each has specific needs and limitations; each should be perceived as an integral part of HRD development.
- An HRD programme must be local, national, and regional; various components have specific demands. A distant learning component is critical.
- GIS is establishing a new profession and a new set of paradigms. It is not merely a computer and special software to make maps, but should be thought as a very flexible and powerful systems, a methodology (an approach, a set of procedures and techniques), and an efficient way to achieve old and new goals. We MUST support it or the loss is ours.

Only the fundamentals of GIS HRD are outlined above and many aspects have not been discussed, yet there is much more to consider and much to accomplish. Success will take a long time, will be dynamic and evolutionary, will often encounter steps back as well as forward, but ultimately it will provide the region with appropriate developments that are needed to achieve its goals. GIS is only a tool, but a very important one that can help to achieve and sustain regional integrity and self-reliance. For that we must dedicate our efforts.

SATELLITE NEWS

SPOT is still working well. MSD-Forestry bought a new scene (436-383) from western part of Vanua Levu recorded at 24 January 1995. The scene is stored on CD-ROM like the other scenes available at MSD.

MOMS-02 is a push broom scanner which will be placed in the Russian space station MIR. The sensor provides panchromatic data with 4.5m spatial resolution (details see article by Dr Barbara Koch in Newsletter 9407 and article in this newsletter). Dr Wolfgang Steinborn from DARA, the German Space Agency which will do the marketing for MOMS data, visited MSD-Forestry. He confirmed that data from Fiji will be recorded after installation of the sensor in the space platform. He will keep close contact with Osea Tuinivanua during his study in Germany.

KVR-1000 and **TK-350** images can be purchased through EOSAT. EOSAT, PADCO an international consulting company from USA and Kiberso a Russian geographic information system company signed an agreement to process and distribute Russian space borne photography world wide. Kiberso situated in Moscow has access to archives of the Russian Military Cartographic Department, where KVR-1000 images (2m resolution) and TK-350 images (5 - 10m resolution) are stored. This photographic products will be scanned and radiometrically and geometrically corrected. Both cameras were based on the Komos satellites. KVR-1000 images cover 34 x 57 km on the ground and TK-350 approximately 175 x 257 km. Radiometrically corrected digital data will cost $US 3,500 if the data is also geometrically corrected $US 4,000 per scene. (EOSAT Notes 4/1994)

RADARSAT, the Canadian satellite, will be launched end of this year. As described in Newsletter 9407 the satellite will carry a Synthetic Aperture Radar (SAR). It will produce images with up to 10m resolution. The frequency/wavelength used by the active sensor will be 5.3 GHz/C-band 5.6 cm. The polarisation will be HH. (for explanation of these terms see article by Thomas Kremmers, Newsletter 9407) In February, Shawn Burns the Canadian sales representative for the South Pacific and Asia was on a promotion tour in Fiji and visited MSD-Forestry and SOPAC. MSD asked for data to investigate the potential of this remote sensing information for mangrove mapping and forest type stratification. Radar data is weather independent because the waves penetrate clouds. It records the plant water content and the canopy structure. It could have potential in forest application.

EOSAT is marketing Russian space photography and data from the Japanese satellite. The American satellite Landsat 5 is still working without any problems, but the data purchase is restricted to ground antennas. The new satellite Landsat 7 (Landsat 6 was launched but did not reach its orbit) will probably be launched next year. There is no further news to date. Further, EOSAT signed an agreement that makes the company the exclusive distributor of data generated during the next 10 years by a planned 10-satellite constallation of Indian Remote Sensing (IRS) satellites (GIS World April 1995).

EOSAT captured data from **IRS-1B** since June 1994. This satellite has two on board sensors named LISS-I and LISS-II. LISS stands for Linear Self-scanning System. LISS-I has a spatial resolution of 73 m while that of LISS-II is 36.5 m. The spectral bands covered are blue, green, red and near infrared (further information see Newsletter 3 from January 1994).

IRS-P2 was launched in India 16 October 1994. The satellite can download data in Hyderabad and in Norma, USA. The satellite is equipped with a LISS-II (Linear Self Scanning Sensor) which has a spatial resolution of 32 x 36 m. The spectral bands covered are blue, green, orange red and near infrared. Every 24 days the satellite can take an image from the same area.

IRS-1C will be launched in mid 1995. The satellite carries three sensors: LISS-III, with 20m resolution, a panchromatic camera with a sub 10m resolution (GIS User April 1995) and a Wide Field

Sensor (WiFS), with approximately 188 m resolution (EOSAT Notes 4/1994). This satellite will have a on boad data recording facility (GIS World, April 1995). This will allow to order data from Fiji!

JERS-1 was launched on 11 February 1992 in Japan for designed life of two years (see Newsletter 9407). This satellite has an optical sensor on board and a Synthetic Aperture Radar (SAR) with a 75 km swath width, a resolution of 18 x 18 m. The Remote Sensing Technology Center of Japan (RESTEC) announced that there are space borne radar data available XXXX which has been stored on the onboard tapes. It can be purchased from RESTEC or EOSAT as a sales representative of RESTEC. In addition, RESTEC advised of the following correction of the JERS-1 description in Newsletter 9407: the SAR has a frequency of 1275 MHz not GHz!

correction uses these points and corrects a sub-image of the satellite scene covering the area of this map. The map-image N26 (Rakiraki) was displayed as a TIFF file on the monitor in MRD´s conference room.

Discussion
The discussion focused on the limitations in the use of scanned aerial photographs in a similar manner to digital satellite images and the following constraints were identified:

For a geometric correction a three dimensional model must be created to convert the central projection of an aerial photograph into a orthogonal projection. Otherwise areas on high elevation are larger than the same area in the valleys.

Scanned aerial photographs have large file sizes. Geometric correction which may be suitable for flat terrain (coastal areas) would need very large disk space and excessive processing time.

The illumination within an aerial photograph is not uniform as it decreases from the centre to the edges and in addition there is a bright area (hot spot) where the sun rays have the same angle from the sun to the surface and from there to the camera.

To accomplish the above, special scanners and software are required which are currently not available in Fiji.

Updates
At **MRD,** a GIS awareness week was organised 10-13 April. This function was available to all MRD staff and consisted of a series of videos on GIS and Remote Sensing (Videos from Bruce Davis and also some taken during the February ESCAP regional GIS/RS workshop).

The database application (first version) MINTENET for the management of mine tenements has been completed.

FLIS is currently initiating moves to have at least one candidate from each FLIS agency, to undergo a introductory paper on computing and information technology, in recognition of the need for computing expertise in existing FLIS agencies.

FLIS announced that the final report on the February 1995 ESCAP workshop has still not been received.

FLIS is currently working on a charging structure for all FLIS data, and will be conducting a survey of all existing GIS/IS agencies that are providing GIS data to the public. The purpose of the survey is to ascertain the charges that are being made in each department, and obtain their responses to the proposed charging structure.

MSD-Forestry checked some plantation areas with GPS and estimated the inaccuracy of areas shown with the earlier sketch maps. A new survey of plantations will start soon.

Satellite data was corrected to the new topographic maps series of the Lands Department. For six sheets map corrected images are available.

The file transformation from NLTB via FLIS to MSD does not work yet. Further investigation is necessary.

SOPAC provided ongoing MapInfo training for the South Pacific Island Country Nationals. As a part of the Earth Science certificate, a two days training course has been carried out on beach profiling.

SOPAC also developed new utilities under MapBasic.⊕

GEOMETRIC CORRECTION

OF SATELLITE DATA FOR THE FIJI MAP GRID

Introduction
Digital satellite images are recorded relative to the direction of flight of the satellite and due to the track inclination of satellites with sun synchronous orbits every scan line is shifted progressively to the right (see Figure 1). In addition, the sensor records every line in nadir direction which results in the image having near orthogonal projection. However, the image is not fully orientated to north and does not fit on the local map projection.

It was impossible to get the satellite data geometrically corrected from Germany where the satellite data analysis was carried out. The image data is available mostly in original form (some are geometrically corrected to UTM which is not applicable in Fiji). The image data has to be geometrically corrected to:

- visualise forest change by overlaying SPOT data recorded 1994 and 1995 with Landsat data recorded 1991 and 1992;
- overlay image data over plantation areas which are in FMG maps in order to analyse the status of areas planted with introduced species, areas covered with natural forest and areas without tree cover.

Normally, the geometric correction for satellite data is done for a complete scene. Image analysis software contains common projections such as UTM, Transverse Mercator along with common spheroids. Fiji Map Grid, which is only used in Fiji, is not included in most software and MSD decided to do the geometric correction for each map sheet separately. This reduces the error to an insignificant scale.

The Ground Control Point Data Base
At MSD, Landsat TM data from 1991 and 1992 is stored as well as SPOT data

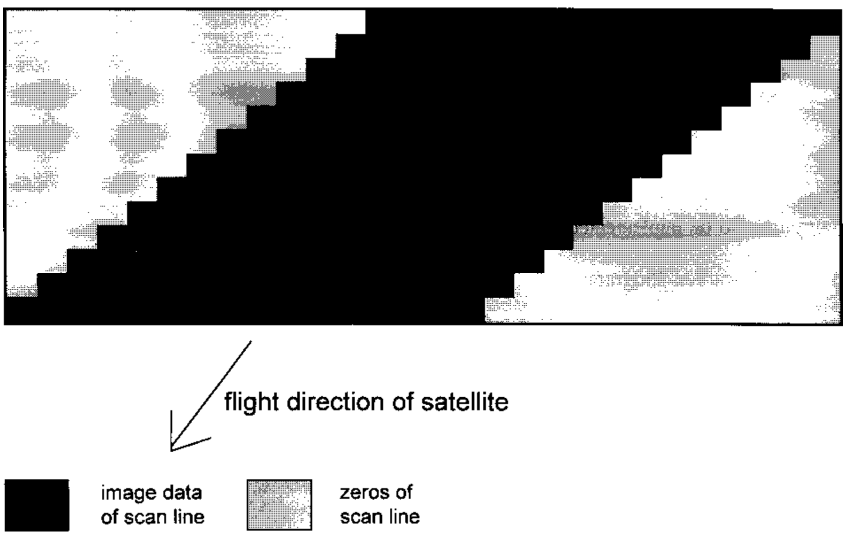


Figure 1. Geometry of a Landsat or SPOT image.

from 1994 and 1995 covering the same area and additional TM data will arrive. See Figure 2. The geometric correction has to be done for every image separately even if it covers the area only recorded at a different day. In order to use the same Ground Control Points (GCP) these are stored in a dBASE data base which contains the GCP name, a short description, the FMG X and Y value and the file positions (line and column numbers within the different image files) as shown in Table 1.

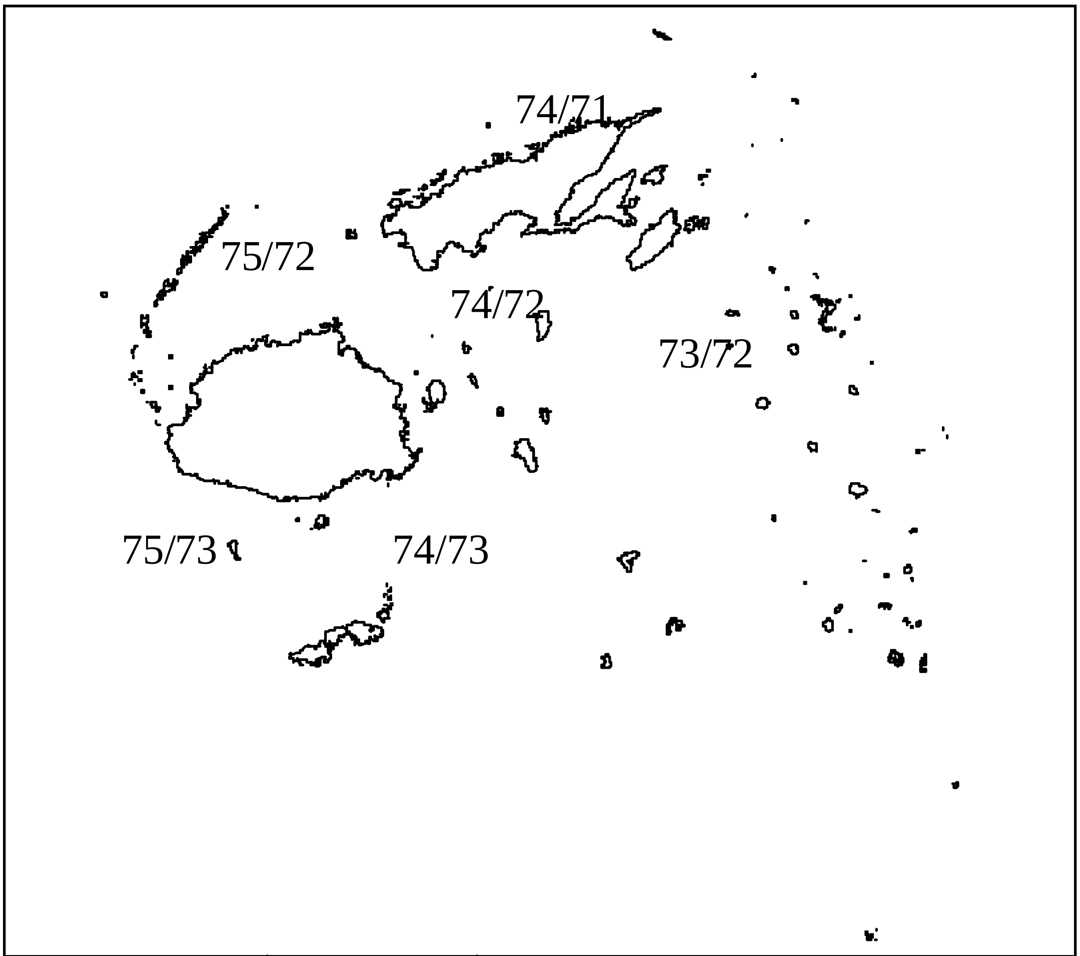
The establishment of a GCP data base allows this data to used for geometric correction of different satellite images. The data base can be updated directly from the ERDAS menu by calling a MS-DOS batch file which starts dBASE and an associated program which opens the GCP data bank base in and browse mode. The operator can include additional GCPs or correct FMG values or image file positions.

Creating a Transformation Matrix

A transformation matrix is necessary for the geometrical correction of digital images. Transformation matrices can be used to calculate the position for every pixel in a new raster file which will contain the rectified or corrected image. The transformation matrix consists of coefficients which are used in polynomial equation to convert the co-ordinates and are calculated from the GCP image file positions and FMG co-ordinates. The coefficients are stored in a separate file with the CFN extension.

Table 1. Ground Control Point data bank. The field "MAP" contains the map sheet identification and the number of the GCP within this map sheet. The description makes the identification of the GCP easier. The FMG co-ordinates are very precise because they are digitised from the corresponding map sheet. The fields "T03_X, T03_Y, T04_X etc. indicate the line and column number of the pixel within the satellite image file (image file position).

MAP	DESCRIPTION	FMG_X	FMG_Y	T03_X	T03_Y	T04_X	T04_Y
N26-07	Penany Junction	1935009	3960311	1143	3424	0	0
N26-08	Mabua Island	1945776	3963351	1501	3261	0	0
N29-04	Wainiburu creek M	1954547	3875178	0	0	1956	1488
N29-05	Nanuku Island	1937623	3851573	0	0	2416	580



world reference system (path/row)	date of acquisition	coverage	MSD internal scene ID
075/072	25/12/91	full scene 175x180 km	T01
075/072	15/05/91	full scene 175x180 km	T02
074/072	27/07/91	full scene 175x180 km	T03
074/073	06/03/92	quarter 1 90 x 90 km	T04
073/072	06/12/92	quarter 1 90 x 90 km	T05
074/071	16/04/92	full scene 175x180 km	T06

Figure 2. Landsat TM scene coverage. A similar coverage is available with SPOT scenes.

To establish the transformation matrix all GCPs of a subarea covering one map sheet have to be selected from the GCP data bank and stored in a Ground Control Point file. This can be done semi automatically at MSD. The user starts a MS-DOS batch file from the ERDAS menu which calls a dBASE program. This program asks the user for the map identification and the MSD internal satellite image identification (see Figure 2). Using this information the program selects all GCPs from the data base which have the selected map identification and image file positions. The program then converts the GCP information into an ERDAS GCP file.

The transformation matrix in then calculated by a the COORDN program which also calculates the error of the transformation in the X and Y direction. Using the inverse of the transformation, it is possible to recalculate the GCP coordinates in the original image file. The distance (in pixels) between the original location and the retransformed location is called the RMS error. The program also shows a list of error contribution by GCP. This indicates which GCP position has to be checked. The user can correct detected errors quickly in the way explained above.

This interactive process continues until the RMS error is minimised to an acceptable level (for map sheets covering landmass it should be smaller than one). Then, the operator starts the transformation process for the subset of the original data file. To use only a subset is appropriate because a geometric correction of image files is a time consuming process. The operator cuts a part out of the satellite image (subset) which covers a frame of approximately 10 km to each side of one map sheet.

This subset then is geometrically corrected by applying the transformation matrix (see Figure 3).

Creating Map Sheet Image Files

Because of the overlap, the corrected image subset is larger than the corresponding map sheet. The user has to identify the part covering exactly the map sheet. Therefore the user has to locate the pixel indicating the upper left map corner. All pixels (one pixel covers 25 x 25 m on the ground) of the corrected image have a FMG value indicating their centre. The user has to identify the pixel which FMG co-ordinate is most closed to the upper left map co-ordinate plus 12.5 m in X and minus 12.5 m in Y-direction[1]. Knowing the file co-ordinate of this pixel he is able to identify the pixel indicating the lower right map co-ordinate by adding 1600 columns and 1200 lines. With the information of the upper left and lower right pixel position the operator cuts out the part which covers exactly the corresponding map sheet.

A geometric correction of satellite data (30 m spatial resolution) at 1:50 000 scale cannot have the precision of a topographic map. However, for further GIS analysis it is necessary to have the exact reference. This can be done by readjustment of the FMG grid. A ERDAS program (FIXHED) corrects the FMG position connected to the pixels. The operator tells the program that the upper left pixel has the FMG coordinate it would have in the corresponding map. The other pixels are corrected correspondingly[2].

This shift is always less than 12.5 m. After this process all pixels fit exactly to the corresponding position on the 1:50 000 topographic map.

Results and Recommendations

Corrected image data is available for 16 map sheets of Viti Levu. Further data will be corrected in the same way. For every file the file name indicates the map identification, the satellite image identification, the spectral band(s) used and the type of rectification. The corresponding GCP and CFN files are always stored on the same optical disk. In addition information about the RMS error, the shift and other parameter is written in an ASCII file with the extension TXT.

The image data is stored in a defined way which allows other users to work with it. In an island country like Fiji this data should be used for other purposes and satellite data should be shared to for cost reduction. Other users who are starting to rectify satellite image data should follow the procedure as described.

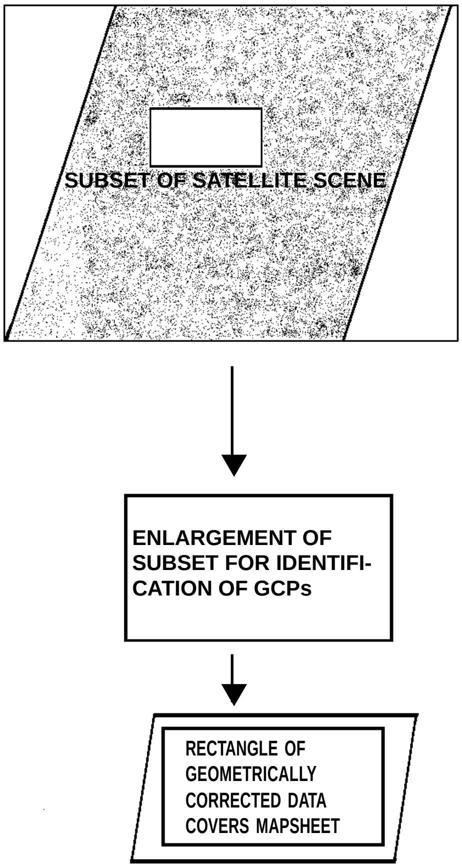


Figure 3. Steps of geometric correction.

[1] The operator has to add 12.5 in X-direction and subtract 12.5 m in Y-direction because the FMG value indicates the centre of the 25 x 25 m pixel and not the upper left corner.

[2] In reality the FMG co-ordinates are only stored in the header of a ERDAS raster file, the pixels only contain 8 bit for every spectral band

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■ *by Asesela Wata, Management Services Division, Forestry Department*

LAND SUITABILITY ANALYSIS FOR POTENTIAL HARDWOOD PLANTATIONS

Abstract

"Eighty percent of all decision requires some use of land related data. They are tools which help people to answer locational problem. For example, where to site a new school, where to release building land, how to manage natural resources, whether or not to close down a bus service and how to plan for the impact of an industrial accident." *Professor Kent Lyons, University of Queensland*

Land Suitability Analysis

Determining suitable land for forest establishment has been an on going process for forest development for the past years. The lack of an information base and also the lack of equipment/technique to derive and formulate scientific and meaningful plans has been resolved.

The build up of GIS within the Management Services Division has improved the capability of the information system and helps to decide ome of future plans on land to be acquired for forest establishment, that in the end will support a sustainable timber production within the forest sector.

Mahogany species is currently the dominant tree species planted to date. Based on past assessment, it grows extremely well on soil type Humic Latosols and Latosolic soils.

Slope ranged from 0^{0}-32^{0} are regarded ideal for reafforestation and above 32^{0} are avoided due to steepness. The logged out information which is yet to be updated were digitised from 1:50 000 Lands Department Base Map transferred from the 1:50 000 DOS map. Together with the existing forest cover (derived from satellite image) we are in a position to calculate the estimated forest area removed up to 1986. It is hope that with the Introduction of GPS (Global Position System); all logged out data will be captured and updated so that land suitability study can continue. ☛

LAND SUITABILITY FLOW CHART

STEP I — SOIL TYPE | SLOPE | FOREST COVER | LOG OUT AREAS

SOIL TYPE: RECODE — SLOPE: RECODE — FOREST COVER / LOG OUT AREAS: IMPORT — GISMO Retain Plantation area

STEP II — REC SOIL TYPE | REC SLOPE | FOREST SUITABLE (With loggout)

Values	Values	Values
1 - 4 ==> 100	$0^0 - 10^0$ = > 1	6 - 8 ==> 100
5 - 5 ==> 1	$11^0 - 31^0$ ==> 2	9 - 9 ==> 6
6 - 6 ==> 2	> 32^0 ==> 3	11 - 11 ==> 8
7 - 99 ==> 100		

< === RECODE

GISMO PROGRAM

STEP III — LAND ACQUISITION (LA) Result in Appendix I(a) — RECODE — RECOLA Appendix I(b)

GISMO PROGRAM

STEP IV — LAND SUITABLE (LS) RESULT IN Appendix I(c)

STEP V — BSTATS — Area Calculation

RESULTS

Appendix I(a) Land Acquisition (LA)

GIS VALUES	DESCRIPTION
11	Moderate slope on Latosolic soils
12	Moderate slope on Humic Latosolic soils
21	Steep slope on Latosolic soils
22	Steep slope on Humic Latosols soils
31	Very steep slope on Latosolic soils
32	Very steep slope on Humic Latosols soils
100	Background

(b)

RECODE VALUES FOR LAND ACQUISITION (LA)

11 ==>1, 12 ==>2, 21 ==>3, 22 ==>4, 31 ==>5, 32 ==>6

(c) LAND SUITABLE (LS) DESCRIPTION

11 - 19	Moderate slope with latosolic soils in (a)
21 - 29	Moderate slope with Humic latosolic soils in (a)
31 - 39	Steep slope with latosolic soils in (a)
41 - 49	Steep slope with Humic latosols soil in (a)
51 - 59	Very steep slope with latosolic soils in (a)
61 - 69	Very steep slope with Humic latosols soil in (a)
(a) -	Information within non-forest, hardwood, softwood, scattered forest, medium dense forest, dense forest and logged out areas.

Statistics can be produced for various conditions under description....*continues overleaf*

■ *by Thomas Kremmers, Barbara Koch, Freiburg, and Christel Lingnau, CNPq, Brazil*

MOMS-02 DATA FOR FORESTRY PURPOSES – A FIRST EVALUATION –

Abstract

MOMS-02 NIR and HR data were investigated in comparison with LANDSAT TM data to evaluate their information content for forestry inventorying and monitoring tasks. Due to the missing information in the mid infrared, the spectral separation of different vegetation covers is less successful for MOMS-02 data. The spatial performance of MOMS-02 HR proved to be excellent and provides forestry related information superior to comparable earth observation sensors.

Introduction

Within the next future different new earth observation systems will provide the user community with high resolution digital image data. One of these systems is the Modular Optoelectronic Multispectral Stereo Scanner MOMS-02.

The technical concept of MOMS-02 was explained in detail many times [1-3], and the major system parameters were described in the GIS and Remote Sensing News, issue number 9, December 1994.

It is expected that one of the groups especially interested in high resolution image data is the forestry community, in order to integrate remote sensing data more intensively into inventory and monitoring tasks.

Unfortunately the data quality of the evaluated MOMS scene was unsatisfactory due to a low sun elevation and strong detector striping in band 2 and 3. The results presented will therefore demonstrate the possible perfomance of MOMS-02 data under worst case conditions.

Test site

The test site is located in southern Brazil and is characterised by extended pine plantations (*Pinus taeda*) covering the moderately undulated parts of the area. Steeper slopes, especially those facing the river are dominated by gallery or secondary forest (Figure 1).

The mature pine trees have a mean age of 25 years and are planted row-wise with a high stand density (left part of the shown subscene, Figure 1). Therefore, pine stands that have not been treated by selectiv logging show a very high degree of canopy closure. Selective logging is carried out in the form of row-thinning. Every third or second row of trees is cut out, so that the pine stands appear 'stripy' when seen from the bird's-eye view, e.g. on aerial photographs.

A regeneration area is located at the upper right hand side of the mature pine stands. The plants have a mean age of three to four years (1994) and the canopy is far away from closure. Old root plates and other wood residues from the last clearcutting have been pushed together to form long straight rows, crossing the regeneration area vertically. The region between the regenarating plantation an the secondary forest following the river is mostly covered with bare soil or dry grass.

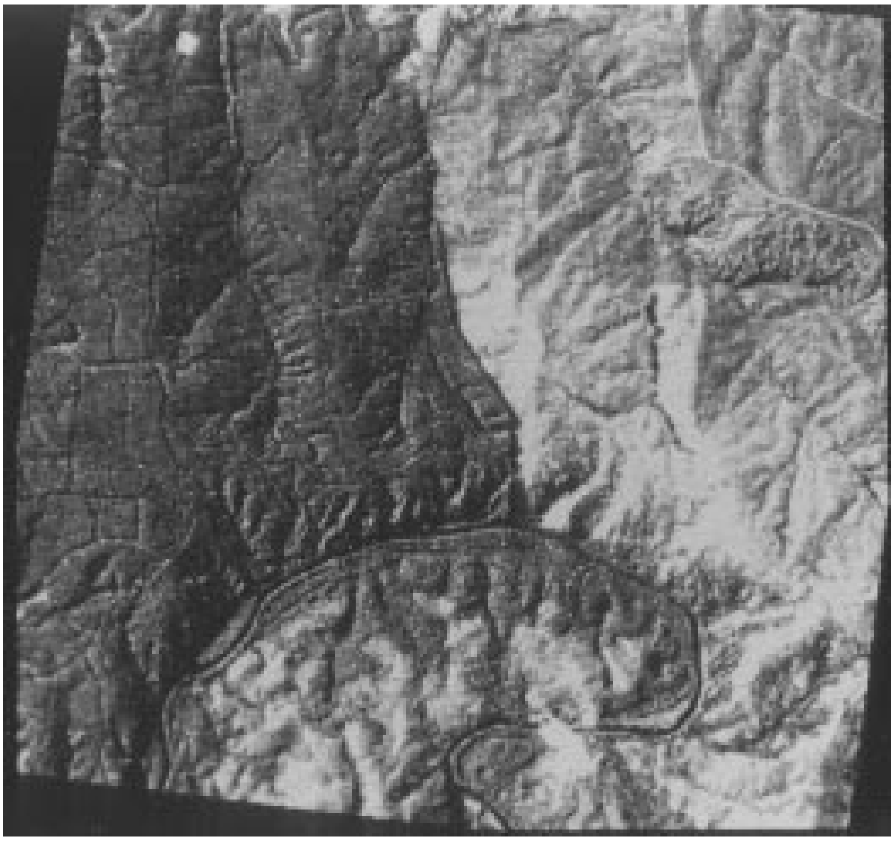

Figure 1. MOMS-02 high-resolution panchromatic image of the test site.

Data base

The MOMS-02 data used for this analysis are a subscene of data take 43. They were recorded in the afternoon of the 4th of May 1994 using imaging mode 6, which is a combination of the bands 2, 3, 4 and the high resolution (HR) panchromatic band 5. During the data take the sun elevation changed from 21.84 deg at the beginning to 16.09 deg

Recommendations

For better yield production, it is recommended to acquire accessible areas with moderate/steep slope on Humic Latosols/Latosolic soils in area loggout. Proposal could be made for unlogged areas in moderate/step slope on Humic Latosols/Latosolic soils which are currently within a logging concession.

Inaccessible areas which are yet to be logged could also be highlighted if they fall on adaptable soils with moderate to steep slopes.

The production of area statistics for suitable area will help us to prepare a reliable and acceptable budget for future forest development. Without doubt constraints will be easily detected and can be avoided as all small operations are well monitored.

Likewise, logging licenses and allocation of concession can also be monitored and controlled, using the land suitability data. Together with the forest reafforestation plan, we are in a position to cooperate and control all log removal within our forest resources.⊕

at the end. This fact causes the strong and very distinct shadows in the MOMS-02 image. Unfortunately the data quality of band 2 and band 3 was not satisfactory because of a very strong row- and column-wise striping. So only the HR band 5 and the NIR band 4 were incorporated in this study.

The LANDSAT 5 TM data utilized are a subset of scene 220_79 and were recorded in the morning hours of the 10th of April 1993 with a sun elevation of approximately 36 deg. Aerial color-photographs taken with a non metric 35 mm camera and a scale of approximately 1:8000 were provided for this analysis.

Data pre-processing

The MOMS-02 typical image striping was eliminated quite well for the HR and NIR band during the preprocessing carried out by DLR. Nevertheless the image quality of the HR band was slightly reduced by the randomly distributed appearance of single picture elements with relatively high grey values within uniform dark sorrounding areas. To minimize this noise effect the HR image was filtered with a 3x3 low pass convolution filter. After that a rotation was performed to orientate the image approximately to the north direction. For the comparative analysis and the later on combination of MOMS and TM data, the MOMS NIR band with 13.5 meter pixel size and the TM bands with 30 meter pixel size were registered to the MOMS HR band.

Data analysis

A signature analysis incorporating 13 test areas was carried out to evaluate the seperability of the main land cover classes. The test areas were collected according to the exposition dependent illumination conditions and were then compared with respect to their mean value and their standard deviation.

To to give an estimation for the accuracy of a Bayesian classification, a land cover seperability matrix was computed for the MOMS data using the separability index S for two classes, i and j,

$$S = \frac{|\mu_i - \mu_j|}{\sigma_i + \sigma_j} \quad (1)$$

where μ and σ are the mean and standard deviations [5]. For Gaussian distributions, index values S 2.0 indicate a correct classification for the training areas of 95.44% or better.

The matrix (Table 1, p.12) shows the separability indices for the HR band left of the diagonal and those for the NIR band on the right. Bold framed areas highlight indices of those training areas belonging to the same illumination class.

Looking at the separabilty matrix for the HR band, it is obvious that spectral discrimination between mature *pinus taeda* stands and secondary forest is very poor in all illumination classes (indices ranging from 0.28 to 0.32).

Grassland can be separated quite well from the *pinus* stands and from secondary forest, whereas regeneration mixes up moderately with *pinus*, secondary forest and grassland. Even the separation between water and those vegetated areas showing low reflection is not significant.

As the spectral behaviour of the different land cover types is similar for all illumination classes, an exposition dependent pre-stratification will not improve the differentiation among the land cover types when looking only at the panchromatic band, but it will help to avoid mixing between the illumination classes.

Due to the larger dynamic range in the MOMS NIR band, the higher indices indicate an improved separation between some of the classes. Regeneration can be distinguished significantly from *pinus* and secondary forest when looking at the illuminated and shadowed classes. Some mixing occurs between regeneration and grassland for shadowed

■ *by Osea Tuinivanua, Forest Management Officer*
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RS and GIS application for Monitoring Fiji's Natural Forest

Abstract

A national forest inventory was carried out for Fiji's natural forest and forest plantations. The detailed data base for all hardwood plantations and natural forest are now available locally. Fiji's natural forest inventory also included the production of forest type and forest function maps. The mapping required satellite data analysis for forest type stratification and GIS technology for the definition of forest functions. There were some unexpected challenges and problems which undoubtedly other South Pacific Countries will face. These were the acquisition of cloud free satellite data and the inclusion of local knowledge. A practical solution is the installation of remote sensing and GIS technique in Fiji, operated by local foresters on a permanent basis and supported by regional organisations in the region.

Introduction

The lack of up-to-date information about Fiji's natural forest resources development was expressed by Fiji in Geneva and a natural forest inventory was decided along with the Tropical Forestry Action Plan. The German Agency for Technical Co-operation (GTZ) then contracted the Consultant Companies GOPA/SIGNUM to complete this task in 24 months.

The expected output was:

- statistical report on current status of natural rain forest
- 1:50,000 scale map showing forest types and forest functions

The forest inventory covered all the main islands forest area and forest tree species independent of its social and economic values. It took also into account regeneration potential, minor forest products and environmental parameters. The field survey was completed in 1992 whereas the map production is not fully completed yet.

Components of Fiji's Natural Forest Inventory

The Terrestrial Survey

Over 500 sample plots have been measured during the field work. These plots have been randomly distributed throughout the country. The three four men team for the inventory consist of a forester, a treespotter and two labourers carrying out measurement of all trees, natural regeneration counting and the identification of plants used by the villages as food or areas whereas for illuminated areas the discrimation is quite good. Unfortunately differentiation between pinus and secondary forest is very poor in this classes. Except for shadowed *pinus* and secondary forest there is no mixing up with the water training area statistics.

As result it can be stated that reliable separation of different vegetation formations is not possible when using the MOMS HR and NIR channels alone under such worse illumination conditions.

Based on the experiences with LANDSAT TM data it can be expected that the incorporation of the MOMS band 2 (visible green) and band 3 (visible red) will only slightly improve multispectral vegetation discrimination.

The combination of LANDSAT TM band 7, which is sensitive in the mid infrared region, with MOMS HR and NIR bands (Figures 2a and 2b, next page), improved the class separation significantly. Except the signature overlap between water (ellipse 13) and the *pinus* stands (ellipses 1, 2, 3), the different vegetation coverages can be separated from each other quite well. The sequence is from pinus (ellipses 1, 2, 3) and secondary forest (ellipses 7, 8, 9) to regeneration (ellipses 4, 5, 6) and grassland (ellipses 10, 11, 12).

The results of the spectral data analysis indicate that neither the MOMS-02 NIR band nor the HR band prove sufficient radiometric dynamic for a spectral classification of forest types. Even though it is to assume that under comparable illumination conditions the radiometry of MOMS-02 band 4 is superior to LANDSAT TM band 4 [6-7], a distinct improvement of spectral separation is not expected because important information in the mid infrared is missing. The

Table 1. *Landcover separability matrix for MOMS-02 HR band (left of the diagonal) and NIR band (right of the diagonal).*

	flat terrain				Illuminated				shadowed				
	pt1	re3	sf5	gr2	pt2	re2	sf1	gr1	pt3	re5	sf4	gr3	w1
pt1	-	1.10	3.24	0.34	1.62	6.95	0.60	2.42	4.66	1.64	4.07	2.44	5.74
re3	1.07	-	3.81	0.59	0.46	5.05	0.48	1.17	5.14	2.41	4.61	3.11	6.10
sf5	0.32	1.29	-	3.01	4.36	9.44	3.54	5.09	1.41	1.91	0.87	0.45	2.32
gr2	1.96	0.96	2.09	-	1.01	5.25	0.16	1.67	4.14	1.66	3.66	2.33	5.00
pt2	0.24	0.79	0.53	1.67	-	4.54	0.96	2.24	5.29	3.12	5.07	3.55	6.57
re2	2.23	1.23	2.33	0.25	1.93	-	5.79	3.76	10.59	8.88	10.01	8.09	11.76
sf1	0.52	0.45	0.76	1.30	0.28	1.54	-	1.70	4.85	2.13	4.30	2.77	5.85
gr1	3.68	2.48	3.68	1.22	3.26	0.92	2.71	-	6.29	3.95	5.77	4.21	7.28
pt3	1.15	2.30	0.68	3.17	1.37	3.46	1.58	5.30	-	3.44	0.51	1.73	0.85
re5	0.07	1.00	0.38	1.90	0.17	2.16	0.45	3.60	1.23	-	2.83	1.21	4.54
sf4	0.78	1.85	0.38	2.70	1.00	2.96	1.22	4.56	0.30	0.85	-	1.24	1.38
gr3	0.96	0.03	1.18	0.93	0.71	1.18	0.39	2.33	2.10	0.90	1.7	-	2.58
w1	1.56	1.76	1.07	3.62	1.76	3.92	1.96	5.95	0.39	1.64	0.68	2.51	-

pt = pinus taeda; re = regeneration; sf = secondary forest; gr = grassland; w = water

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local medicine. The Department of Environment enumerated birds in the vicinity of plots. All data are stored in a relational data base (dBASE) for linkage with spatial information.

Digital Satellite Image Analysis

Recent aerial photographs were not available, incomplete and too expensive to produce. Landsat TM data was chosen because of its higher radiometric content and low cost compared to SPOT. Many cloud covered areas were replaced by cloud free parts of a corresponding scene. The separation of forest cover area from non forest area processed in Germany includes the forest stratification into scattered, medium and dense forest.

The Geographic Information System

A PC raster data based GIS (ERDAS) was an acceptable software for the task. The information layers are available in form of digital maps at the Forestry Department. It can be shared by other Government Departments. This information includes:

- soil map of Fiji
- digital terrain model and slope map
- declared areas (declared reserves, water catchments etc.)
- areas with high Biodiversity
- mean annual rainfall
- seasonally rainfall
- district and province boundaries
- road network
- major rivers
- hardwood, coconut and pine plantations
- forest cover of last inventory (1969)
- forest types (forest cover 1991/1992)

The **"forest function map "** has been the resulting combination of these overlays. The forest function map shows the forest cover (dense forest, medium forest and scattered forest) and a management categories indicating Reserved Forest, Protection Forest and Multiple Use Forest.

The "forest cover (1969)" was compared with the "forest types (1991/1992)" to establish a "forest change" layer.

Installation of Forest Monitoring System

The inventory design was upgraded to be able to monitor the forest change permanently and for any change detection in the tropical Fiji. Therefore, a modification was forced on all three components including the terrestrial survey, the satellite data analysis and the GIS analysis.

Satellite Image Analysis

A PC base digital image analysis system was installed by the project in the Management Services Division (MSD) of the Forestry Department. This system includes input facilities to import all types of satellite data. User friendly image analysis software along with training allows the forestry staff to stratify the forest cover using their field experience. Apparently, further stratification is possible with additional test areas[1, 2].

GIS Analysis and Data Capture

Upgrading of software and hardware made map production possible within the MSD and enabled the direct data exchange by network to other projects in the Division. Parts of the hardware now improve the map production. The problems of recalculation from one co-ordinate system to other is solved by an expert of an AIDAB funded project within MSD. His locally designed software package was

[1] *see Tuinivanua O., Possibilities of Mangrove Mapping with Landsat TM Data, GIS&Remote Sensing Newsletter, October 1993*

[2] *see Tuinivanua O., Raintree as a New Forest Type, GIS&Remote Sensing Newsletter, December 1994*

decisive advantage of MOMS-02 data is therefore the high spatial resolution and the on track stereo capability.

Visual Interpretation

A visual image interpretation was carried out based on single band images of the MOMS-02 NIR and HR bands as well as on a color composite of MOMS-02 NIR band (assigned to red), MOMS-02 HR band (assigned to green) and TM band 7 (assigned to blue).The interpretation proved a correct deliniation of all different landscape elements in the test area. The images showed the road netwok down to forest paths (approximately 5m in width) and gave a good overview on the disclosure of the wooded area. Extraction lines in forest land were discernable in most cases as well as the lineaments of old root plates and wood residues in former clearcuttings. Large single trees, tree rows and groups of bushes were distinguishable. An estimation of forest crown closure seems to be possible and openings within stands were displayed clearly.

According to image texture, a reliable differentiation of pine plantations (uniform smooth texture) and secondary forest (‘cauliflower’-like texture) was possible. Differences in color allowed the seperation between young regenerating plantations and older parts with mature trees.

This first visual interpretation does not allow any statements on tree species or age class assessment, but it can be confirmed, that the information content according to geometric details is significant for forestry applications, e.g. mapping logging roads, forest/ non-forest boundaries and monitoring logging schedules.

Conclusion

This study was based on MOMS-02 data with low quality and was restricted to a small test area and a single forest management system. Therefore conclusions on the information content of MOMS-02 data for forestry purposes are limited. However, for the spectral separation of forest classes the NIR and HR bands alone were not sufficient, because the important missing information from the mid infrared region cannot be compensated by these channels. The integration of the visible channels 2 and 3 will hardly improve the separabilty of vegetation coverages as the experiences with SPOT and LANDSAT TM show. Therefore an improvement in the spectral separability of vegetation classes is only achievable in combination with mid infrared channels, as it was demonstrated with LANDSAT TM band 7.

Even though it has to be taken into account that the combination of different sensor data can cause a lot of problems (illumination conditions, data integrity, geometric properties) data fusion techniques will become more and more important to exploit the advantages of different sensor systems. The decisive advantage for incorporating MOMS-02 data in such data merging procedures is its excellent geometric resolution, especially in the HR band.

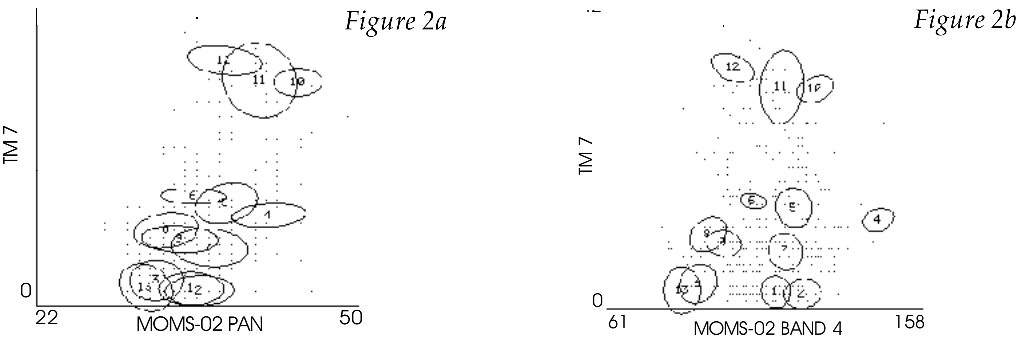

Figure 2. Signature ellipses with ó = 2, for numbering of the ellipses see text. a: MOMS HR and TM 7; b: MOMS NIR and TM 7.

Acknowledgements

The MOMS data set was provided and system corrected by the DLR, Oberpfaffenhofen. The GFZ, Potsdam, supported this evaluation study by their advices in data handling and pre-processing.

Ground truth information and aerial photographs were kindly put at disposal by MODO - Battistella

available to other Departments.

Terrestrial Survey

One team continues to establish permanent sample plots nation-wide. The plots were concentrated on secondary forest including forest not initially enumerated. The MSD also established an additional data base containing socio-economic data. The field team collecting data to investigate the socio-economic benefits of Fiji’s forest.

Problems with Fiji’s Environment

The inventory was planned in Germany by experts who have experienced the tropical countries. However, the South Pacific countries have its own unique features and characteristics making it different from other countries with tropical rain forest.

Satellite Data Acquisition and Analysis

The project **data acquisition** was based on two Landsat satellites that were fully functional in orbit, Landsat 4 and Landsat 5. However, only Landsat 4 was able to download data, recorded from Fiji, via relay satellite to the ground antenna in USA. SIGNUM in Germany had to purchase 19 scenes (instead of 6) to mosaic a cloud free coverage of Fiji. Unexpected haze over forest cover which was not visible in the quick look images created other difficulties for the digital image classification. The forest stratification using satellite data was delayed due to the mentioned reasons.

The satellite data received from Germany had been **geometrically corrected** to UTM. However, the image data had to be corrected to Fiji Map Grid. Further, all pre image enhancement modules such as destriping do not work with geocoded data.

In other tropical areas such as West Africa or South America, there is often a structural difference in canopy be-

Reflorestamento, Rio Negrinho, S. C., Brazil.

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tween virgin or dense forest and logged forest, because the logged forest has a rough and shadowy canopy. The canopy closure is often a good indicator for the forest density. This is highly irrelevant in Fiji. The **canopy closure is not related to forest density** in terms of standing biomass per hectare. Due to frequent cyclones the forest has a rough canopy structure. Furthermore, tree ferns as a pioneer species covers the land slides, have no woody biomass but exhibit tree reflections in the satellite image.

The geographical distance between the digital image processor and the foresters with local knowledge has been an ongoing problem. It's also an **economic challenge** in developed countries to do all computer work by foresters with experience in tropical rain-forest. Such an operator will not realise many phenomena and he will not ask the foresters in the South Pacific Country, even if a good communication link such as fax and e-mail is established. For example the seasonal effect (defoliation) with African Tulip *(Sparodae campanulata)*, Raintree *(Samanea saman)* or Mahogany *(Swietenia macrophylla)* will not be recognised by an off shore operator.

Terrestrial Survey

The review of the forest legislation carried out by an FAO expert did not include the forest definition. The boundary between **forest and non forest was not defined**. The plots were checked in Germany with satellite images if they were located within or outside the forest cover. A non local operator will always underestimate the forest area. However, there were secondary forest mapped as none forest in the last inventory[3].

Spatial Data Collection and Analysis

Many spatial information already available in the country had to be redigitised because it was impossible to obtain these map layers due to administrative and technical reasons. Many donor countries have kindly donated computer hardware and software to various Government Departments and institutions. Quite often, these products are **not compatible** which makes an information transfer impossible.

The mentioned use of **different spheroids and projections** created an enormous amount of additional work because it was not always possible to transfer differently digitised maps to the other grid system.

Recommendations

Before starting an inventory related to nation wide forest cover, the legal ***definition of forest*** should exist.

Within the Management Services Division of the Forestry Department, several technical and financing projects are working harmoniously together. This was possible because all experts form an integral part of the Division and Department of Forestry. In the future, more emphasis should be put into project planning to be aware of ***full integration in the administration***, rather than creating an own independent project infrastructure outside the administration.

It is necessary to get agreement from the satellite data distributing agencies to ***share data*** between different Government Departments. Such an agreement has been reached with EOSAT for Landsat data, but it is also necessary for digital SPOT images.

Cloud cover will be a continual problem in South Pacific Countries until a break through in space borne Radar data. It will be an important step to have a ***Mobil ground station*** able

[3] *see Tuinivanua O., Change Detection of Fiji National Forest Cover Using Landsat TM Data and GIS Techniques, GIS&Remote Sensing Newsletter, September 1994*

■ *by Hervé Dropsy & André Vial, Mineral Resources Department*

NAMOSI DIGITAL ELEVATION MODEL

The Digital Elevation Model has been produced for the Namosi area of approximately 5 by 7 km with the pixel size of 20 m x 20 m. We will see the different steps in the production of this DEM from the base data to the end-product, the GIS map.

The map produced (Figure 1) contains :

- a raster image derived from the DEM
- the contour lines produced from the DEM
- geographical information such as rivers, village...

This exercise is part of MRD assessment of the resources of the possible Namosi Copper Mine. A Digital Elevation Model is one of numerous information required to calculate the volume of ore minable and its content in copper and by-product such as gold. The viability of the prospect is currently being explored by Placer company.

The base data set which was provided by the exploring company, is a tabular ASCII file. It contains also position of villages, roads, rivers, flood areas. The elevation values, called Z, are classically associated with easting and northing value and with a line number. These original elevation data were produced using classic photogrammetry method. The data are scattered along parallel lines to receive Landsat TM, SPOT and ERS-1 data.

Forest mapping which includes forest stratification is a complicated issue in the South Pacific. It requires the ***involvement of local foresters***. Therefore satellite data analysis should be carried out in the Forestry Department, which makes it necessary to provide necessary hardware, software and training.

However, the Forestry Department will not be able to update this modern technology and will be incapable in carry out all its own maintenance. This could be shared with a regional organisation in the South Pacific, as SOPAC[4] is doing this. Such an organisation should be extended to a ***regional centre*** for central data register and for performing jobs such as high quality image output, which requires expensive hardware.⊕

[4] *SOPAC = South Pacific Applied Geoscience Commission*

spaced at approximately 25 m as shown in Figure 2, and every 10 to 20 m along the lines themselves (total number of points: 86,511).

The first part of the exercise was to separate the geographic information from the elevation data. A database application Microsoft FoxPro was used to import the ASCII file, then isolate the geographical information (rivers, village) using the data type identificator, and export it into a CGDEF format (interchange format used by Mapgrafix). From this CGDEF file, a first GIS map containing geographical vector information was produced.

The elevation data were imported from FoxPro to the GDM (Geological Data Management) system in order to create a grid of elevation and elevation contours.

Kriging was used to estimate elevation values at nodes of this regular WE-NS grid (size : 365X242 spaced 20 m in easting and northing). 67818 values were calculated. The rest of the nodes was given the value "undefined" by the software (where data were lacking or insufficient, cf the irregular shape of the original data in Figure 2). The GDM software offers different griding (= modeling) algorithms, the kriging techniques giving the most accurate estimation in such a case. (as it is also the case for many natural sciences applications). Furthermore these techniques allow to calculate at same time the standard deviation value for each evaluated altitude, value which can be stored in the elevation model. It represents the degree of accuracy of the estimation and can be contoured to indicate where the evaluations are of good quality and where more data are required to get correct values. A contoured map of the elevation was produced with the GDM software from the elevation model, using at new time the kriging technique, and then was exported to a DXF file. The model itself was exported as an ASCII file (one pixel value per node).

The integration of the various type of data (geographical, vector DEM, raster DEM) presented a few challenges.

The vector DEM (contour line in DXF format) was converted into CGDEF (ASCII interchange format used by MapGrafix) using the module MapLink. The resulting file was imported into Mapgrafix without difficulties. However contour in the DXF were coded as a series of segments (line linked two points). The CGDEF was processed using a small program (using FoxPro) to aggregate the segments into line. This alone decrease the size of the CGDEF file from 12 Mb to less than 4 Mb.

The grid was first classified

NAMOSI COPPER MINE PROSPECT AREA

Scale 1:30 000

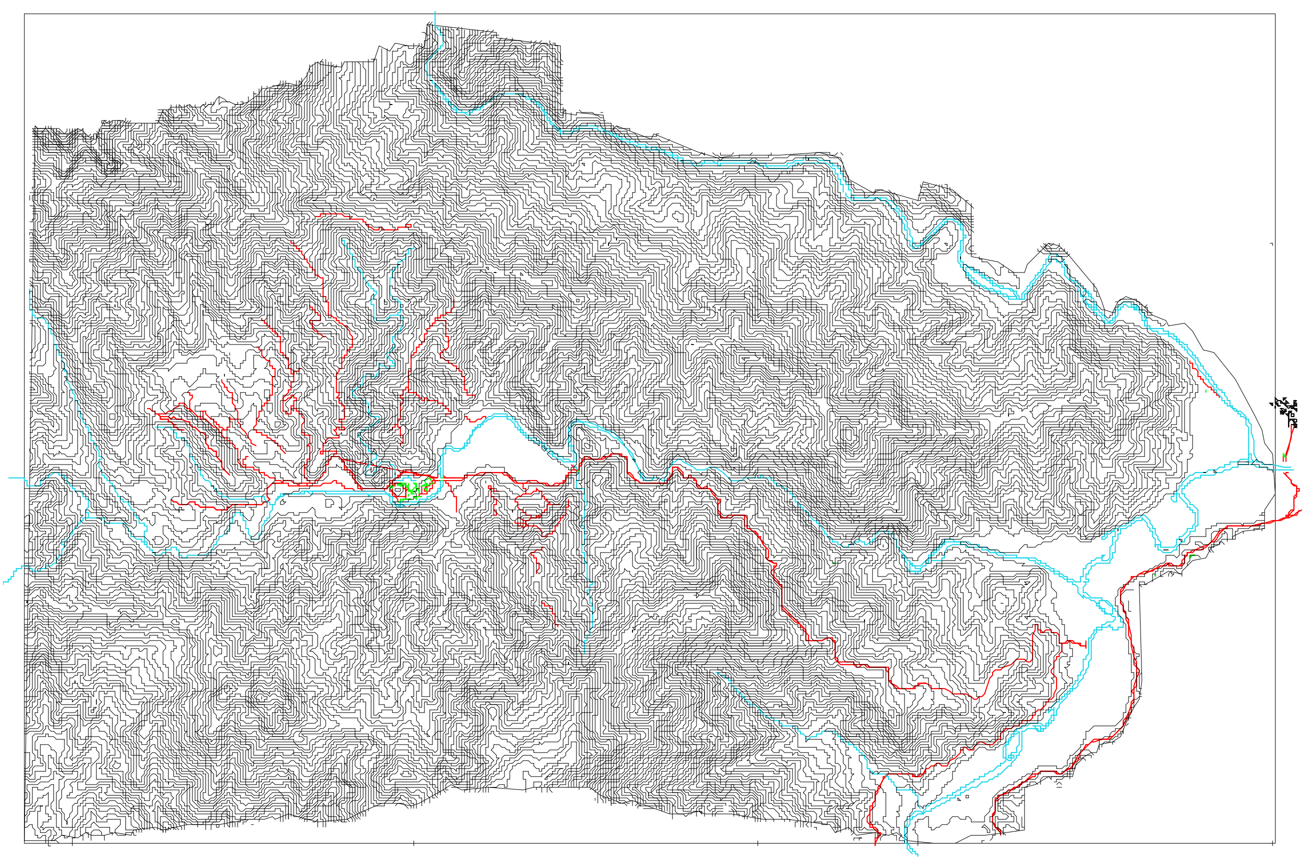

Figure 1.

into 5 m interval classes, and then Idrisi 4.1 was used to import the grid ASCII file produced from GDM and to export it as a TIFF file. Due an incompatibilities between TIFF file format with MapGrafix and Idrisi. A image processing shareware was used to produce a compatible TIFF format, the lookup table was also changed.

The TIFF file was then imported into MapGrafix GIS as a background image to produce the final document.

A contoured map of the elevation was calculated from a relatively small number of point (250) on a part of the studied area. It was compared with the one produced from several tens of thousand of measured points (approximately 30 000). Results are of sufficient good quality where points are regularly placed, are not too far apart from each others, and are also measured on significative position. Associated with the values representing the accuracy of evaluations, this DEM can be used in natural resources estimations which do not required a too high degree of precision. If this is the case the number of measured values must be increased taking in consideration the information given by the contour map of the degree of accuracy. It is then easy to demonstrate that above a certain number, extra measures do not increase the exactness of the calculus.

So the combination of a griding & contouring software with a GIS can provide a quick and cost-effective way of producing maps representing in vector and raster form a digital model of elevation or other type of data (rain, mineral content, ...) from a scattered set of measures.◍

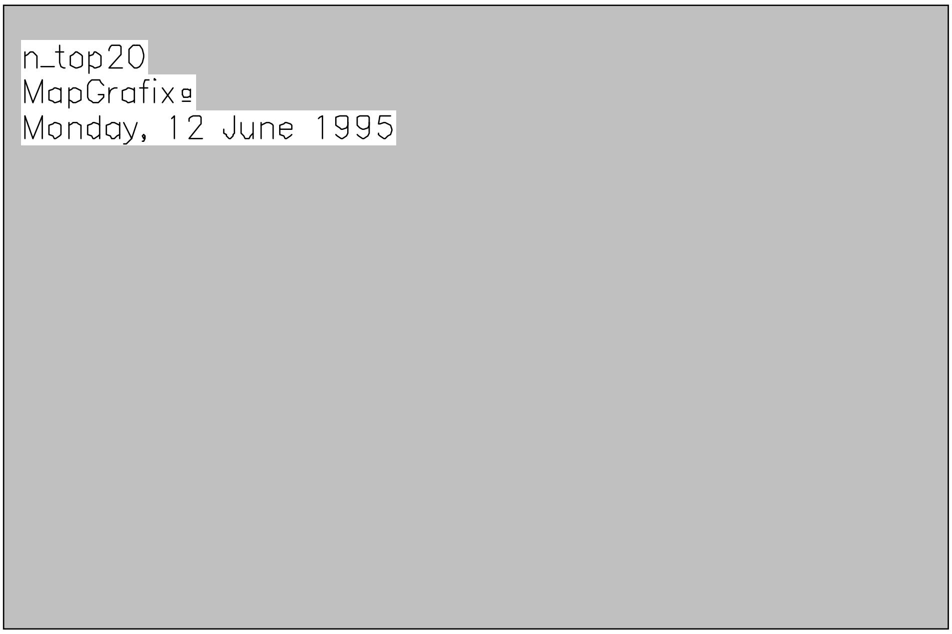

Figure 2.

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