NOTES

AN ACTION PLAN TO MAKE GEOSCIENCE EDUCATION IN INDIA EMPLOYMENT-ORIENTED AND RELEVANT

The key elements of the action plan are Proactive, employment-oriented, relevant, web-based, flexible, adaptable, affordable, modern and of good quality

Background

Geoscience knowledge covers an enormous spectrum A country or a university may choose that part of geoscience knowledge spectrum that serves best its ethos and needs, and that is affordable to it in terms of geoscience tools needed For instance, the teaching and research activity of an earth sciences department in USA may be largely devoted to planetology (e g geochemistry, and geomorphology of the Martian surface and the possible presence of frozen water and life in the subsurface of Mars) This is no doubt exciting fundamental geoscience, involving the use of the most sophisticated tools of remote sensing It is not as if one has to do only this kind of geoscience in order to achieve excellence It is perfectly possible to achieve excellence in monitoring the soil moisture using METSAT (India) data, and using the data for the mundane but socio-economically useful purpose of advising farmers about cropping patterns

In the case of the developing countries, any pathway for the economic progress has to be job-led Water, soils, mineials and biota constitute the most significant natural resources of a community Innovations in technology are generating new jobs in the process of converting into a resource what was yesterday a non-resource ("Resources are not, they become"- Zimmerman), in developing process and control technologies to minimize wastes, and in recycling of wastes In the case of the developing countries, the technologies of choice have not only to be ecologically sustainable and economically viable, but more importantly, people-participatory The new kinds of jobs (eg in poverty alleviation projects via micro-enterprises based on value-added processing of natural resources) have a strong environmental relevance, and tend to he at the interfaces of several traditional scientific disciplines Geoscience graduates in the developing countries are best placed to take advantage of these new job opportunities involving earth materials, but only if they are exposed to broad-based geoscience instruction covering cognate knowledge and collateral skills

This approach could be illustrated with an example Wastewater, which is customarily considered as a nuisance, can be put to economic use through biopond technologies, which are low-cost, energy-saving, employment-intensive, environmentally-beneficial, and economically-viable The digested sludge is used to raise mushrooms and earthworms, and in the production of biogas and fertilizer The supernatant water is used to grow fish (typical yield 6000 kg/ha/yr) before being subjected to geopunfication, and so on

Management Systems for Resource Use and Geoscience Jobs

Systems of resource management have to be operated at three levels, each of which has provision for geoscience jobs under different kinds of employment

Level 1 - "Think-tank" activity, with geoscience employment under government/public agencies - for integrating and optimizing the biophysical and socioeconomic aspects of resource management, and coming up with various techno-socio-economic options to be discussed with stakeholders

Level 2 - Technology transfer activity, with geoscience employment under NGOs, companies or self-employment Designing institutional arrangements for adapting the technologies to the specific, local biophysical and socioeconomic situations Developing mechanisms and modalities for the training of all the concerned entities (such as, managers, stakeholders, financial institutions, community institutions, etc)

Level 3 - Implementation activity, with geoscience employment under NGOs, companies or self-employment - Designing institutional arrangements for the management of implementation, monitoring and servicing of the micro-enterprises and other mechanisms for implementation "Hand-holding" with the stakeholders, where necessary

Geoscience Jobs in Water Resources Management and the Collateral Skills Needed

Geoscience jobs to assist individual families, through micro-enterprises: Rooftop harvesting of rainwater for drinking purposes; water storage in large capacity (~ 250,000 L) butyl bags for drinking water for humans and *animals; economizing* the application *of water* through the use of animal-driven drip irrigation, and low-cost greenhouses to grow high value but low water need crops, such as oil seeds, vegetables, medicinal plants, flowers, etc.; growing of low-water need crops such as millets and sorghum in water scarcity areas, and rearing of live stock and poultry in years of drought, since they are capable of surviving water scarcity better than crops; growing of fodder shrubs and trees (e.g. saltbush plantation, spineless fodder cacti, wattles, and acacias) in strategic locations, in order to provide an extra source of fodder for the animals, when drought occurs; game ranching - some animals (such as some species of Cervidae, antelopes and ostriches) are better adapted to dry conditions than cattle. (Presently, there are 20 Mhaof game ranches in South Africa, Namibia, Botswana and Zimbabwe, where they are coupled to commercial hunting and green tourism, making them economically viable).

Geoscience jobs for assisting communities, through cooperatives or companies: Construction of check dams, and water ponds for the harvesting of surface runoff; Desilting of tanks and river beds; Biopond and geo-purification technologies; Wellhead protection of groundwater resources through the use of vulnerability criteria; Conjunctive use of surface water and ground-water.

Geoscience jobs for assisting the state/central governments: Construction and maintenance of dams, reservoirs, canals; Monitoring the use of water resources, to prevent the degradation of water resources; Delinking the water rights from the land rights of the farmers, and enforcement of regulations regarding the use of non-renewable deep groundwater; Development of drought-resistant, salinity-tolerant crop seeds; Information Technology inputs, involving the digitization of map data; Preparation of digital overlays for soil moisture data (derived from METSAT), groundwater and surface water data, precipitation, geology, geomorphology, soils, land use; Preparation of composites for specific purposes, such as, drinking water, agriculture, livestock, poultry, fisheries, horticulture, forestry, and Transposing the watershed data to *mandal* (county)/ village levels, and updating the data (such as, soil moisture), etc.

Evidently, for a geoscientist to be able to offer this kind of advice, he needs to acquire a number of collateral skills. Even though a candidate may have specialized in (say) water quality, he needs to know how his water quality expertise has relevance *to* considerations *of water use* and *reuse, effect* of land use on water qual ity, allocation of water to competi ng users, water economics, etc.

Geoscience Jobs in Soil Resources Management and the Collateral Skills Needed

Geoscience jobs to assist individual families, through micro-enterprises: Soil nutrient management; appropriate use of phosphatic fertilizers, NPK fertilizers and sewage sludge; mitigation of soil acidity through liming; providing appropriate sub-soil drainage; identification of crops based on ESP range; gypsum amendment for the reclamation of alkali soils; fabrication of stabilized soil blocks.

Geoscience jobs to assist communities, through cooperatives or companies: Use of stabilized blocks for the construction of community structures, sub-base for roads, earth dams, etc.; construction of waste disposal facilities, using clays as sealants.

Geoscience jobs to assist the state / central governments: Providing soil testing services (geotechnological characteristics, nutrient status, etc.) of the soils, to help the stakeholders to take appropriate measures; use of geomembranes for various civil constructions, such as building embankments and foundations for roads, sealing water reservoirs, etc.

The principal collateral skills needed are soil biogeochemistry, and soil geotechnology.

Geoscience Jobs in Mineral Resources Management and Collateral Skills Needed

No other resource use has such serious adverse impact on environment as mining - the mass of mine tailings produced worldwide (18 billion rnVyr) is of the same order as the discharge of sediments in the oceans. Geoscience jobs will increasingly be in the area of the beneficial uses of mining wastes, and rehabilitation of the mined land.

Geoscience jobs to assist individual families, through micro-enterprises: Artisanal mining of gold, cassiterite, tungsten, antimony ores; Preparation of bricks and concrete blocks from mining wastes.

Geoscience jobs to assist communities, through cooperatives or companies Use of "Portable" plants for the p]ocess]ngofores,bio-rehabihtation of mined land, and plants for the purification of mine water for drinking and II ngation purposes

Geoscience jobs to assist the state/central governments Mineial resource inventories, methods of mining, transport, process technologies, wastes that are expected to be genei ated, health hazards, monitoring of the mine effluents, R&D for amelioration of mined land, beneficial use of mine wastes, mine water, control technologies for minimizing the environmental impact of mining, Acquisition and maintenance of mobile mineral testing and processing units

The pi incipal collateral skills needed are geotechnology, mateuals technology and bioremediation technologies

How to Broadbase Geoscience Instruction to Address the Market Reality

The following components are involved in the proposed paradigm shift in geoscience instruction in order to address the emerging job market (1) *approach wise* The most important and by far the most difficult component of the paradigm shift is psychological the university should try to orient the student to be proactive, to anticipate changes in the job market, and equip/adapt himself to fit into the emerging job market This is happening already in the Information Technology sector, and will almost certainly become the norm in the job market generally, (n) *knowledge-wise* linkage with cognate subjects, such as, pedology, agriculture, meteorology, land-use, etc with focus on Anthropocene, neogeomorphology, exogenic processes, and the "skin" of the earth", (in) *skills-wise* remote sensing, GIS and GPS, optimization methods, and systems analysis in regard to the use of resources of water, soils and minerals, sociological skills for interacting with individuals and communities, and economic skills for making cost benefit analyses of various options to be piesented to the stake-holders (Aswathanarayana, 1997,2002,2003 a, b) As most of the geoscience departments are poorly equipped in terms of library and laboratory facilities, the instruction will have to be based on PC, and linked to Internet (as the source of archived data, software for the collection, analysis, integration, interpretation, display, etc of locally gathered data, and "virtual" imagery), and the satellites (for on-line repetitive, monitoring information) The National Academies Press has more than 2500 books in science and engineering, which are available online free *{http //www nap edu/books)* A good website for virtual geosciences is *http //www uh edu/~jbutler/anon/course andresources html*

How to Incorporate the New Paradigm into the Existing Geoscience Instruction Structures in India

The new paradigm can be implemented in the following ways

Institution of a four-year B Tech course on Natural Resources Management The Course will be Internet-based, employment-oriented, and focused on economically-viable, ecologically-sustainable utilization of natural resources, namely, water, soils and minerals Admission requirement EAMCET or its equivalent after 10+2

Year I Two semesters - A course on Earth Processes (on the lines of Understanding Earth by Press & Siever or Exploring Earth by Davidson, Reed and Davis, 2002) and Prerequisite custom-made courses in Mathematics, Physics, Chemistry, and Biology, with optional courses in Sociology, Economics, Engineering, etc (Field training for six weeks at the end of Yr I may be related to general geological and geomorphologic mapping, using geospatial technologies)

Year II Semester 1 Linkage courses in Geomorphology, Agriculture, Meteorology, Land-use, oceanography, etc custom-made in the context of the local biophysical situation Semester 2 Environment and Sustainable Development (Field training for six weeks at the end of Yr II may be related to soil, land-use and geohydrological mapping and preparation of resource inventories)

Year III Two semesters devoted to Natural Resources Management - waters, soils, sediments, rocks, biota, etc - their dynamics and linkages and optimizing their productive use This will constitute the core of the instruction Semester 1 Waters and soils, Semester 2 Rocks, sediments and biota, etc Training for six weeks attached to appropriate institutions, related to specific applied problems, such as waste disposal, engineering geology, hydrogeology, mineral processing, etc

Year IV Semester 1 - will be devoted to specialized supplementary courses/skills needed for pursuing the dissertation topic (e g remote sensing, engineering geology) (which has been identified in Yr III) Semester 2 Dissertation

Institution of two-year M Sc in Natural Resources Management (for B Sc Geology candidates), by incorporating Yrs III and IV curriculum as given above

Providing for courses a la cfarte from among the above, to B.Sc. Geology graduate? and other graduates, as supplementary learning, through evening courses / distance learning . There should be provision for updating the courses, depending upon the rriarket requirements.

Other Structures

The exercise, could be yetfo<med in the following chases:

Phase I: Preparation of curriculum for a four-year undergraduate course, and other courses, and drafting of course content for all the courses (core and electives),

Phase 11: Preparation of course manuals for all the courses (incorporating the published material, and supplementing it with new material as required, laboratory and field exercises, data acquisition, collation and analysis, etc.). Design of assessment techniques for the evaluation of candidates.

Phase III: Interactive training of university teachers in the new methodologies.

Relevance to the Developing Countries

As the developing countries in general face the same kind of crisis in geoscience education that India faces, the Action Plan that is sought to be developed to address the Indian situation is likely to be eajuallv, relevant to the other developing countries. India will gladly share its experiences, instructional materials and teaching modules in this regard with the other developing countries, through organizations such as, the WMO, IUGS, UNESCO, Commonwealth Secretariat (London), etc.

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