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Digital Earth Technologies Forming Community Decision-Support Systems for Enhancing Human Welfare and Environmental Resources in the Qinghai-Tibet Plateau

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ABSTRACT

Addressing the challenges associated with seeking sustainable development, along with the explicit goals of enhancing human welfare and conserving environmental resources to ensure adequate ecological services, cannot be deferred to governments alone. Experience has demonstrated that only through comprehensive and community-based grassroots efforts, in partnership with government agencies, can achievements be made towards sustainability objectives. Type II partnerships, as championed by the UN secretary-general, Kofi Annan, have been identified as the optimal approach to community cooperation and collaborative efforts requisite for improving lives and the environment. The information underpinnings and the tools for assessment and planning for collaborative efforts have been rapidly advancing and are now more easily available in remote regions. Under various Asian (both China and Japan) Digital Earth initiatives an experience base has developed related to methods of encouraging local communities to use advanced spatial technologies and models for assessment, education, and environmental remediation. Based on these experiences, a proposed initiative for environmental conservation and social improvements has been communicated and accepted by members of various Chinese government agencies, Chinese universities, and international NGOs. A center of excellence is being created to foster a series of community-based meetings in Xining, China in conjunction with a comprehensive set of environmental and social assessments that are being conducted in cooperation with teams of Chinese and international scientists. These efforts are being aligned with the integrated assessment methodology of the Millennium Assessment to promote shifts in the societal behavior modes regarding approaches to the artificial conundrum of economics versus environment. Sets of signed agreements and a conceptual design have been completed for the 2004 initial workshops and field exercises.

Introduction

Humankind's capacity to reach harmony with the Earth's natural processes represents a critical, if not paramount, component for our survival as a society, civilization, and species. Globalization no longer allows for societies of peoples to remain isolated and successfully survive within insular enclaves without regard or consequences from other human activities of trade and commerce, resource extraction and utilization, and social/political activities or movements. All societies and tribes are becoming inextricably enmeshed in a global fabric of commerce, culture, and politics. Sustainability, or sustainable development as a concept, has arisen from the collective conscious and awareness that throughout the globe, many national, industrial, or local practices affecting land cover and ecological resources are not sustainable and indeed are fostering unprecedented negative consequences on the ecosystem services which in turn manifest numerous degradations on social and eventually economic conditions for a great many people. Consumption patterns from one nation may have profound consequences on other nations thousands of kilometers distant (Wackernagle and Rees, 1996). The magnitude of these integrating factors on human society and the environment they depend upon for fertile soil, food production, clean water and air is extremely complex in both time and space. This complexity effectively defeats conventional approaches or general comprehension by the populace that would ameliorate negative effects, and promote conditions of dynamic equilibrium for humans and their environment. No single course of study, no unique school of political thought, and no major religions have ever provided the foundation for addressing the serious threats tipping human ecosystems to every increasing conditions of unsustainable capacity. Recently, a team of international scientists recognizing the magnitude of this reality, raised the specter that a new science was needed to deal with our intellectual lack of preparation for the manifest global phenomena (Kates *et al*, 2001). Sustainability science initiative seeks to build an underlying foundation of the interdisciplinary and complex interoperating human-ecological factors and processes that influence the prevailing conditions of sustainability. This initiative should be consider in conjunction with the international effort to define consensus on the enumeration and functional evaluation of ecosystems goods and services (Alcamo et al, 2003). It is envisioned by this author and others, that sets of objective conditional rules and norms can be derived that will enable citizens and policy makers the criteria for daily and planning decisions that will not only continue survival of the various societies but provide a basis for improving the human conditions more equitably (Laszlo, 2001; Strong, 2000).

A series of basic tenets regarding "rules of nature" perhaps, needs to be recognized and respected to prevent the biosphere's unraveling and the resultant loss of ecosystem goods and services that will manifest in myriad forms to confound the best of intentions by farmers or politicians. Soil loss and degradation of fertility through over use and inappropriate or unbalanced chemistry and land use management provide impetus for a cascading series of system responses that inevitably lead to lower production of ecological goods and services. Concomitant with overpopulation pressures are the increasing demands of traditional economic/industrial/mechanical processes which accelerate the loss of productive natural capital and exacerbate worsening conditions for humans through the loss of clean water, sufficient food, adequate natural resources for economic enterprise, leading to poverty, sickness, and individual and social suffering (UNEP, 2002; WRI, 2003). Therefore, advances in intellectual resources and community understanding must be pursued to establish a fundamental and foundational framework for individual societies to first recover their natural capital and then to manage in perpetuity the ecological life-support systems in harmony with their cultural and spiritual values for human well-being. To reach this noble goal will require more than a series of academic or policy-relevant publications; the current productivity index. It is the premise of this paper that first, an effort must be forged and focused on effectively advancing societies' understanding or appreciation of the human-ecosystem functions and interdependence and the implication of daily, collective human behaviors impacting these systems. And second, this forged effort will need a fundamental augmentation of science tools and methods incorporated into the community decision-making processes. And third, a radical shift in societal *modus operandi* at multiple scales will be required to stem the tide of negative consequences and begin the transition to societal norms of sustainability. Incumbent upon this enlightenment, tooling, and societal-shift hypotheses, is the technical feasibility of implementing community-based decision support systems under a collage of differing social-political settings. If technical feasibility can be demonstrated through a spectrum of geographic and political environs, then there will exist an increased probability that significant genetic and cultural resources of the planet can be conserved by the end of the 21st Century and that human-ecosystems will be managed more effectively under regimes that promote sustained operations and enhanced well-being for the majority.

This paper offers a perspective of the foundation arguments for establishing community-based decision support systems that would attend to the actions and policies requisite to curtail loss of ecosystems services and goods and enable communities, at various scales, to better control their destinies in the face of pressures, such as climate change, through enhanced use of science-based understanding of the human-ecosystem framework. A set of guiding principles, or operational laws of behavior, will be sought in relation to establishing a living laboratory context for the Qinghai-Tibet Plateau for the long-term, real world experiment in sustainability. The proposed living laboratory is currently under development and consideration by the key members of the regional society, creating a Type II partnership that incorporates a range of social constructs, from urban to rural to agricultural and ecological constructs, from glaciers to meadows to riparian systems. Preconditions necessary to ensure successful genesis of the proposed sustainability living laboratory will be based on soundness of the questions posed and acceptance by the communities involved. This endeavor targets the identification of these questions.

Background

Sustainable development has been gaining momentum in the minds and actions of many, since the arrival of this concept on the world stage at Stockholm in 1972 with the first thematic UN Conference on the Human Environment (UNEP, 2004). A more detailed elucidation of the sustainable development concepts was provided by the "Brundtland Report" in the 1980s (WCED, 1987), that was a precursor leading up to the 1992 UN Conference on Environment and Development in Rio de Janeiro, Brazil. The term has become ubiquitous throughout the literature regarding social, economic, and environmental conditions and trends and was highlighted at the recent gathering of world leaders and activists in Johannesburg, South Africa, at the World Summit on Sustainable Development. Notwithstanding the formal definitions offered for this concept (WCED, 1987), a deep understanding of the meaning, challenges, and solutions to this issue remains an elusive target for many regions, nations, and communities faced with ever increasing pressures from climate change, population growth, environmental decline, and social unrest and poverty. And yet, this conceptual compass heading, encapsulated by the term sustainable development, provides the only commonly held objective for a growing international community of dedicated scientists, citizens, and governments who share a concerted belief toward improving the world we live in.

Limits imposed on the potentials for human growth on our planet, regulated by finite resources of land, air, and water has been proclaimed to the world over a century ago (Laszlo, 2001). Buckminster Fuller provided a clear picture of our self-contained life-support system nearly half a century ago using the metaphor of Spaceship Earth, while also reminding us of the infinite resources available to humankind from the sun's energy through science and unlimited resources from our ideas or imaginations for our survival as a species (Sieden, 1989). The Club of Rome (1972) provided a quantitative perspective of immediacy to the global community regarding the chances for survival for many people on this planet using resource projections against the population growth curves. Both information and perspective on the planetary pressures have been available therefore, for some time. Effective action, at the appropriate scales to directly confront the magnitude and scope of these pressures, has been the ingredient most challenging to the people of this planet.

In part, the missing ingredient for effective action can be explained from a quote of Robert Disch (1970):

"The environmental problem, on the other hand, is frequently invisible to the eye; it works slowly, silently, and undramatically; when diagnosed it often requires actions that are in conflict with deeply rooted social and religious values, life styles, and economic systems. In other worlds, the crisis is potentially lethal because it can only be met through levels of international cooperation unknown to world history."

This perspective may identify the pathos of paralyzed behaviors often witnessed with much of the global environmental challenges. Actions, however, that can and do make a difference tend to be implemented on the local, or most appropriate scale and associated with shifts in community values that consequently affect peoples daily habits. The Montreal Protocols for the reduction industrial FCC refrigerants that had proven destructive to the stratospheric ozone layer is a prime example of shifts in community values.

Since the Age of Reason, use of science in the affairs of humans has become more readily accepted. Technological advances over the half-century, related to geo-information and Earth sciences, has demonstrated remarkable potential for enabling and enhancing humankind's mobilization for action towards sustainable development, Figure 1. Beginning in the 1940s the effective birth of our modern age of computing was launched with the creation of the room-sized University of Pennsylvania's ENIAC computer (Foresman, 1998), setting the stage for a staggering pace of development, best captured in log scale by Moore's Law. Geographers began to explore quantitative methods in the following decade to better understand the Earth-human processes. The Soviet Sputnik satellite launched the space age in 1957, adding fuel to the use of computers for the information age. NASA's 1970 Apollo photography of Earthrise, provided a new generation with a greater appreciation of the fragile blue biosphere we live on within a vast and isolated solar system. Launch of the Landsat satellite series in 1972, created the first comprehensive and exacting record of our land management behaviors for the whole globe providing a three-decade planetary history. Satellite data combined with spatial data systems has provided an unprecedented capacity to map, monitor, and manage our planet's resources.

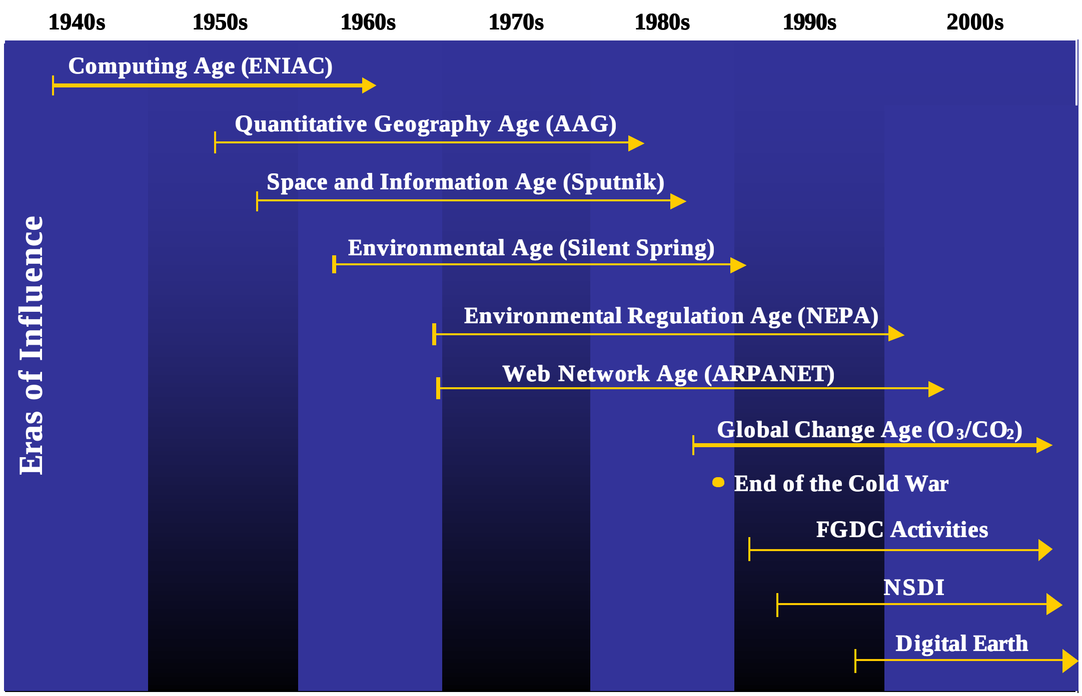


Figure 1. Decadal Trends of Influencing Factors for Geo-Information toward Sustainable Development.

Global awareness for the environment accelerated with Rachel Carson's bellwether book, Silent Spring (Carson, 1962) and mobilized a generation of people who began linking our industrial and commercial behaviors with the welfare of our planet's living resources. The crystallizing effect of this book has been linked to policy makers in the United States beginning with the National Environmental Policy Act, which set into motion a litany of environmental regulations and that helped influence an international community, including the 1972 Stockholm Conference on the Human Environment, which in turn established the United Nations Environment Programme.

Improvements in communications and networking, followed the foundation of the Internet, known then as the ARPANET, which allows for today's unprecedented capacity to exchange ideas and transmit information to all corners of the globe. Concepts of standards, and software tools for the exchange of spatial data and information among cooperating institutions quickly spread across the globe with the establishment of Clearinghouse nodes on all continents for the sharing of geo-information that was championed by national mapping agencies and likeminded industry supporters, for the careful construction of a progressive global network infrastructure for the exchange and interoperability of data, information, as well as suites of tools for analysis, visualization, and decision support (GSDI, 2004). This conceptual framework, or philosophical common ground for the application of a growing global geo-information network had not however, been well formulated or easily conveyed outside the limited domains of the technically proficient pioneers, much less available to the average citizen or political decision makers. This had been the conundrum for the many dedicated geo-information technologists.

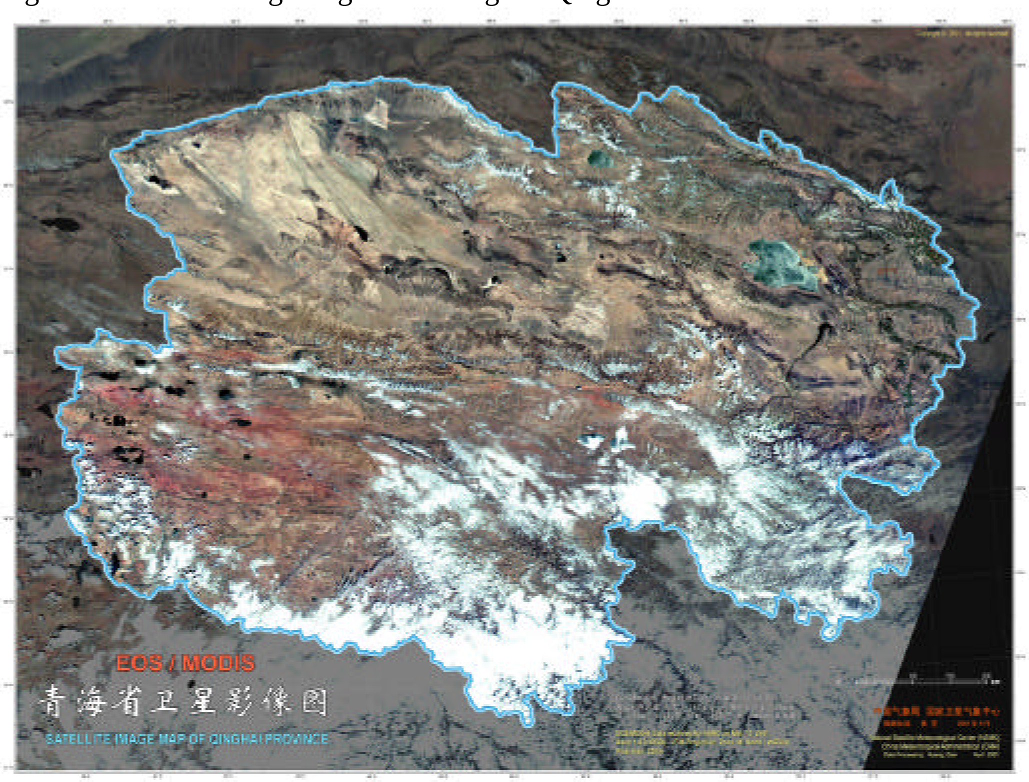
Many visionary leaders have been haunted by the question of how to connect with the people who need these information tools and how to get a non-technical society to utilize these tools for the addressing the challenges of sustainable development

In 1998, Vice President Al Gore presented a speech in a crowed auditorium in Los Angeles, wherein he expressed a vision for the future where a young girl would sit before a virtual representation of the Earth, a three-dimensional digital Earth, and it would provide her with a facility for query about the planet and its resources and about issues related to humans, their history or art, and any other question that could be addressed for science, art, and the humanities. The Digital Earth movement has pursued development of this effective metaphor, much like Fuller's Spaceship Earth, to fully engage non-scientists' targeted use of information technology and various special interests. This rapidly growing international community has recognized the clear path set under this vision to encourage the cooperative study of, and directed actions for, the solutions toward sustainable development. What now remains is the continued development of this vision for clearly identified communities, as they address the challenges of sustainable development and the issues address under the UN Millennium Goals.

Regional Setting for Living Laboratories Case Study

The Qinghai-Tibet Plateau incorporates the Qinghai Province and the Tibet autonomous regions, Figure 2. A varied landform of mountains and basins defines the plateau with world's most notable and highest mountain range providing a distinct geographic demarcation and at the same time delineating the geopolitical boundaries between India, Nepal, and Bhutan the south, and Tajikistan and Kyrgyzstan to the west. These landforms serve as the structural cross bracing for the series of mountain meadows and xeric basins creating a mosaic of ecotypes, at the headwaters of three major Asian rivers; the Mekong, the Yangze, and the Yellow. In the east is the transition part between the Loess Plateau and Qinghai-Tibetan Plateau, which is mountainous and of low elevation, with Xiachuan Mouth in Minhe County, 1,650 meters above sea level, as its lowest point. In the west are plateaus and basins, with Bukadaban, the highest peak in Alge Mountains in Qinghai between Qinghai and Xinjiang and 6,860 meters above sea level, as its highest point. Tibet claims Mount Everest as the highest peak. The difference of relative altitude in its surface structures is as high as 5,500 meters. There are many great mountain ranges over 1,000 kilometers long spanning the province, among which those more than 5,000 meters above sea level are covered with snow all year long and with glaciers everywhere.

Figure 2. Satellite Image Regional setting for Qinghai Province



Qinghai radiates grandeur and glory to residents and visitors alike with the long and high mountains creating its landform. The Qinghai Province, and its capitol city of Xining, will serve as the focal point for the Living Laboratory project engagement. The average height of the Qinghai province is cover 3,000 meters above sea level, of which those regions with a height from 4,000 meters to 5,000 meters above sea level amount to 54% of the total area of the province. All the mountain ranges run either from east to west or from south to north, forming the backbone of the general configuration of Qinghai Province. They include the Altun Mountains that run along the north rim of Qinghai with the base of the Dangjin Mountains as the dividing line with the Qilian Mountains. The northern mountainous area is also rich in mineral resources. The Qilian mountain body runs 2,000 kilometers long from north to west and 350 kilometers wide from north to south. Approximately 3,306 big and small glaciers spread across the mountain range, known for various kinds of minerals and often referred to as “China’s Ural”. The terrain of the province can be categorized into the Kunlun Mountains, Qilian Mountains, Danglin, the Qaidam Basin and the Southern Qinghai plateau area.

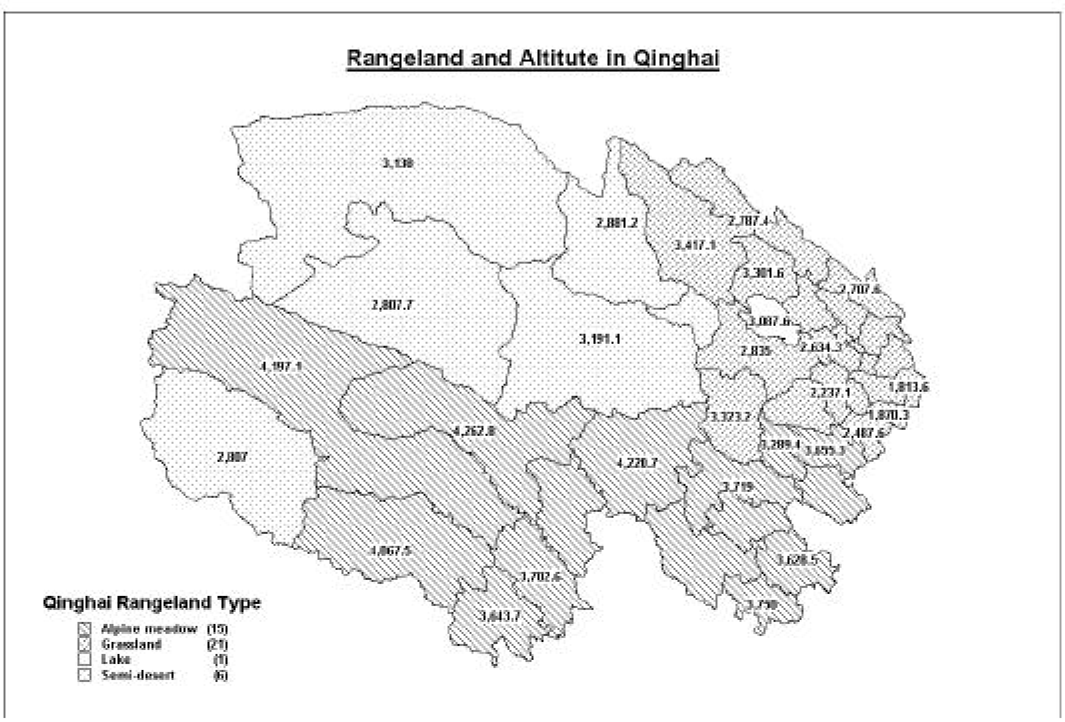
The Kunlun mountains, rising from the Pamirs in the north and running across Xinjiang and Tibet autonomous regions, extend eastward to Qinghai reaching the northwest part of the Sichuan Province for with 2,500 kilometers length and the average elevations between 5,500 to 6,000 meters. East Kunlun Mountain, a part of the Kunlun Mountains, runs along the southern rim of the Qaidam Basin formed by three parallel mountains-the Hohxil, Bayan Har, and Anyemagen. Here mountain ranges stand shoulder to shoulder with rolling snow mountains and big valleys. There are more than 10 mountains with elevations above 4,500 meters. Rich in rare animals and mineral resources, the Kunlun Mountains are famous for their cultural implications in China. Hence it is called “the backbone of China” and “the ancestor of Chinese nation ”.

The Dangla Mountains, rich in various kinds of mineral resources, are situated between the Hohxil Basin and the North Tibetan Plateau, and stretch southeastward to join the Hengduan Mountains where the “Fountainhead” area is formed. Geladandong, its highest peak, is composed of 21 snow peaks located more than 6,000 meters above sea level and scattered with glaciers.

The Qilian Mountain range, lying in the northeast of the province, consists of a series of folded and fault mountains and valleys spreading 1,000 kilometers from east to west and 200-300 kilometers from north to south, with a total area of 110,000 square kilometers, representing about 15% of the total province area. The general height of the mountain range is over 4,000 meters above sea level. The terrain of its west part is high and steep, with modern glaciers growing everywhere. Major natural pastures situated right in the valleys of these mountains, Figure 3, present an ecologically diverse set of rangeland types that supports many types of indigenous flora and fauna, yak, sheep, and nomadic peoples. . Its east part is of low terrain, which makes excellent pastures and the main cultivated land supporting the city centers. The Qilian Mountains, known as “a mountain of treasures”, is abundant with mineral resources.

The Altum, Qilian and Kunlun mountains surround the Qaidam Basin, situated in the northwest of the province. With an area of 250,000 square kilometers, or 35% of the province total, it is 800 kilometers long from east to west and 350 kilometers wide from south to north. As the lowest elevation in the Qinghai-Tibetan Plateau, the basin is 2,675 to 3,200 meters above sea level. High mountains, hills, gobi, grasslands and a series of mostly saline lakes compose the five types of the landform from the edge to the center of the basin. Abundant in mineral resources, the vast and level basin is known as a “treasure bowl”, which in combination with the surrounding mountains has created an area remarked as the largest collection of rare earth minerals in the world (Lu, 2003).

The Southern-Qinghai Plateau, to the south of the Qaidam Basin, Nanshan Mountain and Bayan Mountain in Guide County, Southern-Qinghai Plateau, occupies a vast area of 361,000 square kilometers, approximately half of the province total. Rangeland



stock and herding predominate in this area, which represents the highest elevation in the province. While the surface melts into swamps in summer, the area is scattered with permafrost. The eastern part of Qinghai Province located in this plateau is known as the "Fountain Head" area and serves as the birthplace of the Yangtze, Yellow and Mekong rivers.

Ecology - Located more than 1, 500 km from the East China coast, with little rainfall and plenty of sunshine, the Plateau is home to a host of endemic plants and animals. Ecological drivers include short growing seasons and annual precipitation averages of 700 mm in the river valleys in the eastern part, while that in the Qaidam Basin in western below 50 mm, and many microclimates with approximately 10 mm. The province has a mean annual temperature of 0° to -8°C in the Southern Qinghai Plateau and the Qilian Mountain area and 0°- 6°C in other parts. Qinghai Lake, which is saline, is the largest of a series of lake both fresh and saline. Indigenous species of fish, like the famous scaleless or naked carp are joined by many halophytes and arthropods of interest to biologists and chemist alike. The lakes provide habitat for flocks of migrating and endemic bird species that attracts amateur and professional birders from around the world. There are calculated to be 370 kinds of birds on the Qinghai-Tibet Plateau, of which, 30 are under Chinese government protection. Recent research by Li Laixing, a research fellow with the Northwest Institute of Plateau Biology under the Chinese Academy of Sciences, showed the while the types of birds in the region have remained consistent, the amount of birds, especially rare species, has decreased sharply. Birds of prey, such as eagle have been reduced in numbers rapidly. The black-neck crane, a worldwide endangered wildlife species, is a rare bird that can only be seen in the remote areas of Qinghai-Tibet Plateau, and the adjacent Yunnan, Sichuan, Guizhou provinces. Expansion of agricultural areas and the shrinkage of wetlands further exacerbate the considerable drop in habitat used by flocks of the black-neck crane leading to a considerable drop in species numbers. Owing to the decrease of many birds of prey, rats run rampant in some pastoral areas causing sever rangeland damage. These factors are pushing a biological chain of events on the Qinghai-Tibet Plateau that is reaching alarming proportions in terms of degraded hectares of the landscape and shifts in community structure.

Social/Cultural – The population increase over the past couple decades has been the result of a Chinese programs that forced emigration to the province. Current estimates range from 5-8 million people that demonstrate a wide range of cultural backgrounds representing people of the Tibetan, Hui, Tu, Salar, Mongol and other ethnic groups. The Taer temple defines a major Buddhist influence for the region that now blends with a mosaic of religions, included Islam. This multi-cultural setting provides for a colorful array of foods, fabrics, and festivals; which presents a strong attractant for national and international tourism.

Economic - Agriculture is an important component of Qinghai's economic base with livestock breeding a major activity. Livestock includes sheep, yaks, pian niu (crossbreed of bulls and yaks) and horses. Qinghai produces large quantities of sheep wool, meat, leather and sausage casings for other parts of the country. It is also an important producer of medicinal materials, such as caterpillar fungus, antlers, musk and rhubarb. Recent investments in modern pharmaceutical and medical laboratories have been based in part on recognition of the medicinal resources of the region. . The province grows spring wheat, highland barley, broad beans, potatoes and rapeseed.
Qinghai's industry is base on an array of rich resources including petroleum, lead, zinc, copper, chromium, cobalt, nickel, iron, asbestos, mirabilite, gypsum, lake salt, potassium, boron and coal. Historically, Qilian Mountains are called the "Treasure Mountains" and the Qaidam the "treasure basin." The area is also home to the world's largest collection of rare-earth minerals, which are becoming increasingly sought after for high-technology manufacturing.

Political – The region is divided in terms of the stability of the political setting. Qinghai Province is maintained under the normal relations with the Chinese government, while the Tibet autonomous region experiences contested governance by the Chinese who have occupied Tibet for decades.

B. Key pressures [sections to be completed]

Climate change
Land use degradation
Economic policy shifts
Demands for decentralized command and control
Recognition of limits to growth

Cold and arid continental climate with limited opportunities for agriculture
Very low population density; relatively poor area facing access and communication problems
High priority given to developing sustainable and productive rangeland management systems
Good potential for tourism **[http://www.icimod.org.np/rcp/hkh.htm]**

Recognition of Sustainability Underpinnings

Ecosystem goods and services

Toward the end of the 20th Century, economist began thoughtful reexamination of the calculus used by schools of economics regarding the valuation and assessment of natural capital, especially as used in national comparisons statistics, such as the GNP. Led by scholars and field researchers, this reexamination triggered an international movement to questioning the basic assumptions that the economic world had relied upon for centuries. A clarion call for taking stock of the real value of ecological services and goods was established by Costanza and his colleagues (1997) who raised the world's perspective of the multi-trillion dollar value of our planet's ecosystems. This momentum was continued by the international collaboration, led by the World Resources Institute, to begin a comprehensive, global assessment of the ecological goods and services (Alcamo, et al, 2003). In addition to the significant contribution that results from teams of interdisciplinary scientists conducting this unique global survey, is the knowledge bases that are being created at multiple loci that can be applied to regional valuations more in tune with local cultural values. Current MA efforts in China will be incorporated in the Qinghai-Tibet Living Laboratory.

Ecological footprint

Advances in understanding better the impact of lifestyles on the Earth's ecosystems have been evidenced through a plethora of web sites that offer ecological footprint calculation programs. The genius behind this concept is in translating the real impacts of consumption patterns into land area measurements that define the use, or overuse of the land (Wackernagle and Rees, 1996). Similar to the ecosystem valuation approaches of Costanza and colleagues (1997) and the Millennium Ecosystem Assessment (Alcamo et al, 2003), the ecological footprint provides a potent communicating metaphor with a non-technical audience, and hence the opportunity to engage a greater community into awareness and action to seek paths for sustainable development (Chambers *et al*, 2000). Due to the demonstrable success of the ecological footprint approach with the general public and schools, these principles and tools will be introduced into the methodologies for the Qinghai-Tibet Plateau program.

Human-Ecosystem framework

As noted early, while the concept of sustainable development has enjoyed increasing levels of attention and appears frequently in the literature, a universal agreement as to its constituent parts remains elusive. Indeed the Harvard initiative for Sustainability Science attests to the nascent state of our philosophical framework for this critically important topic. A framework is therefore needed to establish an objective perspective for community involvement and understanding of the development process that will unfold as the program for a Living Laboratory matures. The human-ecosystem model or framework (HEF) was developed by social scientists and ecologists to address the need for a common understanding in communities along urban and rural settings (Machlis et al, 1997). The framework has been tested in a variety of research and operational settings and has proven to be effective as a first line organizational construct for incorporating the elements of sustainable development assessments into community settings (Pickett el, 1997). The HEF will be used to initiate the Qinghai-Tibet Plateau community dialogs.

Decision support framework

The process of decision-making has formal and informal influencing components. Formal decision-making processes included such actions as the filing of plans and designs, the review by sister agencies and allowance for public hearings, as well as the legal and engineering documentation for the numerous implementation stages and inspections or audits to any project/program. Examples for these decision-making processes can be seen in environmental impact assessments, permit applications for construction, and public works projects. A myriad of informal elements exist that also may function as influencing factors to the decision-making process. These informal influences may be considered separately or viewed as integral to the process. Such factors as public opinion, influence peddling, and corruption must be recognized on defining the impact of information on decisions whether they can be quantified or not. This combination of factors and stages which allow interaction of stakeholders along the decision-making process can be expressed as the impact-of-information chain (Figure 4).

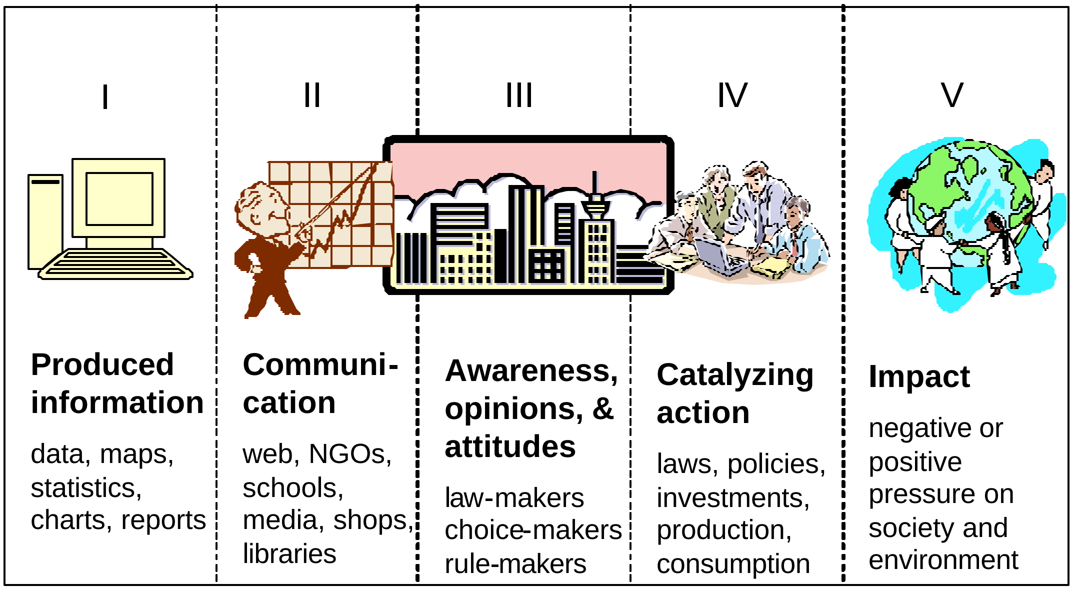


Figure 4. Impact-of-Information Chain (adapted from Denisov and Christofferson, 2001)

Impact-of-Information Chain

The information-chain model can be used to help define the many points of interaction for information as it transitions along the decision-making process among the many types of stakeholders that may be involved. By acknowledging these many interface points, it can be shown that information has value to many stakeholders along this pathway, and that feedback from various groups will be crucial to ensure independent perspectives to any assessments or evaluations and thereby both enhance the quality of the decision-making outcome, and as importantly, provide requisite ownership of the final decision by a larger group of stakeholders or community. This helps define the essence of the value of government-community partnerships and should be an inherent design consideration in the creation of information partnerships for ecosystem protection and other inherent parts of sustainable systems for humans.

Involving citizens/communities into the decision-making process with governments can improve the efficiency of the process by enlarging the monitoring and comment opportunities. However, the extra resources traditionally required by the government to interact with the community and the explicit challenge to the governments' proclivity for decision-making autonomy and authority have resulted in few governments advocating for increased citizen inputs. It has only been through the progressive international awareness of citizen's rights to information and the call for governments to encourage information partnerships that advances have been made towards these cooperative arrangements. Agenda 21, from the Rio Earth Summit, explicitly defined both the need to bring science into decision-making and to engage all segments of society in the process. Aarhüs Convention promoters raised international support for community rights to environmental information (Aarhüs, 2004) The UN Secretary-General, Kofi Annan, further raised the understanding that the information and decision-making process for sustainable development must incorporate Type II Partnerships, which include government, NGOs, industry, and academic sectors. Such arrangements are gaining academic interest for studies to discriminate the effectiveness of such approaches and evaluate their successful characteristics (ISTS, 2004, Alcamo et al, 3003)).

Targets for Information Partnerships

Examination of the information-chain (Figure 4) reveals that numerous targets of engagement of partnerships exist along a continuum. It is not likely that all partnerships will remain fully engaged at all stages along such a process, but a more reasonable expectation would be for a variety of government-community partnerships to be exhibited at the most appropriate phases of a project or program's lifecycle. Scientists and academics would likely lead these information partnerships at the initial stage (I) of producing data and statistics. Stage II would include many community partnerships including schools, libraries, and the media. Stage III should incorporate the government leadership process for creation of laws, regulations, permitting, monitoring, and financing with full engagement of various community sectors, as consumers or operators. Stage IV brings forth the government-community partnership through catalyzing actions that have community acceptance for new mandates, social norms, or marketing shifts. Stage V represents the implementation and operations in the world setting that consequently impact all citizens and again reinforce the need to keep tight the information partnerships throughout the processes.

By analyzing the important target groups along the information-chain, government organizations can focus attention on ensuring more comprehensive communications with these identified constituencies. Technological advances offer unprecedented opportunities to fully engage communities with governments, as demonstrated in the various papers for this symposium on e-government, community risk assessment, and the MANGO (2004) and LEAD (2004). While continued development on the technology is needed and encouraged, the greater challenge remains with fostering participation by community stakeholders. Non-democratic societies remain unfamiliar with decentralized information sharing and participatory governance and therefore require careful strategies for engagement, while democratic societies too often avoid civil participation from either sloth or ignorance. Regardless of citizen or governance origins, the basic features of information partnerships are becoming innate features of the Internet environment (exceptions remain in state-controlled regimes). These features include instantaneous and distributed access to increasing networks of data and tools that can be used to communicate social, environmental, and economic dimensions of communities. Learning how we might best frame government-community information partnerships and how to integrate the full spectrum of stakeholders into the complex and comprehensive world of decision-making may be the primary task at hand, especially as we face the challenge of introducing human-ecosystem concepts to the process.

[section to be completed]

Technology
Institutions
Societal participation
Process flow, info
Political-cultural acceptance
Collective or multi-scale mobilization/capacity
Coping capacities/strategies
Effective feedback loops

Discourse on Potential Scenarios for the Qinghai-Tibet Plateau Living Laboratory

Assuming that the initiative described for the Qinghai-Tibet Plateau continues on course, a number of outcomes can be explored. First, the alignment of citizen, academia, industry, and government segments of society into a long-term dialog of pathways for their future represents a milestone of some import by itself. The current success for this alignment appears to be based in part on both the energy and contributions of a group of international scientists (ACE, 2004), but more profound is the recognition of the Chinese government officials and university faculty in the clear need for corrective actions to prevent ecological disaster and the consequent and resulting human suffering. With the increasing decentralization of political power in China, the provincial governments take on a greater role in defining their paths to the future, albeit with negotiated arrangements for financial and public projects management. Issues like water projects have demonstrated the power of government directives over the scientific and local authorities control. Nevertheless, there is increasing evidence that provincial autonomy may be enhanced if sufficient consensus is developed from all sectors. This consensus must be based on the best of science input and the full participation of the citizens. The university setting will serve as the nucleus for institutionalizing a community decision-support system for sustainable development. Qinghai University, with its full range of academic departments, in collaboration with Peking University and the Chinese Academy of Sciences will host the proposed Living Laboratory.

Initially the Living Laboratory's evolution will focus on issues of local education, technical training, networking to regional and global support resources, and help facilitate the community-based decision-support forums aligned with ongoing development projects and future program developments. The Laboratory will combine the assets and resources of the province with advances in science and technology transfer that are appropriate for the education and training characteristics of the teachers, students, and government staff who will be challenging the goals for sustainable development and environmental conservation. The proposed approach uses the best-practices available from Chinese and foreign scientists to support information fusion, modeling, and visualization as the capacities and capabilities of local talent are enriched and enhanced through hands-on collaborative development. Key features include:

- Qinghai Center of Environmental Excellence for incubation and local application of real-world assessments and decision support located at Qinghai University, and to attract international research scientists,
- Capturing and highlighting environmental-ecology theme for the university to global community; to foster creation of a respected Qinghai-Tibet Plateau center,
- Application of multi-scale government an d international partnerships to design and operational framework,
- Alignment of leading global programs and initiatives to remove risk during development and for obtaining financial, material, and human support resources, and
- Innovation in "living laboratory" concept for the discovery and fusion of sustainable development "new science" components and issues relevant to the regional human and ecological conditions and policy makers' experience.

A selection of specific science and technology disciplines will assist in the centre's creation and support system design in collaboration with a team from Qinghai. The technology transfer education and training team will represent the expertise necessary for design and construction of an integrated system related to environmental and watershed management and protection, spatial information management and visualization, Internet and Digital Earth network technology, sustainability science, risk and vulnerability assessment, and community-based decision support modelling. The collaboration activities will focus on performance of the majority of activities at the centre. Experts will be judiciously applied on site in Qinghai to ensure full technology-transfer for all phases and process associated with the project.

The center will maintain all technology resources (data, software, and hardware) for the performance of the community-based decision support system. Connection with the Centre for Internet services of data resources, educational materials and curricula, and project administration will utilize the Digital Earth network (including "863" achievements), especially the nodes from Japan, China, and North America. The International Society for Digital Earth will guarantee that all available regional information from satellites (remote sensing), geographic information systems, field collection databases, and statistical survey information (Chinese, UN, and international agencies) is accessible through the center. The operational decision support system for community-based fora for sustainable development of the region will be installed at the center on the Qinghai University campus.

In a multi-year implementation scenario, it is expected that the center will continue to function in concert with a series of evolving sustainable development projects that are introduced to the province through education, science and technology, development, tourism, and other agendas for national progress. Step one will be for the design, construction, and implementation of a community-based decision support system (CBDSS) with project tasks organized into three phases, as follows:

- Phase 1 – Technical workshop for design layout. The management team will bring together experts with a key team of local representatives teachers, students, and government representatives to design the informational components (database) and the processes and procedures (design support system) for conducting community fora. Results from this phase will 1) identify and engage key members of the Qinghai team, 2) conduct technology transfer on the design process, and 3) generate a plan for roles and responsibilities in constructing the CBDSS.

- Phase 2 – Construction of community-based decision support system. The management team will coordinate the construction of information components, in cooperation with the Qinghai Centre team of students and teachers, and synthesis the automated ingredients for the CBDSS from a team of global experts from China (CAS and Universities), Japan (government, university, and industry, and North American (university and industry). Results from this exercise will 1) identify the local information resources, 2) network the Centre to information and application programs from the International Society for Digital Earth network, 3) provide on-site technology transfer training, with Internet curricula support, for remote sensing, GIS, environmental modelling, and decision support process, and 4) manufacture an operational decision support system for the Centre.
- Phase 3 – Implementation of CBDSS. Under the direction of the Qinghai University president, with technical assistance of the management team, the centre will conduct a series of community meetings to assess the multiple development projects for environmental balance with the social and economic sectors of sustainable development. The Centre will provide information fusion of the geographic and sector impacts and generate alternative visualization scenarios for the community to review. Output from the community meetings will be used to develop consensus on the prioritising of development projects and the integration for these projects for sustainable development goals of the region. Results from this phase will 1) provide technology training to university staff on application of the CBDSS, 2) transfer operations of the system to the university president and Centre, 3) enable full integration for project evaluations and development planning, 4) inaugurate new series on Sustainable Development Community Meetings, and 5) generate prioritising scenarios for government decision makers.

Conclusions

Technological advances in remote sensing, geographic information systems (GIS), and community decision modeling offer unprecedented opportunities to engage a wide range or audiences with regards to the challenges of protection, managing, and promoting sustainable development for communities and protect the ecosystem goods and services. Experience is being gained throughout the globe with community-based projects and programs that demonstrate great promise for improving the decision-making procedures for local and regional communities, such as LEAD (2004), MANGO (2004). Lessons from these community projects are being collected and studied by various initiatives with the goal of advancing new understanding for applying methods, tools, and interested networks of supporting institutions to an improved future (ISTS, 2004; ISDE, 2004). The value of information partnerships between government and communities will need to be promoted through international programs at multiple scales in real-world community settings to accelerate and transfer knowledge about these advances.

For the Qinghai-Tibet Plateau, there exists a critical mass of regional awareness by the community for the need to address and correct the current path towards an unsustainable future with increasing losses of ecosystems services. This awareness has attracted a cadre of scientists dedicated to creating a center that will foster the development of science-based community decision-support system. It will be incumbent on all participants to recognize the probable need for a radical paradigm shift in the consumption and production behaviors of the region to meet objectives of sustainability.

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