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INFORMATION NETWORKING AS AN INSTRUMENT OF SUSTAINABLE DEVELOPMENT: THE PHOTOVOLTAIC EXAMPLE

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Abstract

Increased information sharing and participation in political planning can empower rural communities to make informed decisions about their development paths. A two-fold approach is proposed to advance communications for sustainable development. Improving information content and improving the outreach of the network are the two key elements of any successful communications project. This thesis will investigate one novel initiative for improving the content of information on sustainable development, one novel initiative for increasing access to this information, and use one example to illustrate the potential to build capacity for both activities in rural areas of developing countries. A strategy for implementation of a decentralized communications network for exchange of information on sustainable development is proposed.

A parallel development activity investigated in this thesis is rural electrification by means of solar photovoltaics. The combination of photovoltaics (PVs) and communications provides an example of *co-capacity building* , in that the implementation of one builds capacity for more successful implementation of the other. Photovoltaics are proposed as a means to power the network telecommunications equipment, for three reasons:

- (1) PVs have proven to be a reliable source of energy for communications technologies in remote areas;
- (2) PV use for communications technologies in rural areas will serve as an example to promote the use of PVs for general electricity supply; and
- (3) PVs are one of several sustainable energy alternatives that will benefit from the information sharing inherent in the use of the proposed communications network.

This thesis intends to explore some of the opportunities and issues associated with this co-capacity building in order to encourage more informed decision-making for information technology investments and sustainable development endeavors in developing countries. A strategy which encompasses the two objectives can result in progress greater than an improvement of each of the parts.

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Introduction

1.1 Communications and Sustainable Development

Technological innovations such as the internet, cellular phones, personal computers and the world-wide web have enabled communications to proliferate at an unprecedented rate and low cost. Information technology can now be used as a tool for important development efforts. Many nations claim internet connectivity and sustainable development as priority objectives. The two goals can often be intertwined. This thesis will investigate the use of information technology as an instrument of sustainable development.

The issues surrounding the combination of information technology (IT) and sustainable development are important to understand for several reasons. First, most of the literature on the topics focus on one or the other. The interface of the two has for the most part been considered only since the Earth Summit[1] in 1992, when the Internet was beginning to surface as a ubiquitous medium for data exchange (primarily in the North). Now there is no shortage of rhetoric praising the possibilities of the combination, but a closer look begins to reveal the mammoth challenges which lie ahead. It is in large part the decisions made by all actors - funding agencies, consumers, and governments - and the "disconnects" among them, which pose the greatest barriers to realizing a communications network for sustainable development purposes. It is the hope that this thesis will bring some of these issues to light in order to encourage more informed decision-making for IT and sustainable development plans. A strategy which encompasses the two objectives can result in progress greater than an improvement of each of the parts.

International Recognition

The international community has demonstrated, through collaborative documents and treaties, an acute awareness of the need for more information sharing on sustainable development, and has in some cases demonstrated a serious intention to meet those needs. The Earth Summit was one of

[1] Earth Summit is otherwise known as the United Nations Conference on Environment and Development (UNCED) held in Rio de Janiero, June 1992.

the more productive catalysts for global environmental accords, with the Rio Declaration, Agenda 21, the Earth Charter and Alternative NGO Treaties all making reference to the importance of information access, capacity-building for increased communication, and exchanges of scientific information and environmental data.

Agenda 21 is "a blueprint for global sustainable development into the 21st century." Over 500 pages in length, it proposes international cooperation to address "the pressing problems of today and also aims at preparing the world for the challenges of the next century."[2] One of the most salient calls for communications networking is Chapter 40 in Agenda 21. Box 1 is a summary of this chapter.

Box 1 Agenda 21, Chapter 40: Information for decision-making

(1) Bridging the data gap, and (2) improving information availability are the two program areas that are the basis for action in this recommendation. "The flow of information is seen as vitally important to all areas of Agenda 21, to ensure that decisions made by everyone from senior decision-makers at the national and international levels to Grass-roots and individual levels are based on sound information. There is a need for more efficient collection and assessment of data and for improved coordination among environmental, social, demographic and development data. There is a tremendous gap in the availability, quality, coherence, standardization and accessibility of data between the developed and the developing world."

Source: Rogers (1993) in Simms (1997) (*sic*).

Two years later, U.S. Vice-President Al Gore spoke at the first World Telecommunication Development Conference of the International Telecommunications Union in March 1994. He defined the Global Information Infrastructure as a "planetary information network that transmits messages and images with the speed of light from the largest city to the smallest village on every continent" (ITU 1995).

Connectivity, Content, and (Co-) Capacity Building

With the advent of satellites, this "global village" could theoretically be created, whereby any two points on earth can communicate almost instantaneously.[3] But reality insists that some of these villages have a few priorities ahead of receiving messages and images from large cities at the click of a mouse or tap of a key. One obvious question is, how relevant is this information to the needs of smaller communities? If these hypothetical communities consist of rural low-income families,

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[2] Preamble to Agenda 21 from URL gopher://gopher.undp.org:70/00/unconfs/UNCED/English/a21_01

[3] Assuming transmission between satellite and two groundstations is seamless (i.e., the satellite is positioned such that it can "see" both groundstations, or there is efficient routing among other electronic network options).

the latest in high-tech audiovisual communication is not on their agenda. This thesis is concerned with the information needs of rural communities in developing countries. Increased information sharing and participation in political planning can empower rural communities to make informed decisions on their development paths, something that "top-down" initiatives cannot accomplish with just one broad brush stroke.

To this end, an enabling institutional mechanism is the cooperation among non-governmental organizations (NGOs), governments, multilateral institutions and local communities on the use of a decentralized communications network for exchange of information on sustainable development, and for development program evaluation, implementation, and monitoring. Such a communications strategy can not only help build capacity for sustainable development efforts in rural areas of developing countries, but can itself be reinforced by appropriate development activities.

The parallel development activity investigated in this thesis is rural electrification by means of solar photovoltaics. Photovoltaics (PVs) and communications are "co-capacity building" initiatives, in that the implementation of one in a rural area builds capacity for more successful implementation of the other. A communications strategy which employs solar photovoltaics for remote power takes advantage of this co-capacity building; a comprehensive strategy for implementation is explored in Chapter 4. In order to avoid the monotony of repeatedly referring to this strategy as the "proposed network," "prototype model," or some such variation, I have chosen to call it SUCCESS (Sustainability Using Communication and Community-based Environmental Strategies). SUCCESS is proposed as a capacity-building strategy for sustainable development in general, and rural electrification in particular.

The term "communications network" espoused in this thesis includes "the set of devices, mechanisms, and procedures by which end-user equipment attached to the network can exchange meaningful information" (Saadawi *et al* 1994: 8). But a *network* as investigated in this thesis goes beyond exchanging electronic bits of data among digitally connected users, to outreach into marginalized communities using traditional communications conventions. We shall see in the next chapter that combining old technology with modern technology can be an effective "new" method to increase information sharing with rural communities of developing countries.

Two-fold Approach

A two-fold approach is needed to advance communications for sustainable development. On one level there is the information content, which can either provide information where it was not

formerly available, or facilitate information-sharing among those who have access to it anyway. The other equally important issue is the outreach of the network, so that the information conveys knowledge to those who need it most, not just to those with access to sophisticated electronic networks. Choucri (1997) groups these considerations into three distinct and convenient concepts: connectivity, content, and capacity. This thesis will investigate one novel initiative for increasing connectivity, one novel initiative for improving content, and use one example to illustrate the potential for capacity-building.

Connectivity means the ability for users to tap into a communications network (via e-mail, real-time direct links, message store-and-forward, or even manual procedures), and the technical expanse of the network itself. The Sustainable Development Networking Program (SDNP) is a United Nations led communications network designed to provide populations in developing countries connectivity with information related to sustainable development.

Content refers to the quality and function of this information. The information must be relevant *and* logically organized in order to be useful. Content is more functional if it moves beyond simple static communications to more substantive and dynamic information sharing. An example of a content initiative is the Global System for Sustainable Development (GSSD), under development at MIT. GSSD is an internet-based platform for coordinating quality-controlled information on and approaches to sustainable development.

Capacity is the synthesis of communications connectivity and information content to provide support for actual sustainable development projects. Rural electrification by means of photovoltaic technologies is one such sustainable development initiative. "Capacity-building" according to the United Nations Development Program is described in the following: "The ability of a country to follow a path of sustainable development is determined by the capabilities of its peoples and institutions. Capacity building is the sum of efforts needed to nurture, enhance and utilize the skills of people and institutions to progress towards sustainable development."[4]

The majority of this thesis will investigate issues surrounding connectivity, content, and capacity for rural areas in developing countries. These three characteristics can be thought of as dimensional parameters, as shown in Figure 1.1.

[4] From "What is Capacity 21?", UNDP document from gopher mail server gopher@nywork3.undp.org, March 30 1997.

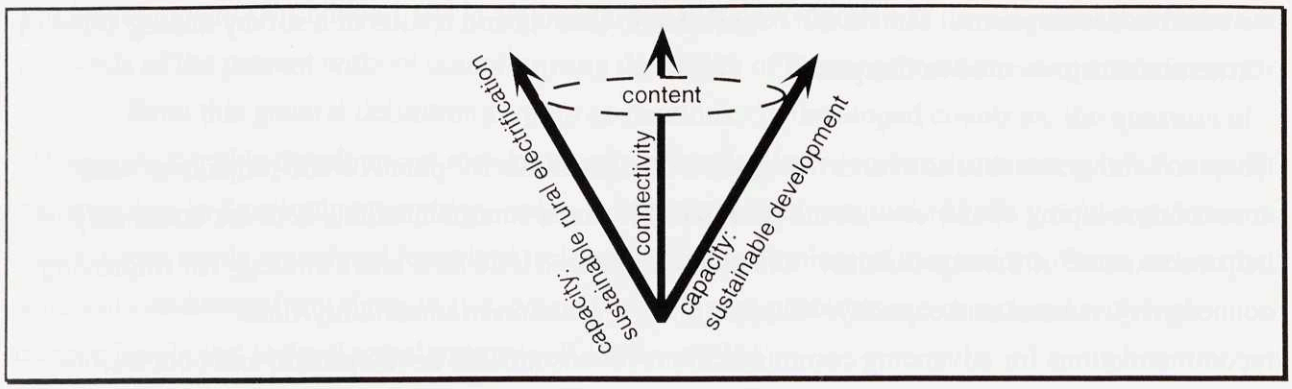

Figure 1.1 The Connectivity, Content, and Capacity Dimensions

The figure actually shows four dimensions: connectivity along the vertical axis, capacity for general sustainable development on the right axis, and capacity for photovoltaic implementation on the left axis. The fourth dimension is content, represented as the area mapped out by the dotted circle, which increases the further a community is along the connectivity and capacity axes. It is proposed that a communications network combined with the use of PVs can increase the "3Cs" of rural, low-income communities more so than development strategies which ignore this co-capacity building. This brief explanation serves as an introduction to the visualization of the "3 Cs" concept, which is developed throughout the next chapters and presented in full in Chapter 4.

Thesis Overview

This thesis focuses on building capacity for *rural* sustainable development initiatives. The purpose of this research is to identify novel initiatives involving either connectivity, capacity, or content for the purposes of sustainable development. The contributions made in this thesis stress the integration of communications technologies and photovoltaics to enhance the "3 Cs." The specifics of the operational mechanisms behind each initiative, are referenced to in either an appendix or in an external reference.

After a discussion of relevant development issues, background will be provided on SDNP and GSSD. The rest of Chapter 1 will present some of the problems, information needs and challenges for sustainable development initiatives in developing countries. This review builds a context for understanding the institutional issues surrounding implementation of a communications network for sustainable development.

Chapter 2 addresses key features of existing communications strategies for sustainable development, with a discussion of the complementarity between information technology and

sustainable development. The SDNP experience in Bolivia and results of a survey among some of its members is presented in Chapter 2.

Chapter 3 integrates results of an investigation on constraints for photovoltaic projects in rural areas of developing countries with the potential role that a communications network could play to help solve some of these problems. Chapter 4 presents SUCCESS and a strategy for improving connectivity, content and capacity. Chapter 5 is a discussion of uncertainty/risks, recommendations for advancing communications for sustainable development, and conclusions.

1.2 The "Web" of Sustainable Development

> *We worship — or rather not worship but respect — a lot of things to do with the natural world, the most important things for us. For instance, to us, water is sacred. Our parents tell us when we're very small not to waste water, even when we have it. Water is pure, clean, and gives life to man. Without water we cannot survive, nor could our ancestors have survived.*
>
> *— Rigoberta Menchú*

In a dialogue between "northern," or industrialized countries (ICs) and "southern," or less developed countries (LDCs), the term "sustainable development" is rife with controversy. Developing countries are sensitive to the clamor for environmental preservation championed by industrialized countries. LDCs feel that the urgency for sustainable development has been imposed upon them while the more developed countries rejected conservation in a rush for industrial development expedited by a myopic vision of cheap and harmless energy.

Yet Rigoberta Menchú's quote exhibits an acute understanding of the need for sustainability, and, more importantly, of the dangers inherent in pursuing an irresponsible growth model. The natural capital she and her fellow Guatemalan natives now enjoy is a function of that bequeathed to her by her ancestors. As her region develops, the importance of a depletable resource such as clean water is respected: there is a trade-off between consumption today and savings for tomorrow. For some communities this idea has been implicitly internalized by ritualistic agrarian practices: "We must only harm the earth when we are in need. This is why, before we sow our maize, we have to ask the earth's permission" (Burgos-Debray 1992: 56). These kinds of traditions existed generations before the term *sustainable development* became popular.

There is a fundamental difference between the North and South even in the mere consideration of a definition for sustainable development. The United Nations World Commission on Environment

and Development (Brundtland 1987) defines sustainable development as development that "meets the needs of the present without compromising the ability of future generations to meet their own needs." Even this general definition is quite contentious. In developed countries, the question of defining sustainable development may be merely of academic or economic interest, while for many communities in developing countries, *today* it is a question of *survival*. LDCs would argue that their current needs are related to underdevelopment and technological stagnation. These are vastly different conditions from those in ICs, where development problems are associated with high income levels and technological progress (Karshenas 1994).

Nevertheless, the North and South share some commonalities on "sustainable development" — independent of a blanket definition. Sustainable development is seen as a priority for ICs and LDCs alike, as evidenced by the Earth Summit documents. Given their different perspectives, however, sustainable development must be a dynamic notion, acted upon according to the needs of the region and the beliefs of the actors involved. "Sustainable development," according to the Brundtland Commission, involves a trade-off between consumption today and savings for tomorrow (future generations). But there are also trade-offs between retaining cultural values and cultural homogeneity (e.g., resettling indigenous peoples for more financially lucrative land-use); between "development" as affluence or as improvement of living standards among the poor; and between resource exploitation or investment in research and development for technological innovation, to name a few. There is an inherent compromise between the pairs of diametrically different choices, but not to the exclusion of extensive linkages between the decisions and an interconnection among them all at a higher level of abstraction. The trade-offs and links which make up this dynamic notion of sustainability is represented in Figure 1.2.

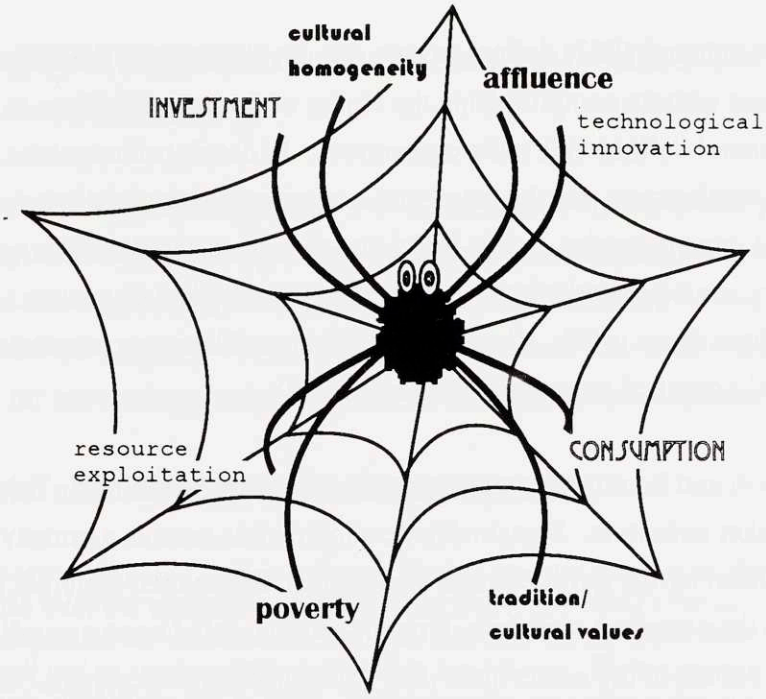

Figure 1.2 The Sustainability Spider[5]

Aesthetic entertainment aside, the "sustainability spider" does express several relevant concepts. The web background serves as a reminder of the far-reaching implications and interconnectedness of any particular development choice. "Success in one set of activities (such as construction, for example) can generate major failures in another (forestry, most notably)" (Choucri and Baker c.1996). The web also resembles the delicate balance between sustainability, and defeat due to powerful external forces. Conditions such as population growth, and the state of technology and natural resources may prevent certain populations from operating within a lifestyle that is sustainable into future generations. The legs of the spider represent, in opposite pairs, the core trade-offs as described above. It is the extent of these trade-offs which "define" sustainable development according to any actor. Working from outside a static notion of sustainable development, rural communities can prioritize their objectives and incorporate (their own) notion of sustainability into their activities.

[5] The author would like to thank Jon K. Magliola, Graphic Designer, for designing the "web" in this diagram.

1.3 The "Disconnect" Problem

One of the problems with a static notion of sustainability is that development projects supported by "top-down" initiatives are often unrepresentative of the needs of the poor in rural areas of LDCs. "Top-down" refers to global regimes such as multilateral agreements, global environmental treaties, and bilateral activities (e.g., joint implementation).

"Top-down" sustainable development projects initiated by multilateral agreements have often failed because the communities affected are removed from the decision-making and feel no responsibility towards their success. Additionally, development projects, no matter what the scale, need enough technical and human support to be able to see the project through to fruition. This lack of participation among the poorer communities is counter-productive to sustainable development. After all, there is a correlation between poverty and environmental degradation — if survival is the immediate objective, poor communities will not place a high priority on *sustainable* development. These differences lead to a real "disconnect" between international, national, and local activities concerned with sustainable development.

The World According to Whom?

A global regime can be thought of as an international political convention in which a set of actors agree in principles and expectations on a given subject.[6] Have the negotiated intentions translated into help for rural communities that are struggling to develop sustainably? If any assistance to these small scale efforts has trickled down from global regimes, the path has indeed been tortuous.

Limitations of global efforts

Unfortunately, many global environmental regimes draw accord merely from the common denominators of agreement among nations. If any number of countries could agree on goals (and translate them into enforceable domestic laws), a global environmental treaty could actually mandate projects and practices that are consistent with sustainable development. One of the biggest problems with the top-down approach, however, is finding common ground. Susskind (1994) suggests three obstacles to cooperation in negotiating an agreement: (1) the North-South ideological divide; (2) national sovereignty as an immutable right[7]; and (3) the lack of incentives

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[6] Owen Greene (1996) has a similar definition: "A regime is thus seen as an international social institution," and cites Krasner (1983) that "an international regime is . . . a set of principles, norms, rules and decision-making procedures around which actor expectations converge in a given issue area."

[7] For the sake of mitigating environmental problems, there is an emerging conscientiousness of states to cede some of their national sovereignty. "The effective management of such problems requires the coordination of international

for enough nations to seriously consider a course of action in response to environmental threats. Given these formidable obstacles, political differences among all parties can quickly dwindle the best intentions down to little or no action.

Another constraint on these "best intentions" is that treaties only bind states that agree to abide by them, after an arduous process that may be beyond the time frame of many development needs. *First* treaties are formed through negotiation. *Second* they are signed by diplomats. *Third* the national governments decide whether to accept them. The government signature does not bind a nation — the treaty must be *ratified*. In the US, the administration can sign it, but the House and Senate must approve it by a 2/3 majority. All this means that it takes a *long time* for any international environmental treaty to effect action.[8] Large development projects have a similarly large time scale. Empowering local capacities to act on their own bypasses such inefficiency.

Nevertheless, international environmental negotiations have at least served as a forum for discussion and formulation of policies to address global environmental problems. An approach adopted at the Earth Summit places emphasis on proactive environmental policies even in the face of uncertainty. The "precautionary principle" (UNCED 1992) reads: "In order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation."

Thus the international community is realizing the need for environmental actions which can reduce risk and eliminate problems before they start. But often, inter-governmental forums do not consult remote stakeholders, and it may be the local poor who have the most information on the use of and impacts to their environment. Low rural participation may be due to lack of ability to communicate down to the local level, and/or lack of effort on the part of global regimes to increase participation.

Global benefits from local efforts

The sustainable development initiative used as an example in this thesis is photovoltaics for rural electrification. Building capacity for these efforts can both assist communities to implement rural electrification programs consistent with (their own) notions of sustainable development, and

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policy. It even requires countries to suppress domestic activities to preserve the environment outside their traditional jurisdictions." See Haas and Sundgren in Choucri (1993).

[8] To put this in context, the Law of the Sea took fourteen years to negotiate, and the Ozone Layer Convention more than three years (Sand 1991).

actually further the objectives of global environmental regimes. Photovoltaic energy systems in rural areas are local projects which carry global benefits (displacing carbon dioxide from fossil-fuel energy sources); regional benefits (generating electricity without acid deposition); and domestic benefits (reducing indoor air pollution from kerosene lamps).[9]

Any benefit to the global environment due to small-scale sustainable development efforts can accrue whether or not the projects are hosted by developed or developing countries. Although the focus of this paper is on projects implemented in developing countries and in Latin America in particular, this is in no way intended to discount the potential benefits of appropriate development in ICs. There are indeed good arguments as to why sustainable development should start with ICs: there is a certain justice in the "polluter pays" principle; ICs have greater access to capital; and relatively lower cost of capital over time (i.e., lower discount rates) make ICs a better forum for experimenting with new capital intensive environmental technologies. But rapid urbanization, population growth, and the fact that LDCs house the majority of the last remaining environmental resources (such as biodiversity, forests, watersheds), whether by fair play or not, all contribute to a sense of urgency for choosing the best development path.

Small, not insignificant

Small-scale rural electrification projects may seem small compared to development projects such as large hydroelectric dams, but local projects such as a small PV module to power a water pump can nevertheless help put a community on a sustainable path. If communities have access to information which will help them develop in a sustainable manner early on, after-the-fact damage control is minimized. As discussed above these local efforts can also help the global community, but global regimes have traditionally been unable to build capacity for these small and fragile grass-roots efforts.

Thus a "bottom-up" process is in order for putting much of the developing world on a path towards sustainable development. There are ways to encourage and support rural sustainable development efforts — and key tools that can aid all actors in this endeavor is information and communication.

Communications for Grassroots Efforts

Although multinational efforts voice a commitment to encouraging grass roots development action, the top-down approach is wrought with inherent obstacles. "Unfortunately, the classical obstacle

[9] Personal communication with Julie Smith, Enersol Associates, December 1996.

standing in the way of achieving this goal is the inability of international and even national funding agencies to appraise, process and monitor large numbers of small projects" (Khosla 1997a). These obstacles are not insurmountable, however. We just need creative solutions. The outreach of development information both *into* small, rural communities, and *from* these communities is a challenge addressed in this thesis. A communications network that can bring underrepresented stakeholders to the negotiating table would raise awareness and interest, improving the effectiveness of development projects. Underrepresented communities can have more access to information which will help them develop in a sustainable manner, and global regimes will have more information on local conditions to better tailor their projects to the needs and resources of all stakeholders involved.

Examples of the connectivity, content, and capacity-building issues of the communications network are introduced in the following sections.

1.4 Connectivity: The Sustainable Development Network Program (SDNP)

Under the auspices of the United Nations Development Program (UNDP) and Agenda 21, the Sustainable Development Networking Program was established in 1991. It is an initiative which addresses the problem of *connectivity* to information. The intended beneficiaries are "stakeholders in the development process" (UNDP 1994). Twenty-four countries have operationalized the program as of 1996.[10]

Working closely with governments, as well as with NGOs, the private sector, and research institutions, the SDNP hopes to establish national plans and policies for sustainable development. The SDNP promotes information sharing using the Internet as a backbone. The Internet protocols (TCP/IP) are hardware independent, so that almost any type of computer can be connected in order to provide developing countries access to the mainstream of world-wide data linked to the internet.

An SDNP workshop in 1992[11] conceptualized an SDNP "starter kit," which was to include hardware, software, databases, printed documents and electronic files. The idea was to physically distribute these kits to national SDNP coordinators to help catapult them into the world of information networking. It soon became apparent that for every SDNP member there was a unique

[10] UNDP Sustainable Development Networking Programme, Report of the Fourth Global Workshop for Coordinators, Mexico City, April 22-26, 1996.
[11] Workshop took place at the UNDP, New York, in September 1992 (UNDP 1994: 2).

combination of hardware and software to meet their needs. Furthermore, the changing IT environment would put any "kit" at risk of quickly being outdated. Now, rather than designing a specific network, the SDNP aims to "enhance the capacity of national institutions to meet their own needs for information on sustainable development" (UNDP 1994: 1). The value-added that the national networks get from cooperation with the SDNP is guidance, equipment, and seed money. This includes:

- Technical assistance to work with existing capabilities and infrastructures. According to the needs expressed by the country users, easy and inexpensive to acquire solutions that can be maintained under existing developing country conditions will first be considered. For example, not all national SDNs (Sustainable Development Networks) need an Internet node; alternative technologies can provide similar connectivity to information sources at a lower cost.[12]

- Guidance from the UNDP and collaborative analyses on how to work with, and not in competition with, existing national or private communications and development programs.

- Information on standardized products and services, to avoid wasting resources on un-tried, esoteric hi-tech fixes.

- The SDN Information Series[13], a newsletter produced in an ongoing and as-needed basis, in electronic or printed form. The series provides information on successful practices for operating SDNs over the long-term. Contributions to the series will at times originate from the UNDP in New York, or from individual national SDNs or collaborating institutions.

- A revolving loan fund for certain hardware purchases (UNDP 1994: 15).

Box 2 outlines the steps followed to establish a national SDN program.

[12] For a description of technology options, please see UNDP (1994).
[13] Referenced throughout the text as (UNDP 1994).

Box 2 SDNP, Creating the Link

"The SDNP is a national information exchange operation run by independent entrepreneurs. To establish the program in each country, the UNDP Country office provides guidance in the formation of a Steering Committee of individuals from stakeholder groups including key ministries such as Environment, Health and Education; the private sector; academia and non-governmental organizations. They commission a feasibility study conducted by national consultants, using Terms of Reference custom-tailored to each country, and if appropriate they then develop a project proposal. SDNP New York approves the project, collaborates on recruitment decisions and provides the necessary equipment. All equipment is configured and tested in New York before it is shipped. All national staff are thoroughly trained in one-on-one sessions, through global workshops and/or with written training materials.

SDNP provides seed money, typically for two years, to enable each node to build its own user community and shift from external to domestic financing. Every SDN is regarded as a service organization that must be demand-driven to survive; consequently the long-term viability of each SDN rests on the entrepreneurial skills of its National Coordinator, a Steering Committee which supports and promotes their policies and the nourishment by a user community whose interest is in SHD" [sustainable human development].

Source: "Spread the Word: the Sustainable Development Networking Programme," UNDP/SDNP brochure circa 1996 (*sic*).

Local expertise is another resource a communications network can take advantage of. For example, many African SDNs have implemented FidoNet nodes, whereas in Latin America, most use UUCP technologies[14] (UNDP 1994: 12). As the network expands, this local knowledge can be used to shorten the "learning curve" for connectivity. The dailup FidoNet and UUCP options work fine for small nodes with PCs that can handle one or two telephone lines at most (say, 50-60 users) (UNDP 1994). Being affordable is also a key to network sustainability over the long term. The number of users and their needs must be anticipated to avoid wasting resources on a network which is an overkill of sophistication, or one which kills demand for the inadequacy of its service.

While there is a prodigious amount of information in the world to be shared concerning sustainable development, communicating it exclusively in electronic form will not be of use to the underprivileged without access to electricity, a telephone line, much less a computer. Although the backbone of the SDNP is internet connectivity, it is flexible enough to work with existing national infrastructures in order to potentially exchange information with remote stakeholders. Bolivia has taken a lead in implementing such a network. Details on SDNP-Bolivia are provided in Chapter 2.

[14] UUCP and FidoNet are both "store and forward" networks which provide access to the internet via modem dial up. UUCP can directly use the internet TCP/IP protocol; FidoNet supports access to the internet through gateways.

1.5 Content: The Global System for Sustainable Development

The Global System for Sustainable Development (GSSD) is an internet-accessible database, which serves as a platform that provides an integrated perspective on sustainable development. It is pursuant to information *content* needs described in Section 1.1.

The GSSD provides a logical framework for analyzing the myriad issues having to do with sustainability - biodiversity, energy use, natural resource depletion, the state of technology, multilateral agreements, etc. It can help users navigate through the "web" of sustainability (Figure 1.2). Because actions in one area can have consequences on several others (e.g., engineering water resources for electricity generation can be linked to international agreements, biodiversity, land use, and climate change, to name a few), the interconnectedness of it all can be mind-boggling. Indeed, it is not surprising that "information overload" can sometimes be *dis*empowering, by numbing our sense of understanding and inviting apathy.

GSSD provides a structure to this chaos by emphasizing the links among (1) environmental factors and social activities, (2) the types of solutions, and (3) the institutional challenges of identifying and implementing appropriate responses to human activities and environmental conditions. Most of the following information on GSSD can be found on its web page[15] and the upcoming book *Global System for Sustainable Development: Theory, Approach, Design and Policy* (Choucri and Baker c.1996).

GSSD embraces the following "working definition" of sustainable development:
"The process of managing social demands without eroding life supporting properties or mechanisms of social cohesion and resilience."[16]

This is analogous to the "dynamic" notion of sustainable development described earlier in this chapter. These definitions imply that:

"1) Sustainability conditions and strategies are context-dependent,
2) There are alternative paths toward sustainability, and
3) We can define some specific criteria for process, path, and outcomes."[17]

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[15] For more information on GSSD and access to the database, please see the URL (Universal Resource Locator) http://gssd.mit.edu/gssd/home.html or send e-mail to: gssd@mit.edu.
[16] N. Choucri, derived from MIT Alliance for Global Sustainability meeting, January 1997.
[17] Ibid

GSSD helps to define these criteria by being a forum for public exploration on the evolution of development processes, a knowledge base which presents research on development paths, and an information base to track development outcomes.

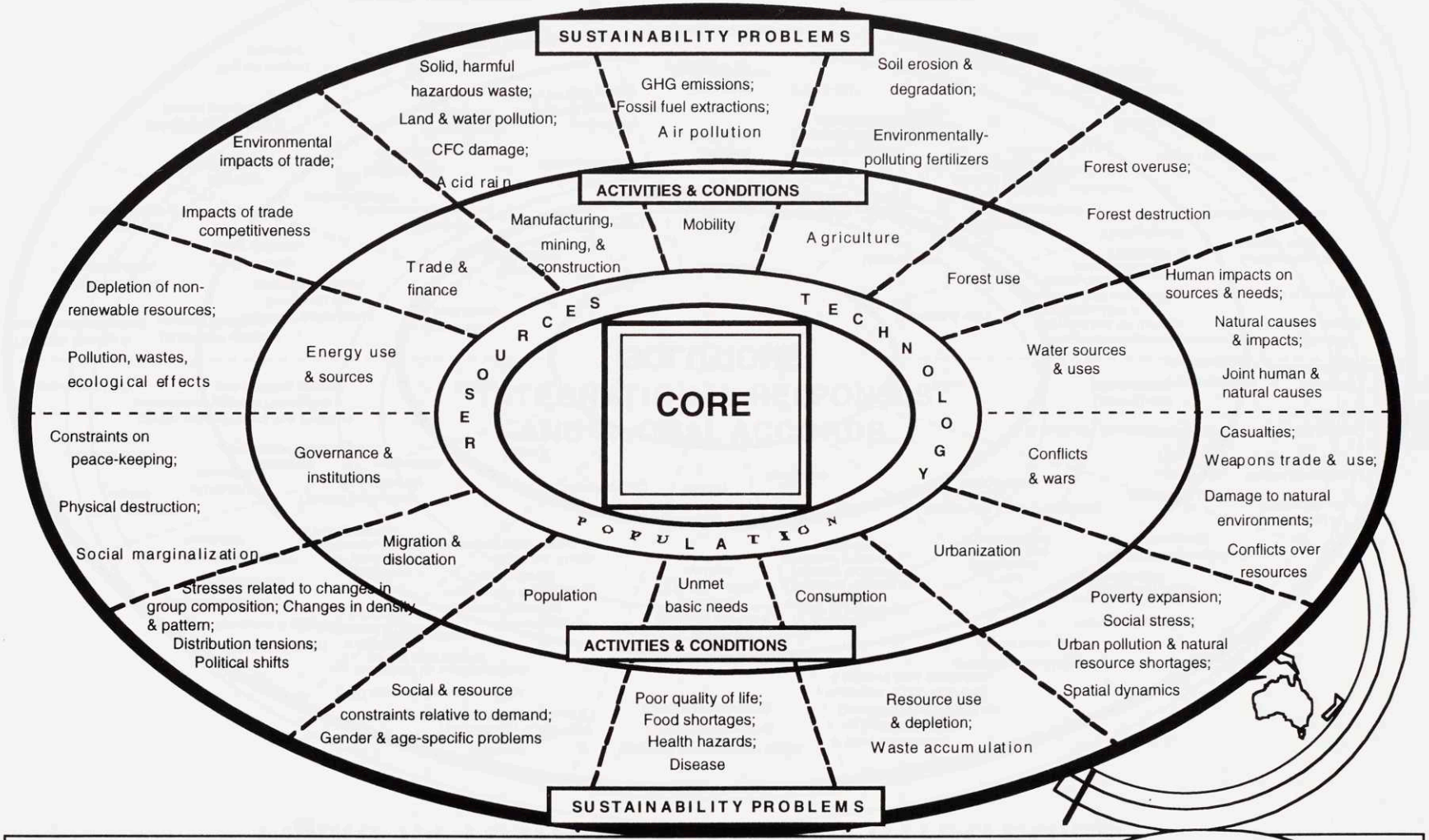
Operationally, GSSD is an adaptive interface on the World Wide Web (WWW). Given the impossibility of any one data server to house and track all information related to sustainable development, the intention is rather to organize and integrate that which is available on other "nodes," or data providers via the internet. It is *adaptive* in the following senses: (1) in the dynamic between user and GSSD, the architecture imposed by the interface on sustainability concepts may very well change the way the user thinks about the issues and help place them in a more holistic context; (2) feedback from among the users via wide area communication capabilities can revise material that is available on GSSD; and (3) because it has the capability of automatically incorporating information and requests to update the interface itself.

Conceptually, GSSD can logically highlight the relationships among:

- Core Problems, which are the pressures on humans and the environment generated by the interactions of population dynamics, the state of technology, and resource use,
- Activities and Conditions, which takes into account economic activities, conflict and governance,
- Sustainability Problems, as generated by activities and conditions,
- Solution Strategies to problems identified above, designated as scientific/technical in form or societal in form, and
- International Responses and Global Accords for sustainable development.

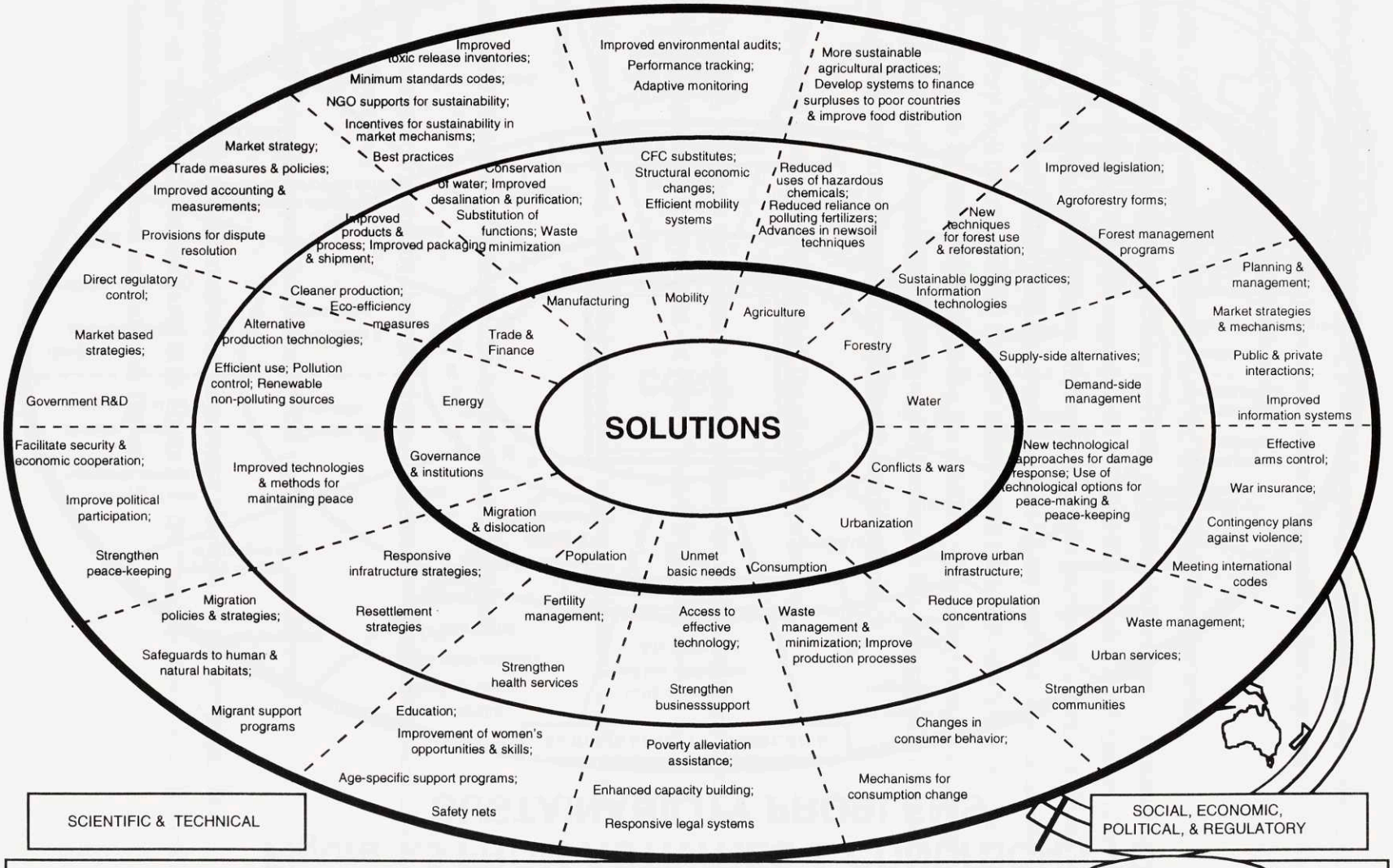
The GSSD user accesses the information on these topics via icons on the web page. The "problems" or "dilemmas" are structured as in Figure 1.3, the "solution space" is shown in Figure 1.4, and international responses are shown in Figure 1.5.

Figure 1.3 FROM ACTIVITIES & CONDITIONS TO SUSTAINABILITY PROBLEMS



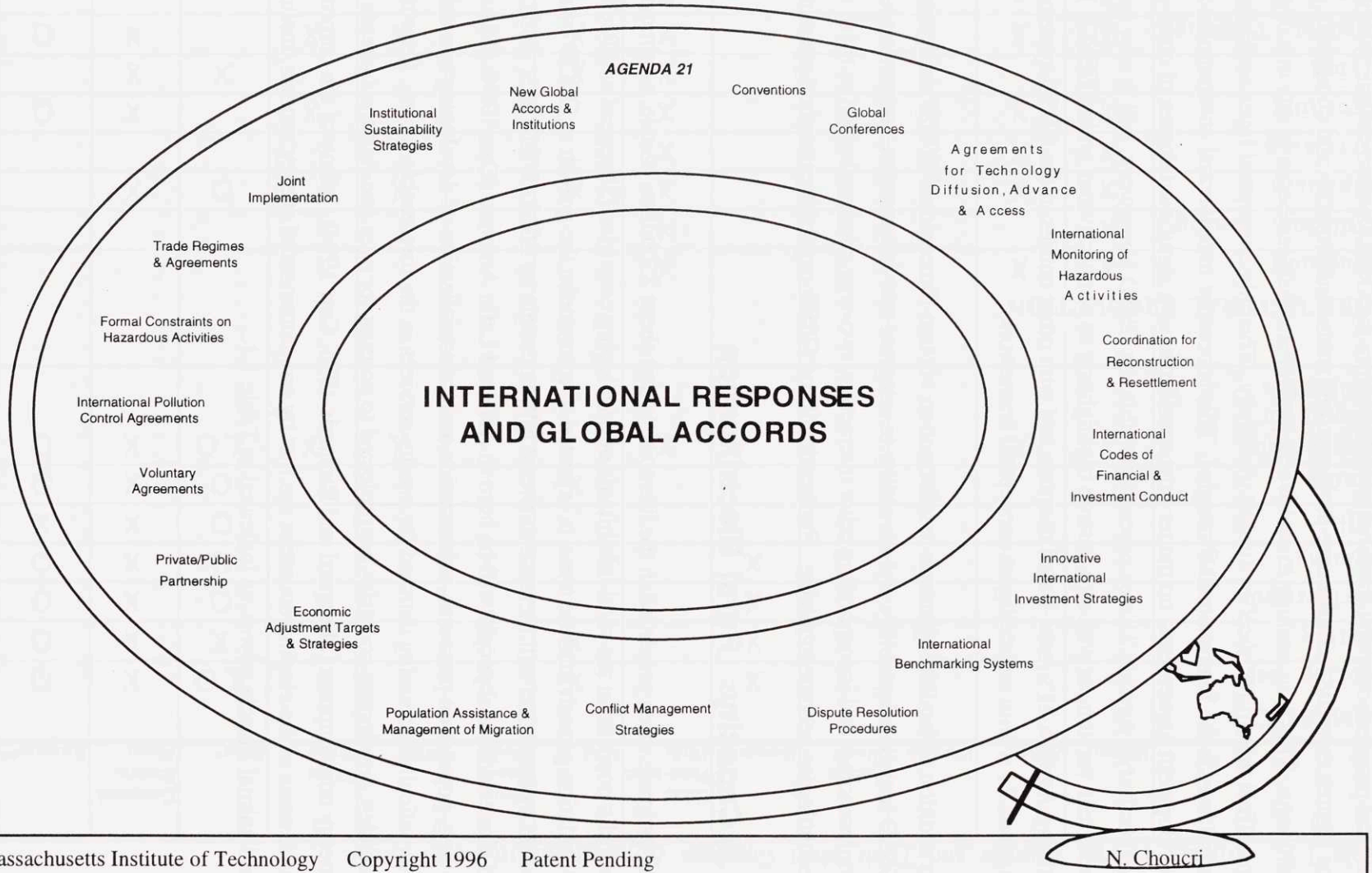
N. Choucri

Figure 1.4 TOWARD SOLUTION STRATEGIES



N. Choucri

Figure 1.5 INTERNATIONAL STRATEGIES FOR SUSTAINABILITY



N. Choucri

Logical progression along these notions stems from the GSSD system design. The radial lines in the figures emanate from the core problems, and transcend activities and conditions, as well as the solutions. This is in analogy to real-world problems which can begin in any one of these layers, and affect the entire "slice" or subject of activity. The only conceptual layer not breached by the radial lines is the International Strategies. This is because international environment and development agreements, no matter how specific, have a significant degree of cross-slice connectivity. Agenda 21 was processed within the GSSD framework, and is now available on-line in its text version, as well as a version highlighting its connectivities within GSSD. Linkages among Agenda 21's issue-based chapters and with other entries in the GSSD system present Agenda 21 within an intelligent conceptual framework.

In addition to facilitating access to information via two-dimensional WWW navigation, the goals of GSSD include adaptability and the ability to integrate new information, supporting wide-area conferencing, and incorporating other interactive, two-way communication as these new technologies become available. Further details on GSSD capabilities are in Appendix A.

1.6 Capacity: Rural Electrification

An estimate often presented in the literature is that about 2.2 billion people, or almost half the world's population are rural inhabitants of developing countries (Shepperd and Richards 1993). Population growth in these areas is expected to overwhelm the growth in OECD countries. The world's population will increase to over 8 billion people by 2025 (WRI 1993: 245), and over 60% of those additional people will be born in Asia and Latin America (Carr 1994). Rising standards of living, population pressures, urbanization and industrialization of developing countries are dramatically increasing demand for energy services in the foreseeable future. Over the next three decades, developing countries are projected to account for over one-half the increase in global energy consumption (Shepperd and Richards 1993, Carr 1994). Many of the current needs in rural areas of developing countries are met by non-commercial energy sources, including human and animal muscle power, as indicated in Table 1.1.

Table 1.1. Primary Energy Sources and Their Most Common Applications in Rural Areas.

	Human	Animal	Biomass	Animal Waste	Kerosene	Other Petro-leum Fuels	Coal	Liquid Gas Biogas	Wind	Water Power	Solar*	Generated Electric Power	Batteries**
DOMESTIC													
Cooking heat			X	X	X		X	X			X, O	X	O
Heating			X	X	X		X	X			X	X	O
Refrigeration					X			X			O	X	O
Lighting					X			X			O	X	O
Radio											O	X	X
Ironing			X				X				O	X	O
Potable water pumping or distillation	X	X				X			X	X	X, O	X	O
AGRICULTURAL PRODUCTION													
Ploughing	X	X				X							
Fertilizing, sowing	X					X							
Irrigation	X	X				X	X		X		O	X	
Harvesting	X	X				X							
Threshing	X	X	X			X				X		X	O
Drying			X			X	X				X	X	
Grinding, Pressing	X	X	X			X	X		X	X		X	O
Transport	X	X				X							

Source: Table layout and entries denoted with "X" are from Munasinghe (1990).

* Entries denoted with "O" indicate potential photovoltaic applications; "X" indicates solar thermal energy.

** Entries denoted with "O" indicate applications which employ a combination of PVs and battteries; "X" denotes battery power only.

We shall see in Chapter 3 that meeting future energy demands exclusively with these traditional energy sources, or by extension of electric grids to rural areas, is unviable. Increased demand would be better served by newer energy sources with higher efficiencies of use.

In a 1975 survey of useful energy output per day, by source, for six developing countries (including Bolivia), the assumed ratio of useful energy output of total input is 2.5% for human labor, 5% for animal labor, and 5% for firewood, crop residues, and dung (Munasinghe 1990: 221). Although these data are a couple of decades old, approximate relative energy outputs per source hold true: the poorest populations (among rural areas in developing countries) work with about 5% overall energy efficiencies (in conversion of wood, vegetable residue, dung, etc.), as compared to the average energy efficiency of 38% for conventional fossil-fuel fired plants (Hinrichs 1996: 78).

Socially and environmentally, fuel-gathering activities (wood, dung) are time-consuming and suppress improvements in living standards, and could result in fuelwood scarcity and increasing deforestation, erosion, or flooding. Increasing dependence on fossil fuels for oil-importing countries is inconsistent with national security concerns. Financially, grid extension is far more expensive than other options for remote areas, as we shall see in Section 3.3.

Sustainable Rural Electrification

Renewable energy sources are good candidates to both replace these old technologies and meet future demand in rural areas. This approach is consistent with the concept of sustainable development. When applied to the energy sector, sustainable development can translate into investment in increased energy efficiency, alternative fuels, renewable energy technologies, and demand-side management. But sustainable development as applied to the energy sector in general can also mean very different things to different actors. Rural electrification promises in many cases to add hours to people's days that were otherwise spent gathering fuel, improve domestic health conditions, and raise the quality of life for rural inhabitants. For industrialized countries, rural electrification is seen primarily as a challenge for climate change mitigation strategies, and a potential market for sales of "northern" technology.

Since energy needs in rural, low population-density areas are distinct from the centralized needs of urban electricity users, this thesis will adopt the concept of sustainable rural electrification (SRE). SRE incorporates the principles of the Brundtland Commission on sustainable development into the dynamic needs for rural electrification. Rural electrification poses challenges different from

urban electrification - and an opportunity. This is the opportunity to depart from the standard energy model, and embark on a development path that is sustainable, avoiding the need for after-the-fact damage control. Upcoming rural electrification projects will be able to "leapfrog" over obsolete technologies and their environmental drawbacks, by following a model that meshes new technologies with specific development needs. Sustainable energy depends on the needs and resources of the region - wind, solar, hydro - and the current institutional framework for its implementation. This follows the dynamic notion of sustainable development described earlier in this chapter.

Dual focus

In this thesis the rural electrification issue is investigated both as a capacity-building mechanism for sustainable development, and as a targeted beneficiary of the capacity-building possible with the proposed communications network. This is the idea behind "co-capacity building." The use of photovoltaics (PVs) is the focus in rural electrification planning, for three reasons:

- (1) PVs have proven to be a reliable source of energy for communications technologies in remote areas;
- (2) PV use for communications technology in rural areas will serve as an example to promote the use of PVs for general electricity supply; and
- (3) PVs are one of several sustainable energy alternatives that will benefit from the information sharing inherent in the use of the proposed communications network.

Recognizing that the bulk of the world's poorest people live in rural areas, communications networks as capacity-building mechanisms for sustainable development in general is explored in the next chapter.

Chapter 2
Communications for Sustainable Development

2.1 Communications Needs for Developing Countries

Although internet connectivity is a reality for most countries on the planet, there are many populations that are not served by this medium. Even if communications is not the top priority for these (low-income) populations, they could nevertheless benefit from information on how to best approach their primary objectives. If other communities have had similar experiences, sharing this knowledge would encourage more efficient solutions to development problems. Communication must be woven into the fabric of sustainable development, as the struggle to diminish the gap between the information "haves" and the "have-nots" goes hand-in-hand with decreasing the disparity of the material "haves" and the "have-nots." Raising the standard of living of the disadvantaged in rural villages must eventually address both issues.

There is an argument (ITU 1995) that the fundamental needs of populations in developing countries - for example, to be educated, attract investment, be entertained, and encourage entrepreneurship - are the same as those of industrialized countries, so there is no need to consider their telecommunication needs any differently. The premise in this thesis is that current activities and conditions in developing countries are very different from those of ICs, shedding an entirely different light on LDC needs for information connectivity, content, and capacity, especially in rural areas. The objectives of a rural peasant in accessing a communications network in a LDC are unlikely to be similar to what motivates the affluent minority to read their e-mail in the very same country, or entrepreneurs in an industrialized country. If a communications network in a LDC is to help promote environmentally and economically sound development, outreach into marginalized communities and existing data gaps on information for development cannot be ignored.

The opportunity to leapfrog over older energy development paradigms was mentioned in Section 1.6. The same holds for communications. With little existing infrastructure, developing countries are in a unique position to leapfrog over older communications technologies and invest in newer ones better suited to the information needs and physical conditions of LDCs. Moreover, investing

in appropriate communications infrastructure can allow leapfrogging to occur for general economic development. Economic development has traditionally moved societies from agricultural-based rural ones to industrialized urban ones. But improving technology transfer and access to information on proven development experiences can help countries skip whole stages of development with unpleasant side-effects such as pollution problems (ITU 1995).

Improved access to information for decision-making and two-way communication on government activities can also be politically desirable for elected officials. In what the International Telecommunications Union terms "electronic democracy," citizens benefit from a medium in which to express their views, and governments benefit from feedback without the time and expense of referendums or trial-and-error policy implementation for lack of incorporating local interests into the decision-making. The ability to dialogue and vote by electronic means is an emerging technology, which will be discussed in Section 4.3.

A communications network for sharing of sustainable development information has been termed Development Support Communications, or DSC.[1] For rural communities, DSC can be an informative interaction among groups of people who share similar values and objectives. SUCCESS, presented in Chapter 4, is the author's proposal for a communications system which can widely provide access to development information for rural areas in developing countries.

Among the development **objectives** for rural areas in developing countries are:

- To provide inhabitants access to basic human needs (clean water, energy, medical assistance),
- To experience economic development and its associated benefits (higher standards of living, increased literacy, improved health),
- To encourage business development and entrepreneurship,
- To preserve cultural heritage and values, and
- To create and improve educational and employment opportunities.

[1] From Oepen (1988) in Steinberg (1996).

To aid in these endeavors, **improvements** are needed in the areas of:

- Decentralization of decision-making, increased autonomy and public participation in the development process. In Bolivia a new reform called Popular Participation aims to enable communities to find their own solutions to their problems. The Popular Participation Law "acknowledges all forms of social organization (traditional, indigenous and grass-roots) through the granting of legal status" and allows them to participate in the "planning and implementation of local decisions" (Bolivian MSD 1997). The law also extends the jurisdiction of municipalities (including rural areas), and distributes more than 20% of public funds directly to the municipal branches in proportion to the number of inhabitants. By 1995, "94 municipal development plans were drawn up through participatory planning, after consultation with the population with regards to its demands and initiatives" (Bolivian MSD 1996).

- Disseminating (and preserving) indigenous knowledge of local ecology and traditional technology. On a survey conducted by the author on potential uses of the SDNP in Bolivia, one respondent related that many of the questions his organization receives by e-mail are requests for information on traditional Andean Technology, social organization and the history of rural communities. He also identified an information gap in providing agricultural and general sustainable development information for areas similar or particular to Andean or Amazon climates (i.e., other than information on countries in northern latitudes). Results of this survey are discussed in Section 2.3.

- Increased public/private partnerships so that mutual benefits can be realized between product or service providers, and current or potential consumers. Collaboration could increase in "contract, profit-sharing, or free enterprising arrangements" (Steinberg 1996: 569). An example is the Pioneer Preference Award given by the Federal Communications Commission "to provide a means of extending preferential treatment in the Commission's licensing processes to parties that demonstrate their responsibility for developing new spectrum-using communications services and technologies."[2] Volunteers in Technical Assistance (VITA) received this award in 1993 and now partners with a commercial enterprise which uses satellites. Some of this bandwidth VITA can use for its store-and-forward message system to exchange development information with remote sites.[3]

[2] FCC FAQ, from URL http://www.fcc.gov, 12 April 1997
[3] More information and contacts from VITA is available from their web page, http://www.vita.org

All of these improvements are related to communications for sustainable development. SUCCESS can help the first and second endeavors (public participation and disseminating indigenous knowledge) by enabling horizontal and vertical communication channels. SUCCESS can benefit from the third (public/private partnerships). Ideally, in addressing the first and second points, a communications network can provide the following general benefits for rural communities in LDCs:

- Reduction of unnecessary travel and physical transaction of materials. Electronic networking frees up time and money for other economic activities in rural areas. Even manual correspondence or person-to-person communication can proceed more efficiently if, for development purposes, they are subsumed under formalized distribution channels.

- The opportunity to document, preserve, and foster indigenous heritage. "Information access and dissemination can serve to enrich the cultural and social life of a country by encouraging diversity, educational horizons and promoting communications between peoples" (ITU 1995).

- Delivery of electronic health information which is particularly relevant to rural communities, where there is limited access to doctors or schools, and insufficient time or resources to exchange information other than in electronic format.

- Increased competitiveness. The ability of investors to quickly access and respond to information about market conditions is critical. Many companies are driven to exchange information electronically because of its low cost. Developing countries without this ability may be overlooked for investment opportunities. This applies more generally to LDCs and not specifically to rural areas, although Section 3.6 presents one scenario whereby competitiveness for photovoltaic firms is increased by its co-capacity building with communications technology.

- "Brain drain" avoidance. There is an incentive for the brightest citizens from developing countries to study abroad, and stay abroad for lack of access to research and opportunities to apply their new skills in their home country. Communications will also help them retain their professional contacts. In short the "availability of information infrastructure will help to attract and retain skilled manpower" (ITU 1995).

- Employment effects. Developing countries will more than ever before have the opportunity to be net exporters of information. Eventually, "electronic markets will widen overall

employment access but intensified competition will drive down wage levels for the OECD economies" (Forge 1995: 13). The key for rural areas of developing countries is the increased opportunities and education an information network can provide, which, combined with the reduction in wage level for developed countries, can begin to put ICs and LDCs on more equal footing.

- Improve the relationship among all actors. An easily accessible communications network helps create a forum conducive to participatory decision-making on development alternatives.

- Enable access to adequate information for stakeholders about benefits, costs, and risks about development alternatives.

- Create awareness of development programs and objectives. Announcements can be made and/or posted via a communications network by manual or electronic means.

- An empowerment of knowledge to help communities solve (at least part of) their problems themselves.

Empowering Grassroots Projects

Certain global environmental treaties have been successful in mitigating global environmental problems — the Montreal Protocol for the protection of the ozone layer being among the most well-known. Other international agreements that benefit the global environment can generally fall within the broad areas of climate change, biological diversity, international waters, stratospheric ozone, and land degradation. Yet, other issues such as human development and population control can be a great threat to sustainable development, but the sensitive nature of these issues has prevented them from ever being explicitly written into environmental treaties. It is up to independent efforts to effect change in these areas, without waiting for global consensus. Even with a mandate unpopular from the standpoint of global regimes, SUCCESS can help these interest groups coalesce and strengthen their voice and outreach in the international community.

In a perfect world, the funding and resources that flow from ICs to LDCs would go to projects that offer the most benefit to the immediate and global communities. In reality, there are often incongruities between regional development intentions, and that which is both acceptable in the global community and compatible with sustainable development on a global scale. The potential decision-makers regarding these trade-offs are host countries, donor countries, private businesses, communities, multilateral institutions and other actors who are explicitly or implicitly involved.

Each of the parties have different priorities, and conflicts can block the implementation of the best projects. One solution is for the actors that can agree on something to find their common ground outside of or in parallel with multinational negotiations. The communications network proposed can strengthen these dynamic relationships outside global regimes, so that parallel gains can be made in a bottom-up, versus top-down process.

Empowering the Actors

In general terms, horizontal information-sharing refers to communication within and among similar groups in the same region or country. Vertical information-sharing means contact between dissimilar organizations, usually in different geographic locations. By facilitating "horizontal" communications channels (among southern NGOs), both centralized and de-centralized coalitions can form to increase autonomy and decrease dependence on the top-down development programs and information. By pooling their resources, information, and capabilities, southern NGOs can begin to wrest themselves free from dependence on aid under unacceptable terms.

Delegation of tasks, expertise, or research can also more easily occur if communities (and most likely NGOs) can easily communicate. Instead of one community or NGO trying to provide for too many needs, other organizations can carry on with what they know best, or what is most needed, with the confidence that information on other issues is readily available. In this way, communities can make the most efficient use of their resources by tackling their immediate problems, with the capacity to form alliances with other organizations as needed.

Extent of Outreach

The issue of outreach into the poorest of the marginalized communities remains to be investigated. The following section briefly describes some existing communications strategies being carried out in developing countries. An investigation of the creative outreach strategy being implemented in Bolivia follows, with results of a brief survey among some of its users.

2.2 Existing Communications Strategies

If we consider the issues of connectivity and content for rural communities in developing countries, there are almost countless projects and initiatives. An attempt to compile a complete list would be out of date nearly as soon as it is written. Below is a summary of some of the more creative and interesting initiatives aside from the SDNP which are most relevant to demonstrating the ability to outreach into poor rural communities.

- Acacia - Conceived by the International Development Research Centre (IDRC) for empowering sub-Saharan African communities, Acacia's objectives are: (1) to build upon local strengths and demonstrate how information and communication can help communities solve their development problems; and (2) "to build a validated body of knowledge, and a networked dissemination process, around the policies, technologies, methodologies and approaches that prove to be effective."[4] Acacia conducts research and demonstration projects on information management and communications using all possible channels, including sophisticated and traditional technologies. It is intended "to facilitate access to, and use of, information especially by disadvantaged and vulnerable groups" (Benmouffok and Nijhawan 1997).

- Communications Boat Project for the Amazonia - A conception of Jorge R. Bodansky and David R. L. Pennington, both filmmakers in Brazil. This new initiative proposes to equip a boat with PCs and other communications technologies[5] which can travel to riverside communities. The boat will have internet access via satellite, and up to-date information on CD-ROM. In each village visited a computer and a local "monitor" (trained by the boat crew) are to be kept. Each time the boat returns, updates are made to the village's computer and the village has the opportunity to relate their knowledge. While the boat is present, the on-board computers are shared with community members to promote wider access. The village computer could be operated by a combination of solar cells, batteries and inverter, or fuel generator. The boat itself is hand-made using local Amazonian artisans, "and the results are astounding in terms of precision, floatability and stability."[6]

- InfoDev[7] - Managed by the World Bank, the Information for Development Program intends to provide support, research and recommendations to help developing countries benefit from information technologies. InfoDev has three sources of funding: the World Bank itself, bilateral and other multilateral governmental and non-governmental organizations, and the private sector. More information on World Bank sources of funding for communication is provided in Section 4.4.

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[4] Quote from a 1997 IDRC/Acacia brochure.
[5] Equipment specifics are currently in development; as platforms rapidly change, the main objective is to ensure compatibility. Personal communication with David R. L. Pennington, April 1997.
[6] For more information on this project, please contact David R. L. Pennginton, University of Brasilia, e-mail: pennbra@guarany.cpd.unb.br.
[7] URL http://www.worldbank.org/html/fpd/infodev/infodev.html

- Inmarsat - a commercial mobile satellite service providing access to telephone, telex, fax, data communications and some limited video services via several mobile Land Earth Stations (Wright 1994).

- Informatics 2000[8] - An InterAmerican Development Bank launching to "help Latin America and the Caribbean deploy information technology solutions that will stimulate economic growth and social development." The IDB intends to encourage heavy investment from the private sector to "improve the efficiency, effectiveness and reach of services to the poor." The initiative also intends to recommend to countries in the region policies which encourage entrepreneurial investment.

- TogetherNet[9] - The communications network of the Together Foundation, a non-profit NGO whose goal is to "facilitate positive global change by establishing communications and information systems that integrate the resources and needs of people, projects and organizations in service to humanity and the Earth." It is an internet accessible interface which provides access to an extensive database, online library, newsletters, surveys, petitions, directories, and events calendars pertaining to the environment, human development, and human rights. Member organizations may have their own private bulletin boards and calendars.

- VITAComm - A communications program created by Volunteers in Technical Assistance (VITA). It allows users, including people in remote areas, to send and receive information several times each day via a network of low earth orbiting satellites (VITASat), terrestrial digital radio networks (VITAPac), and electronic mail systems (VITANet).[10]

The above initiatives address issues of connectivity. Content is equally important, and GSSD is designed to address this issue. There are also attempts to document sustainable development "success stories," such as:

- Best Practices Database[11] - The United Nations Center for Human Settlements and the Together Foundation have documented solutions to a wide variety of human settlement problems submitted by communities from around the world. The aim is to demonstrate proven self-help

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[8] URL http://www.iadb.org/English/projects/projects.html
[9] For more information on the Together Foundation and TogetherNet, please see the URL http://www.sustainabledevelopment.org/ias/ssd/ssd/tgf/
[10] Personal communication with Gary Garriot, VITA, November 1996.
[11] URL http://www.bestpractices.org

solutions to allow for more informed decision-making to occur at the community level. The case studies are available on-line or on CD-ROM for a fee. Contact information is provided to engage colleagues around the world in information exchange.

- Bellagio Audiovisual and New Media Database[12] - "It proposes establishing an integrated information exchange mechanism to link existing databases and hold information about audiovisual projects on sustainable development." This initiative arises out of the Agenda 21 Helsinki group, pursuant to the education objectives framed in Chapter 36 of Agenda 21.[13] "The dissemination strategy for the proposed audiovisual and new media database calls for multiple formats and distribution channels including paper catalogs, faxback, compact disc read only memory (CD-ROM) catalogs, CD-ROM databases, and network-accessible databases and catalogs" (Cader 1995).

- People Count[14] - A series of half hour programs produced by Cable News Network designed to inform and inspire disadvantaged and low-income individuals in developing countries. TV is hence the medium for technology transfer. The programs are publicly licensed, so they can be shown repeatedly with no copyright restrictions. If broadcast via satellite, twice per year there is a nominal satellite fee. Alternatively, the tapes can be shipped. The themes center around overcoming poverty, introducing role models, sustainable agriculture business enterprises, and striking a balance among populations, resources and the environment.

What all these connectivity and content initiatives have in common is the need for *two-way* communication on sustainable development. What many also have in common is the realization that Best Practices are a good way to share learning. We shall return to these commonalities in Chapter 4, to develop a network which can further the objectives of these programs. First, a closer look at SDNP-Bolivia lays the foundation for the connectivity aspect of SUCCESS.

2.3 The SDNP-Bolivia Experience

Since the Rio Declaration in 1992, and the Plan of Action agreed to at the Summit of the Americas on Sustainable Development held in Miami in 1994, Bolivia has actively engaged in defining a

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[12] For more information on this please see Cader (1995).

[13] Chapter 36 of Agenda 21 is "Promoting Education, Public Awareness, and Training." The introduction states "Education, raising of public awareness and training are linked to virtually all areas in Agenda 21, and even more closely to the ones on meeting basic needs, *capacity-building, data and information*, science, and the role of major groups." (Itallics added)

[14] For more information, contact Turner Environment Division, One CNN Center, 6th floor North Tower, Atlanta GA 30303; e-mail: people.count@turner.com.

strategy for sustainable development. Among the elements guiding their plan are a dedication to promoting citizen's participation, and the improvement of people's access to knowledge and the availability and dissemination of information and technology.[15]

Despite the apparent success of some of Bolivia's sustainable development efforts[16], "there is a need to improve the degree of institutional coordination at central government, departmental and municipal levels, and to create a space for dialogue and consensus-building between government and other actors in society" (Bolivian MSD 1997). Mechanisms must be devised to coordinate dialogue with local leaders to identify and prioritize the needs of the people.

In the Summit of the Americas Conference on Sustainable Development held in Bolivia in December 1996, the plan of action calls for:

> "the establishment of a hemispheric network of sustainable development information systems (SDIS), as indicated in Agenda 21 and as one of the responsibilities assigned to the Sustainable Development Network programme (SDNP). The network's objective will be to disseminate among the countries of the Hemisphere the information they require on economic, social, environmental, legal, institutional, scientific, and technological matters at the national, subregional, regional, and hemispheric levels."

Bolivia began experimenting with its own SDN in 1993. By now SDNP-Bolivia has the makings of a powerful program which can potentially link a rural peasant with the most advanced communication and teleconferencing technologies available.

As originally conceived, Bolivia's network could reach even the most remote communities because it meshes old communication technology with new. One need not have a telephone or computer, nor is it even necessary to be literate. A simple need for information related to sustainable development can give an individual or organization a response within a few days. Poor rural communities can use low-cost, low-tech manual or radio correspondence to disseminate information. Eventually a terrestrial link can be made over longer distances to organizations which

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[15] Source: Ortega, Ramiro, "Sustainable Development in Bolivia," draft document circa 1996.
[16] Popular participation was described in Section 2.1. For more information on Bolivia's sustainable development initiatives please see the country reports in the bibliography.

have a telephone line for e-mail, or direct access to the internet. The potential of such a linkage can best be appreciated by a hypothetical (but not unrealistic) example.[17]

A peasant has noticed recently that the fish in a nearby stream have been dying at an alarming rate. She must learn the cause, as the fish are a significant part of her community's livelihood and diet. She contacts the local radio station, a member of SDNP. A query is launched. Her question is sent by telephone line or e-mail (depending on the resources of the radio station) to the over 200 NGOs, academic institutions and other agencies that are network subscribers. Within days, the Bolivian Ministry of Sustainable Development verifies the cause: new mining activity upstream.

The peasant meanwhile has access neither to the internet nor e-mail, but benefits from the network anyway. The information is passed back along to the local radio station. The peasant and her community receive a response broadcast by radio, telling them the cause and whether or not the water and its remaining fish are safe for consumption. An established link between the radio station, local and regional SDNP members (government offices or NGOs) has essentially overcome all impediments to information dissemination, without requiring extensive infrastructure investments, nor training for the hypothetical peasant.

Visually, the network looks similar to the representation in Figure 2.1.

[17] Example is an anecdote conceived by the author after discussions with members of the Bolivian Ministry of Sustainable Development and the Ministry of National Planning.

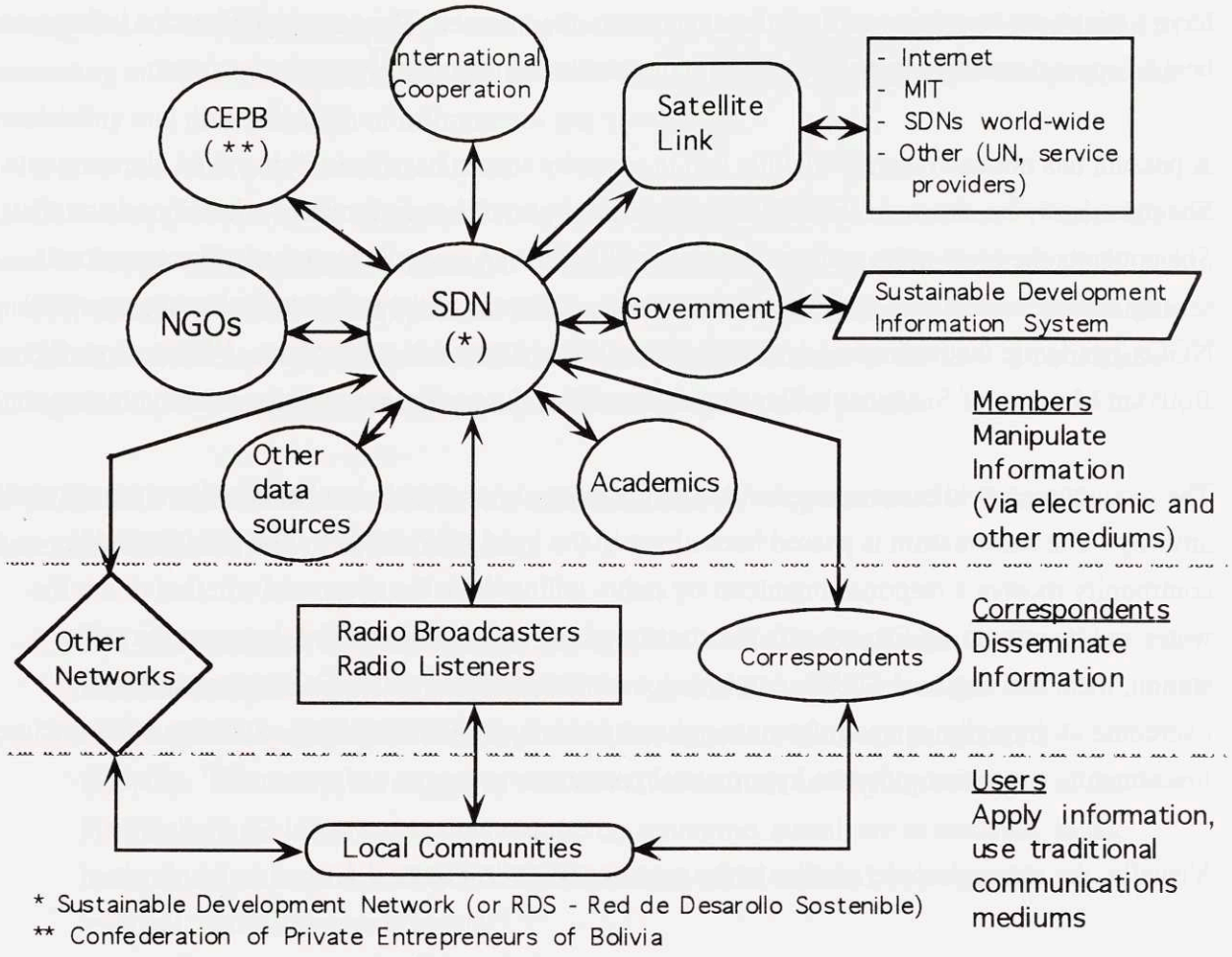

Figure 2.1 Conceptualization of the Bolivian Sustainable Development Network[18]

The actors involved in the Bolivian sustainable development network, or RDS (Red de Desarrollo Sostenible) can be grouped according to their role in the manipulation of information. Their roles are analogous to the content, connectivity, and capacity concepts. SDNP actors can be information managers (members), information disseminators (correspondents), or those who apply the information (users).

Members are governments, NGOs, private interests or academics who either house or manage certain information concerning sustainable development. They generally have access to e-mail or more advanced communications technology, and can be linked in this way to other networks.

[18] *Source:* The author's translation of background information supplied by the Bolivian Ministry of Sustainable Development.

Users are generally the intended beneficiaries of the information, those who have questions or problems concerning sustainable development and who will apply the information towards solutions. These can be social organizations, local scientific institutions, NGOs, or rural or urban inhabitants who generally do not readily have access to communications technologies at any level of sophistication.

Correspondents are local organizations that disseminate information principally by radiowave communication - in the above example, the radio station (Bolivian MSD 1996). Their function is to facilitate the communication between the users and the members.[19]

Network Requirements

The electronic connectivity element of the Bolivian SDNP began with a pilot phase in 1993. Now internet connectivity is hosted by one microcomputer with seven telephone line connections. This server is an internet host which also houses information accessible to the Internet community (such as their "home page." The services it provides are e-mail, gopher, FTP, Telnet, and World Wide Web. Users outside the Local Area Network who only have telephone line access to the internet can dial up for e-mail access only. Appendix B provides the technical details, as well as the project budget.

Usage and Limitations

By now all 311 municipalities are linked to institutional members of the SDNP network.[20] The principal method of correspondence among the members is by e-mail and by subscribing to an e-mail list. The original idea[21] was to send news regarding sustainable development electronically to the radio stations. The news was to be broadcast, with an invitation for feedback and questions from listeners. Last year, this program had some success, but in the last four months there has been almost no interest on the part of listeners.

The unfortunate circumstance is that the Bolivian SDNP team does not have the resources to create participation incentives or publicity among the radio listening audience. The radio stations primarily use their computers and connections to navigate the internet, keep up to date with news, and for e-mail. There has been some public criticisms that not enough is being done to extend the network benefits to "unconnected" rural populations. The priority objective of the two technical

[19] Currently Radio Yungas and Radio San Gabriel are the radio station "correspondents" for the network.
[20] Personal communication with Ramiro Ortega, National Ministre of Planning, Bolivia, January 1997.
[21] Conceived in large part by the former national SDNP coordinator, Juan Pablo Arce (personal communication with Javier Orlandini, National Coordinator for SDN-Bolivia, April 1997).

leaders of the SDNP team, however, is simply keeping the network running. The task of technical management of the network is very different from managing the information content. With one more full-time technical employee, plus a national coordinator in charge of the sustainable development logistics, much more could be done to once again bring the rural populations into the network.

The remaining limitation comes as no surprise, in that the server is chronically overloaded. Approximately two new member institutions are joining per week. One more server is planned in the near future, so that one computer can be dedicated to network connections, and the other as a server for web pages and GSSD.[22]

Currently there is no comprehensive record of specific questions and responses sent via the network, but examples of benefits of the Bolivian SDNP are documented. Their current web page[23] holds information on the impact the SDNP has had on national information sharing/exchange and on decision-making processes. Examples of these activities are given in Table 2.1. "One-way" refers to somewhat static information exchange, such as a simple search and retrieval of data from a remote host, announcements, automatic file transfer, or an e-mail list service. One-way also means an ongoing agreement between information provider and requester, such as supplying periodic file forwarding, published documents, etc. "Two-way" refers to the dynamic information sharing, both top-down and bottom-up, made possible by communications outreach into marginalized communities. Appendix B also contains more details and statistics on usage of the Bolivian SDN.

[22] Personal communication with Javier Orlandini, National Coordinator for SDN-Bolivia, April 1997.
[23] http://coord.rds.org.bo

Table 2.1 Sample outcomes from using SDNP-Bolivia

One-Way Communication	*Two-Way Communication*
Horizontal information sharing	
Through E-Law the SDNP-Bolivia supported the proposal to the new Land Use Law (Ley de Ordenamiento Terretorial).	Exchange of information related to genetic resources between the Biodiversity Office from the Sustainable Development and Environment Ministry and the Office of Science and Technology from the University of Juan Misales Saracho.
Public announcement by the Tourism Secretariat on the concept of ethno-eco-tourism in Bolivia, with descriptions of governmental activities and policies in this sector.	The SDNP-Bolivia improved communication between the Biodiversity Office from the Sustainable Development and Environment Ministry and the Bolivian Collection of Fauna to improve the Amazonian Cooperation Treaty.
Vertical information sharing	
GRAIN of Barcelona, Spain supplies the Bolivian Ministry of Sustainable Development with periodic papers concerning the use and conservation of regional and international natural resources. This information in part guides national policies in this field.	Contact was made between a Bolivian NGO and a university in Texas, USA to exchange research information on beefcattle activity, farmers' croplands and their rural economy in the province of Pacajes.

Member Survey

The author sent out a simple survey by e-mail to the Bolivian SDN list subscribers. This includes the 120 member institutions, plus (approximately) another 80 organizations which subscribe to the list but are not connected to the internet by way of the SDNP. The survey (sent out in Spanish) was designed to take just a few minutes to complete, and solicited information on the demand for the SDNP's intended services (i.e., sustainable development information), and requested feedback on member satisfaction with the current use of the network. Eleven responses were received as of this writing, for a response rate of about 5%. Although no generalities can be drawn from such a small sample, some agreement was evident among the respondents. The survey that was sent out is provided in Appendix B.

Medium of correspondence

The medium of SDN information exchange is for the most part by e-mail. The question was "By which means do you send and receive queries and information via the SDN? Please indicate all that apply." All respondents checked more than one medium; choices given are shown on the figure below.

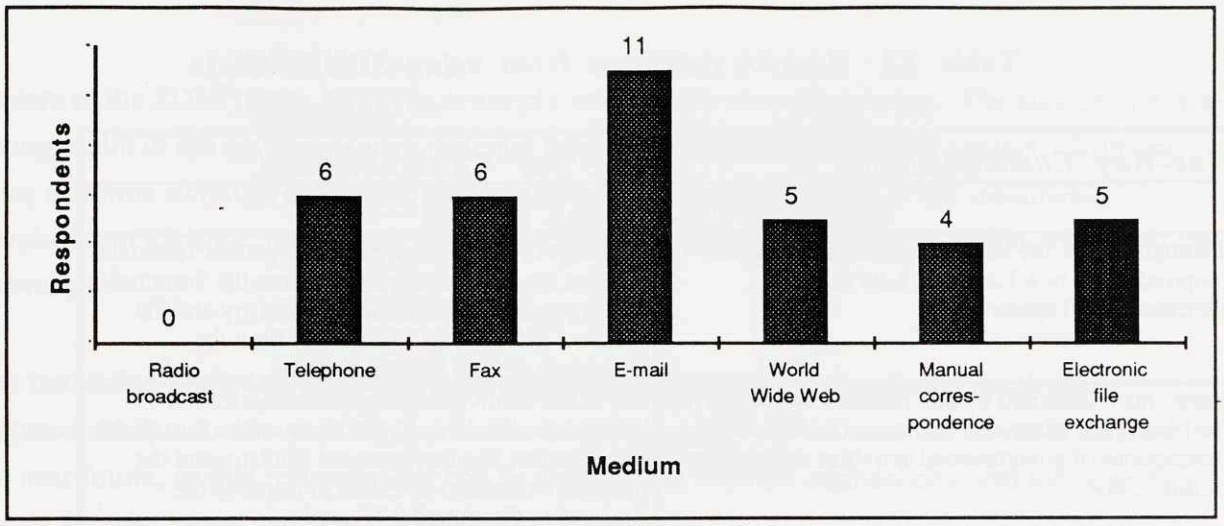

Figure 2.2 Medium of correspondence

Weekly correspondence

Many of the organizations receive a small number of messages by way of the SDN per week.

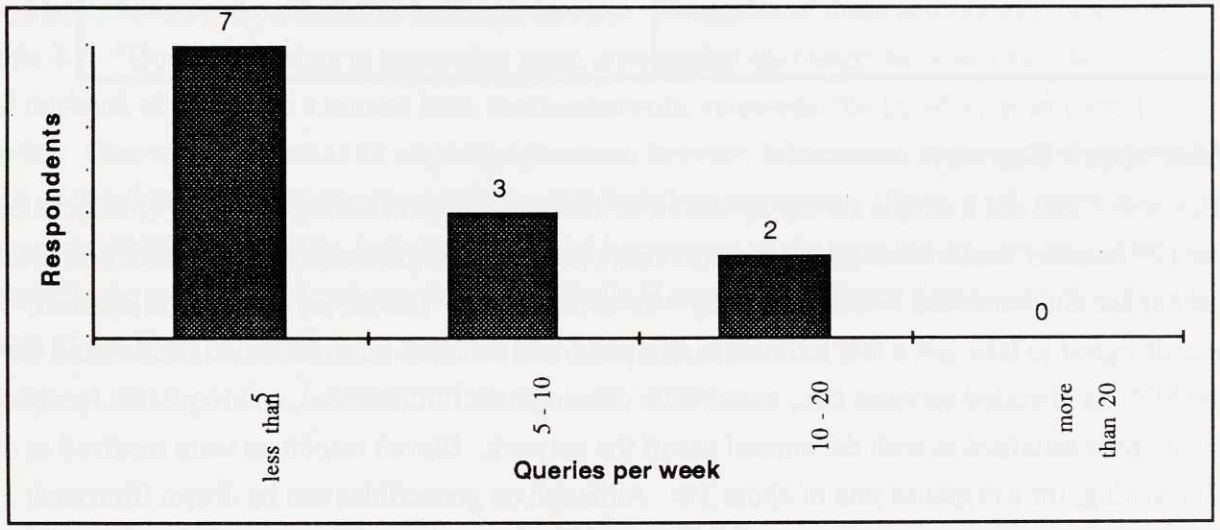

Figure 2.3 Weekly correspondence

Nature of correspondence

Most correspondence is indeed related to sustainable development. Figure 2.4 shows the approximate percentage of messages received per week, per respondent, which are related to sustainable development.

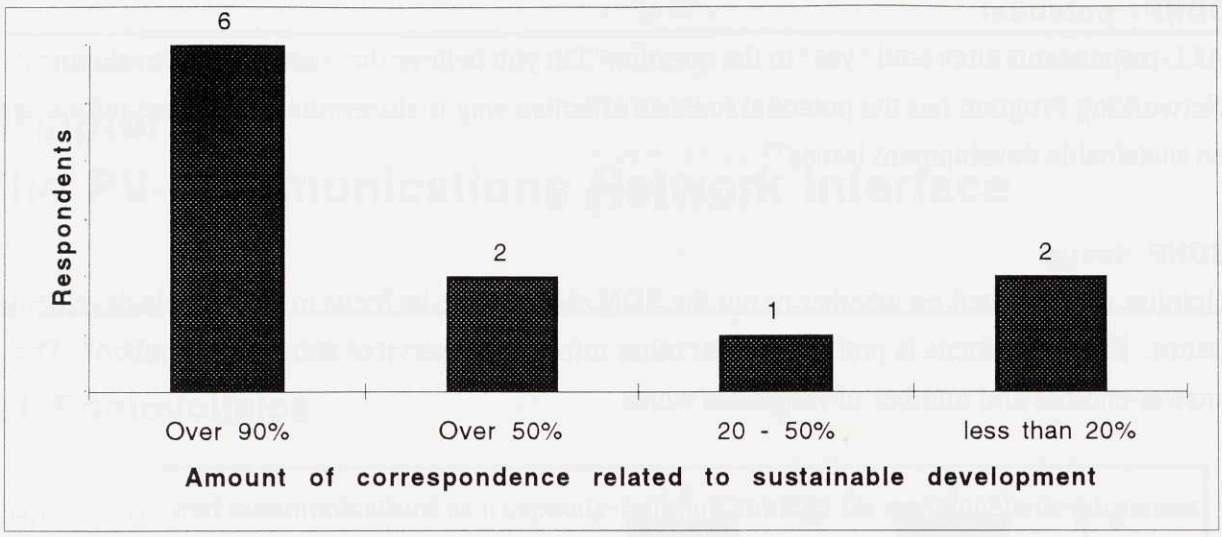

Figure 2.4 Nature of correspondence

Subjects

The question was "Among the queries you generally receive over the SDN, what is their subject?" The answer choices listed only those issues that are currently on the "entry page" of the GSSD platform (the "slices"). These are the 14 issues on the horizontal axis on Figure 2.5. Some respondents checked more than one of the choices (hence the numbers add up to more than 11), and some respondents wrote in their own answers (defined as "other" in the figure).

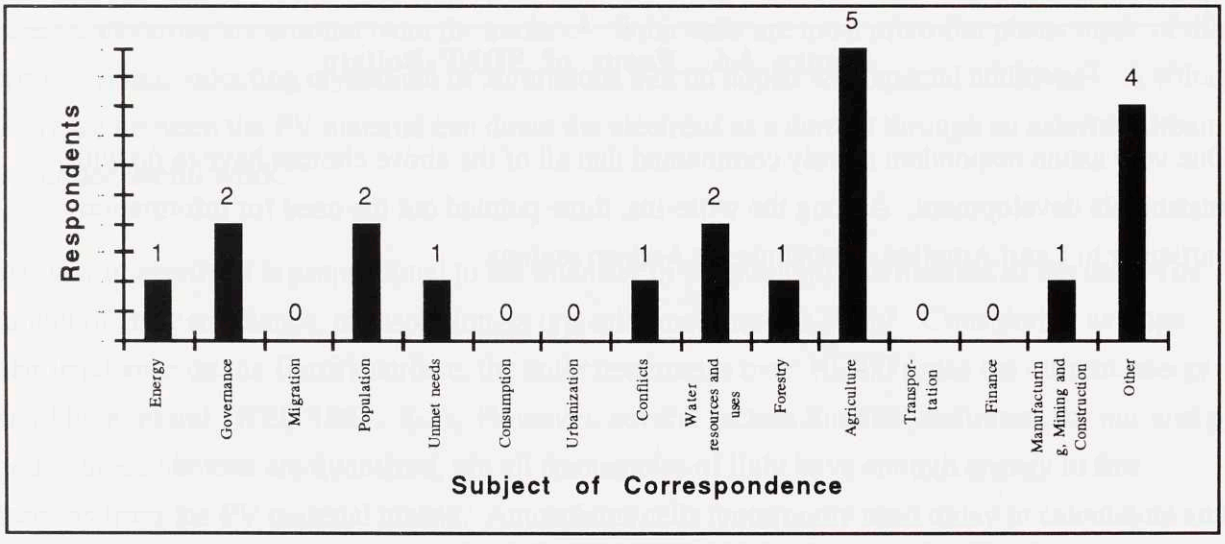

Figure 2.5 Subject of correspondence

SDNP potential

ALL respondents answered "yes" to the question "Do you believe the Sustainable Development Networking Program has the potential to be an effective way to disseminate and share information on sustainable development issues?"

SDNP focus

Opinion was solicited on whether or not the SDN should limit its focus to sustainable development issues. If a wider focus is preferred, what other information services should be supplied? The answer choices and number of responses were:

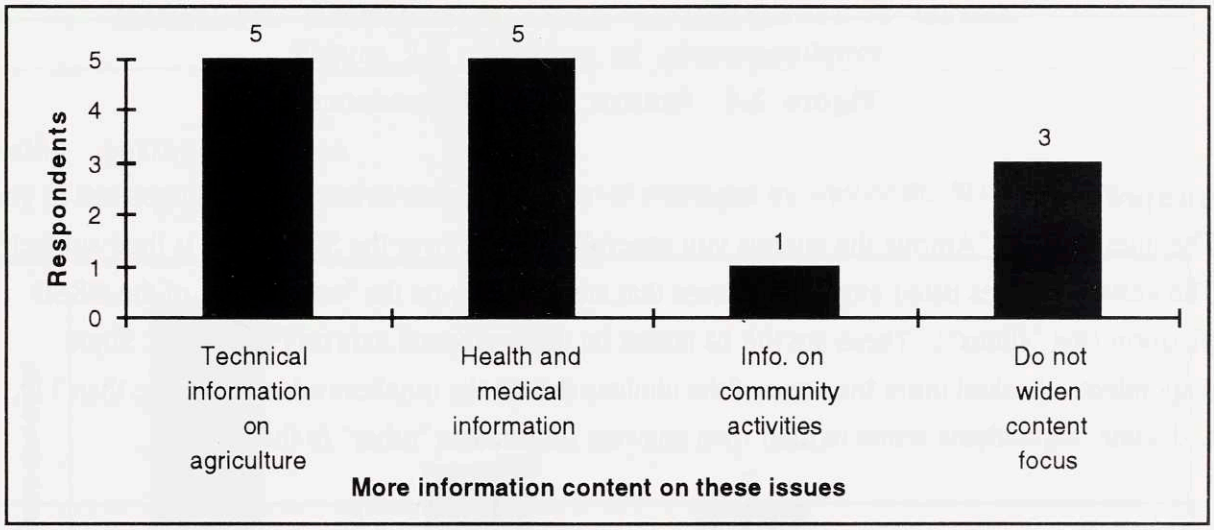

Figure 2.6 Focus of SDNP-Bolivia

One very astute respondent merely commented that all of the above choices have to do with sustainable development. Among the write-ins, three pointed out the need for information particular to Latin America, Amazonia, or Andean regions.

Chapter 3
The PV-Communications Network Interface

3.1 Photovoltaics

Chapter 2 explored communications as a capacity-building strategy for sustainable development. Communications as a capacity-building strategy for photovoltaic rural electrification will be addressed in this chapter. Chapter 4 continues with a study on the co-capacity building possible with the integration of communications technology and photovoltaics. Since the main hypothesis of this thesis is that communications networks can be an instrument of sustainable development, we begin with an introduction to PV technology and how its use for rural electrification is consistent with sustainable development.

The Technology

Photovoltaic cells take advantage of the photoelectric effect. When light strikes a photoelectric material, electrons are emitted from the surface[1]. Solar cells are most often flat plates made of thin layers of semiconducting crystalline or amorphous silicon doped with special additives[2]. A voltage difference between the PV material can direct the electrons as a current through an external circuit to produce useful work.

The flow of electrons is proportional to the intensity of the sunlight and the area of the cell. The amount of solar irradiance, or insolation, is typically measured as W/m^2. Considering average solar irradiance on the Earth's surface, the solar resource is over 10,000 times the current energy use of humankind (WEC 1993: 2-1). However, several factors limit its usefulness for our energy needs. Since photons are quantized, not all frequencies of light have enough energy to free electrons from the PV material matrix. Amorphous cells (commonly used today in calculators and

[1] Photovoltaic concentrating systems employ lenses to achieve higher efficiencies. PV concentrating systems are complex and for various other reasons not practical as a source of electricity for small loads in rural areas. For a description of this technology, see WEC (1993).

[2] Types of solar cells range from single-crystal, semicrystalline or polycrystalline silicone, amorphous thin films, multijunction cells, concentrator collectors and dye-based PV cells. Newer devices can be made from polycrystalline copper indium diselenide or cadmium telluride. For more information see Golub (1993) and Zweibel (1993).

watches) are about 5% efficient (in terms of electricity produced per incident sunlight). Polycrystalline cells typically have efficiencies of over 10%, and new materials and configurations have produced demonstration cells with efficiencies as high as 40% (Hinrichs 1996: 387). Photovoltaics for development applications can generally rely on about 12 - 14% efficiencies. This may seem like a marginal increase over the efficiencies of traditional fuels (around 5%), but the abundance and zero cost of our solar resource certainly sheds a better light on current efficiencies.

This chapter deals with PV units not connected to an electric grid, for development applications in rural areas. These photovoltaic systems consist of at least:

- A photovoltaic cell module, and
- A mounting unit for the module (which in some cases tracks the sun's apparent motion)
- Wires and switches

For many applications a PV system may require any of the following:

- A dc/ac converter. PV cells produce direct current which can be used to power devices such as portable radios or street lights. Some home appliances, however, use alternating current, which require the converter.
- Batteries. PV cells can only produce electricity when the sun is shining. Batteries are needed for electricity storage to ensure availability of electricity, even when no sunlight is available.
- A charge controller. This regulates the flow of electricity and protects the battery when it becomes full.
- A tracking device[3]. When mounted on a tracking mechanism, the module or array is always aimed at the sun, producing more electricity throughout the day.

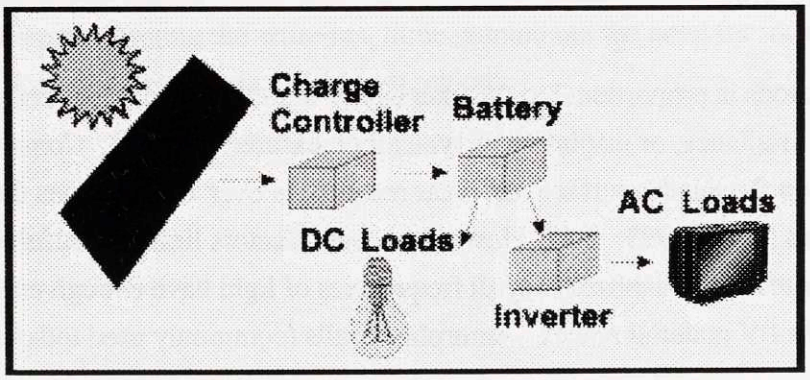

Figure 3.1 Typical photovoltaic system[4]

[3] Employed mostly in PV concentrating systems.
[4] *Source:* Solar Energy Industries Association, URL http://www.seia.org/pvapps.htm#Photovoltaics, May 1997

These components put together comprise the balance of system, or BOS. Figure 3.1 shows a simplified diagram of a PV system, but the BOS will vary according to the specific application. Solar energy is a stochastic source, but this fluctuation may be acceptable for individual homes or for powering water pumps for irrigation and drainage. If a more consistent electricity supply is needed, the extra expense of energy storage must be incurred in order to achieve uniform supplies.

3.2 Applications

Potential applications for photovoltaics are as numerous as there are needs for electric services. The services most immediately useful for low-income rural areas of developing countries are those which provide energy for basic human needs, agricultural activities, and other relatively low energy-load domestic amenities such as radios, lights, or television. Below is a brief list of some of the most popular applications known today. Applications which do not have near-term relevance to the needs of the targeted communities (such as using PV for solar-powered vehicles), are not included. All of the following are feasible given the current state of technology. Success of each application in rural areas of developing countries varies.

- *Lighting*, both indoor and outdoor. Hand-held lanterns are also available from a kit which includes a small 2-10 watt PV module and battery charger. Their cost ranges from $100-$300 (Shepperd and Richards 1993: 11) and it's not clear that a large consumer base would be willing to spend that amount in lieu of a larger system. For example, a 50-watt system which can power about 5 lights and other small household appliances costs $500-$700 installed (Shepperd and Richards 1993: 11). A comparison of this cost with traditional fuels is made in Section 3.4.

- *Water pumping* for household use, crop irrigation, animal farming and land drainage. PVs for these applications can replace human power and/or diesel engines;

- *Communications* equipment such as repeater stations, relay towers, cellular telephones, satellite earth stations, or mobile radio systems. Lower-end communications technologies for individuals or villages include short-wave radios or simple AM/FM receivers;

- *Health services*, such as electricity for hospitals, refrigeration for medicines and inoculations;

- *Icemaking,* which is especially valuable for fishing villages;

- *Remote sensing* to collect data on weather, seismic recordings, irrigation control, or insolation. Photovoltaics are a reliable source of power for these instruments, and offer the advantage of being able to operate while unattended;

- *Hybrid systems*, which use fuel engines as back-up or for night time running if sufficient storage is not available. Relying on engine generators alone requires that engines be sized for peak electric loads as well as possible future growth. Oversizing requires the generator to operate very inefficiently most of the time. A typical range of fuel efficiency for an engine powered generator is 6 kWh/gallon of fuel at 10% load and 13 kWh/gallon at 90% load. Using PVs and batteries, the engine can operate at full load while it is turned on and store excess power in the batteries. This reduces or in some cases eliminates except for emergency use the engine running time, and maximizes fuel efficiency when it is on (Thomas *et al* 1994: 26).

- *Minigrids*, which are larger systems (or networks of smaller ones) for the entire community: lighting of public areas (streets, work areas, schools, hospitals), and homes.

PV systems are also useful in rural areas for customers other than the rural inhabitants themselves. *Water desalination, aviation and maritime navigational aides, railway signalling,* and *cathodic protection* are all activities which require reliable electricity.

3.3 Photovoltaics for Rural Energy Needs

The land area available in remote regions and high insolation make rural areas in developing countries particularly suited for photovoltaic electrification. Seasonal variation is much less and average yearly insolation is higher for tropical latitudes (less than 23°27' from the equator), where most developing countries lie (WEC 1993, Stevens 1990).

Benefits Over Grid-Connected Power and Fossil Fuels

Photovoltaics are appropriate technologies for sustainable development in rural areas of developing countries because they carry important benefits over other energy options. Unique to PVs are simplicity and modularity, and the ability to be sized in almost infinite granularity according to demand. These features also make PVs easily adaptable to varying topographical conditions in remote areas. They have also proven to be a reliable source of energy. In urban areas, consumers are frequently inconvenienced by power outages and erratic billing practices (Rockefeller Foundation 1996: 4, Shepperd and Richards 1993: 2). Poor service poses more of a problem for rural areas where energy demand is highly correlated with the cropping seasons, or when peak

demand is unpredictable and inflexible. For example, the absence of needed energy for irrigation during a dry spell could irreversibly damage crop yields. Farmers could minimize this risk by purchasing fossil-fuel motors as back-up; the cost-competitiveness of photovoltaics would depend on the particulars of each situation. Nevertheless, the competitiveness of PVs increases with unreliability of grid-connected power, "especially as the powercuts in smaller towns and villages become more frequent, longer lasting, and less predictable" (Khosla 1997b).

Besides being more reliable than a lot of grid-connected energy services in developing countries, PV systems avoid the huge transmission and distribution expenditures associated with grid extension. A useful rule-of-thumb estimate for the cost of grid connection is $10,000/km of extension line.[5]

Although there is a demand for energy services in rural areas, for each household the cost is too high and energy load requirements are too low to make grid extension economical. For example, in the Dominican Republic in 1993, the cost per kilowatt-hour (kWh) of electricity to households connected to the grid could be as little as $0.11 per kWh. If a home with a typical load (6 kWh/month) were located just 1 mile from the grid, it would cost the utility over $11.00 per kWh to provide electric service (Shepperd and Richards 1993: 3). The prohibitive expense for extending the grid tends to lead utilities to ignore the market for rural electrification.

PV vs. fossil fuels

Several cases demonstrate the cost-effectiveness of these small PV packages compared to kerosene lighting or diesel generators (UN 1989, Barozzi 1993). Since the high capital cost of PV systems dictates that operating costs must be less than the price per kilowatt of the diesel or kerosene fuel, the break-even point for PV systems in the literature appears to be in the vicinity of the typical demand for domestic use.

Back to the Dominican Republic example, we learned that grid extension is not a viable option. In the meantime, to provide their own energy, rural communities may rely on kerosene lamps and candles, diesel generators, automobile and dry cell batteries. Although purchasing these devices in small quantities can be affordable for a household, prices per kWh are still appallingly high. In 1993 dollars the average monthly combined price for these conventional energy sources is $1 to $2 per kWh; by using dry-cell batteries people routinely pay from $30.00 to $60.00 per kilowatt-hour (Shepperd and Richards 1993: 3). For the same typical household, a single-module PV system

[5] Shepperd and Richards (1993) uses $7500 per mile of extension (= $12,075/km).

can supply electricity for about $0.75 per kWh.[6] This is higher than grid supply, but cheaper than the cost of any real option. This includes the capital cost of the module and battery replacement over the 20 year lifespan of the system (Shepperd and Richards 1993: 3).

Consistent with Sustainable Development

Besides being competitive with other energy options in certain niche markets, PVs can: increase productive time for reading and working by providing quality night time lighting; spur business development; reduce reliance on fossil fuels; and cause very little environmental impact. All of these benefits are consistent with a development strategy for rural areas that is sustainable over the long-term.

Reading aide

Lighting at night may increase literacy. Children may be more inclined to study at night with a bright, well-placed light as opposed to a kerosene lamp which is limited in brightness and placement (Shepperd and Richards 1993: 11), as well as a fire and health hazard. PVs may not only displace traditional lighting, but raise the quality of the lighting as well. By way of comparison, a good kerosene lamp can yield 60 lumens, while a 40-watt electric bulb or 10-watt fluorescent lamp provides about 500 lumens (UN 1989: 130).

Business development and access to capital

Generation of employment opportunities is necessary for long-term sustainability of low-income communities. One photovoltaic firm has witnessed that by introducing photovoltaics in the community, not only is confidence in the energy source instilled, but the local "entrepreneurial spirit" can then take over and catalyze growth.[7] Local businesses can manage credit schemes for investment in PV systems, provide repair and maintenance services or spare parts, operate photovoltaic battery chargers, or provide technical training. In other words, businesses start to support businesses, and distribution channels can begin to develop an infrastructure more favorable for PV use. Communications along this supply chain can be an added capacity-building mechanism. Supplying energy efficient appliances is another distribution channel and business opportunity that could be opened up. By providing basic energy services, a power supply for businesses and spurring economic growth, the use of PVs *may* curb rural-urban migration, although no firm data is available at this date.

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[6] Assumptions (from Shepperd and Richards 1993): A 50-watt PV system costs $700 installed and requires battery replacement every 18 months over a 20-year system life. Average of 5.5 peak sun hours in the D.R. are derated to 4 hours to account for various power losses in the system.

[7] Personal communication with Julie Smith, Assistant Director, Enersol Associates, November 1996.

Domestic resource

Meeting an increasing fraction of energy demand by renewable energies such as photovoltaics can help improve a country's trade balance by making it less dependent on foreign resources. Sunshine is an abundant and free domestic energy resource for the many developing countries that are located near the equator. Even though using PVs implies reliance on high-tech imports, Section 3.6 presents an example of the in-country capacity which a national commitment to PV power has generated in Saudi Arabia.

Environmental benefits

Photovoltaics for household use displaces kerosene, diesel, and candles, which improves domestic and local air quality and the associated adverse health effects. Use of PVs also minimizes fuel handling. Experience in the U.S. has shown that the clean-up cost of one fuel spill, whether on land or water, usually exceeds the total cost of converting an engine-powered generator to an all-photovoltaic power system (Thomas *et al* 1994: 26). The hassles of getting fuel to isolated sites, and seasonality of road and shipping conditions are also avoided.

3.4 The Market for PVs

Current annual world PV production is about 80 MW, current PV deployment in rural areas was about 25 MW in 1995 (Rockefeller 1996). Figure 3.2 shows the growth of *major* PV applications. PV use for remote commercial power shows the greatest increase.

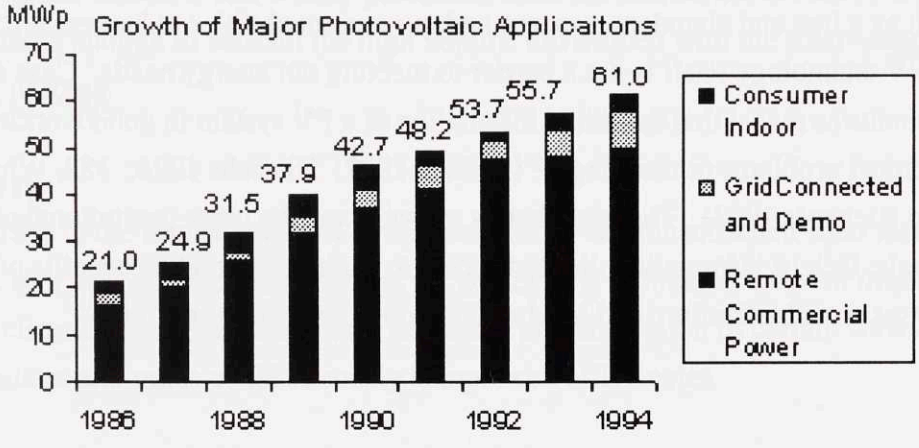

Figure 3.2 Growth of Major PV Applications (*sic*)[8]

[8] *Source*: Solar Energy Industries Association, URL http://www.seia.org/pvgraps.htm, May 1997

Photovoltaics are a declining cost technology. In the past two decades, the cost of PV production has decreased by more than a factor of 10. Indeed, since the first solar cells became operational for the U.S. space program in the 1950s, prices have dropped by a factor of almost 1000 (Hinrichs 1996: 381).

Economic viability for PV depends on the ability of manufacturers to take advantage of economies of scale, mass production and assembly, and sufficient distribution channels extending to all users for the BOS components. These are among the implementation challenges discussed in the following section. The potential role of information networks in overcoming these challenges is then presented in Table 3.1.

3.5 Implementation Challenges

Despite the environmental and health benefits of PV technology for rural energy needs, their diffusion has been slow. For almost any rural energy need there exists a unique opportunity for using a renewable source, but there are at least as many unique technological and institutional factors preventing this from happening. Despite these myriad constraints, certain generalities can be drawn. It is hypothesized that a communications network can build capacity for PV projects and encourage their incorporation into rural communities. This section summarizes the constraints and proposes where information sharing via a communications network can add value.

Technological Challenges

With sunlight as a free and abundant resource and our current abilities to harness it for electricity production, PV technology itself is not a barrier to meeting our energy needs. Case after case in developing countries reveal that the initial installation of a PV system in good working order does not pose technical problems or challenges[9] (Aldrich 1997; Hinrichs 1996: 382, Whiteley 1994, Shepperd and Richards 1993). The trick then is to overcome the other institutional challenges: subsidized fuels, lack of information, limited access to capital, and realize benefits of scale from group purchases, standardization, and local replication of user-installed "kits."

[9] Evidence from personal communication with Clay Aldrich, Division Director for Photovoltaics, Solar Energy Industries Association, March 1997, as well as Hinrichs (1996), Whiteley (1994), and Shepperd and Richards (1993).

Storage and balance of system

Data on inspections and follow-through of installation performance of the BOS over time have been more difficult to come by. Where these data exist, batteries are the most common problems associated with poor performance of PV installations, revealing poor maintenance as the primary culprit (Huacuz et al 1994; Huacuz et al 1995; Aldrich 1997). Even with battery replacement every 3 to 5 years, there is ample opportunity for damage by unskilled handling. The PV cells themselves, on the other hand, have life expectancies of 20 years or more.[10]

Thus storage seems to be an Achilles' heel of a PV system. Power, or work output per unit time, is much easier to come by with a PV system than energy, which is power for a period of time. If a stochastic power source is all that is needed — for example to power a fan on those hot, sunny days — a battery is not needed at all. But for electricity through extended periods of little or no sunlight, a battery is necessary. Adding a battery to the system adds bulk, cost, environmental effects, and another degree of freedom for error. Until more user-friendly and reliable storage systems are available, maintenance, periodic replacement, and education and training on the upkeep of the storage system should allow users to work around the storage limitations.

PV Panels

Technological innovation has been pushing the envelope for cell efficiency and decreasing cost. High-volume solar-grade silicon cell production, if it could replace current semiconductor silicon cell production with its economies of scale, would be a leading driver for lower costs (WEC 1993: 2-19). By streamlining the various manufacturing steps and employing the latest technologies for purification of the cell material, an energy payback time of less than one year could be achieved, compared to the current payback time of almost 10 years (WEC 1993: 2-20). Today, however, semiconductor-grade silicon is still widely purchased from the electronics industry, and PV demand is not large enough to warrant the high volume envisioned with the solar-silicon manufacturing process.

Applicability

An obvious barrier to the implementation of this technology is an insufficient solar resource for a particular area, or a lack of good resource data per se. Even if latitudinal location implies favorable insolation, the climatological characteristics, pollution, and absorption of certain wavelengths by ambient particulates and gases could seriously hamper cell efficiencies.

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[10] Many manufacturers issue 10 to up to 20 year warranties on their PV panels. Personal communication with Ed Kern, Ascension Technology Inc., April 1997.

Institutional Challenges

The market penetration of photovoltaics depends on the state of technology, as discussed above, the amount of support available from other enterprises (for spare parts, repair, etc.), competition from other energy sources and public policies which can promote or prevent its use. Some of the challenges discussed below are particular to PV implementation, some are rural electrification issues in general, and some are ubiquitous problems associated with providing new goods and services to rural areas of developing countries. A classic constraint to introducing new technologies in remote areas is a chronic unavailability of spare parts, lack of training for servicing, and education for would-be users. This chapter ends with a summary in table form of both technological and institutional implementation challenges, along with a description of the possible role that communications can play to overcome these constraints and create better opportunities for the rural PV market.

Communications and Credit

With a lower overall life-cycle cost for PV systems, it is nevertheless the high up-front cost that is prohibitive for low-income families. Creative credit schemes have proven quite successful in giving low-income families opportunities for loans to afford the high initial cost of PV systems. For example, in 1993 grants from the Rockefeller Foundation and the International Fund for Renewable Energy and Energy Efficiency (IFREE) created the "Fondo Solar" (the Solar Fund) . These funds are used as collateral for local banks in Latin America to provide credit to NGOs, who then lend funds directly to families in need of assistance to purchase PV systems. As the loan is repaid, the funds become available again to leverage other finance loans for PV systems (Enersol Associates 1994/95).

Perverse market signals

Some governments charge heavy import tariffs on PV systems and spare parts. But the governments may be unwilling to consider raising the price of diesel, put quotas on purchases of diesel generators, or even remove existing subsidies on diesel motors.

Financial constraints

Financial issues are considered "institutional" challenges rather than ones arising solely from the state of technology, and therefore are not included among the "technical" challenges in the previous section. Cost competitiveness depends heavily on identifying and appropriating the proper market niches and incentives for PV use. Cost competitiveness is also more of an institutional rather than a technical issue because PVs have been proven to be cost-effective for certain uses. Financial

solutions are more contingent on the diffusion of correct information concerning the benefits and costs of PVs as compared to other alternatives, rather than a decrease in price in the short-term.

3.6 Mutual Benefits

The main hypothesis is that communications technologies can help rural communities plan and execute projects towards sustainable development. The case of photovoltaics for rural electrification is not only an illustrative example, but the use of PVs can accelerate the process of providing reliable communication services to rural areas.

This co-capacity building is evidenced by a recent deal between Saudi Arabia and ASE Americas. They entered into an $8 million deal whereby ASE Americas will ship over 2 million PV cells to Saudi Arabia over the next 3 years, license its solar-cell lamination technology to a firm in Riyadh, and provide technology transfer assistance to enable local manufacturing. This deal is part of a $5 billion package by the Saudi Arabian Ministry of Post, Telephone, and Telegraph to extend phone service to mountain villages along the Red Sea and throughout the desert interior. The ASE Americas solar cells will power 7,200 remote radio towers.[11]

Incorporating both telecommunications and photovoltaics into national development plans provides an economic basis that goes beyond a simple transaction for solar cells. Out of the entire system for powering remote telecommunications stations, ASE provides just the solar cells, some technology transfer to help them build the cells into modules, and a license for the lamination process. Saudi Arabia will buy some manufacturing equipment from another U.S.-based firm for production of the lamination material and module assembly. The "high-tech" part of the operation, producing the solar cells, will be done in the U.S. Building the modules, which is "low-tech" but nevertheless a significant part of a PV balance of system, will be done in Saudi Arabia. Saudi Arabia can benefit from the more labor intensive process which employs their in-country resources, and buy the more technology-intensive process from a firm with such expertise. In this manner Saudi Arabia will not only get their PV-powered telecommunications system, they'll also receive some in-country technological, educational, and economic capacity.[12]

Photovoltaic technology is very transferable to LDCs because of this high-tech/low-tech duality. A firm in an industrialized country can ship the PV cells to a LDC. The biggest shipping cost is the

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[11] Information related to this deal is from personal communication with Azzam Moneer, Sales and Marketing Director, ASE Americas, April 1997 and Boston Globe (1997).
[12] Personal communication with Azzam Moneer, April 1997.

glass and aluminum, which can be left for the LDC to supply domestically, avoiding the expense of buying the assembled materials abroad. Eventually, as the host country for the technology, they will gain enough knowledge and skills to build their own plants if need be.

PV for Rural Telecommunications

In areas where grid extension is prohibitively expensive, the main competitor to PV systems for telecommunications operation (and for that matter, for most rural electricity needs) is the diesel engine. But before the advent of solar and wind power generation, rural telecommunications was perceived as inevitably unreliable and a net revenue-loser, primarily due to the heavy maintenance associated with diesel engine operation and fuel requirements.

Many existing repeater or exchange stations use diesel generators (two are required to ensure backup power) to recharge batteries, or frequently exchange and recharge batteries at a nearby village. Photovoltaic cells can provide automatic recharge, reducing the risk of battery discharge and failure as well as eliminate the logistical hassles of manual recharging (UN 1989: 203). This decreased dependence on engines also lowers the cost of fuel storage, transport, and maintenance (Thomas *et al* 1994: 7). Moreover, the labor freed up from repairing diesel engines or replacing batteries can shift to the telecommunications equipment itself, or improving the information content and services it provides.

Telecommunications for PVs

Since modern telecommunications equipment such as cellular phones and satellites are not constrained to existing terrestrial infrastructures, there is no need for these applications to rely on grid connected power. For such small and remote power requirements, photovoltaics are ideal power sources for outer space *and* ground satellite stations. It is anticipated that the telecommunications industry will be an increasingly large consumer in the photovoltaic market.[13]

Building capacity for PV projects

The capacity PVs can offer for rural telecommunications was discussed above. PVs are a proven source of energy for rural telecommunications. But a communications network can, in turn, encourage and support the deployment of PV systems in rural areas.

In the emerging global economy, geographically disperse corporations need inexpensive, reliable, and efficient communications. "The levels of economic development and telecommunications

[13] Personal communication with Ed Kern, President, Ascension Technology Inc., April 1997.

infrastructure and connectivity has already become a major competitive factor for attracting foreign direct investment in sectors other than telecommunications"[14]. The ASE Americas/Saudi Arabia deal is a case in point. Following is a short and necessarily incomplete list of recent initiatives which recognize the advantages that communications can offer for energy expansion in developing countries.

- The E7 is a consortia of eight of the world's largest electric utilities in G7 countries[15], with an emphasis on collaboration to promote sustainable energy development. The objectives of sustainable energy development are "to make the most efficient and productive use of energy, human, financial and natural resources by means such as: maximizing energy efficiency, fuel switching, and by promoting renewable energy technologies" (E7 1997: 2). They established the "Network of Expertise for the Global Environment," which acts as a pro-bono advisory group on electricity, energy and environmental issues.

  Part of the E7's objective is to disseminate information among themselves and to the rest of the world on sustainable energy experiences. One of their recommendations submitted to the Rio+5[16] Organizing Committee reads: "The E7 recommends that an international communication plan be developed to facilitate the exchange of information on areas where economic benefits can [and] are being realized by integrating sustainable development into business practices" (E7 1997: 20). The E7 also plans to build a database of sustainable energy development (SED) practices and to place these "SED Practices" documents on an E7 web site (under construction at the time of this writing) to share lessons learned from practicing sustainable development in the electricity sector.[17]

- GEO, the Global Energy Observatory, is a project currently in its infancy pioneered by a staff who intends to "coordinate information flows that can help provide a global picture" on sustainable energy practices. By selecting a number of quality indicators of sustainable energy practices, GEO intends to monitor and report on the progress of energy sustainability since the

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[14] D'Orville (1996) in Simms (1997)

[15] E7 members are Électricité de France, ENEL (Italy), Hydro Québec (Canada), Kansai Electric Power Company (KANSAI) (Japan), Tokyo Electric Power Company (TEPCO) (Japan), RWE-AG (Germany), Southern California Edison (USA) and Ontario Hydro (Canada).

[16] Rio+5 was a conference (Rio de Janeiro, March 1997) which brought together civil society and business stakeholder groups to assess and advance the implementation of Agenda 21 since the Earth Summit. Several organizations were asked to submit "special focus reports" as background on specific development issues and to draft recommendations for the Earth Charter, a document which is expected, through further negotiations, to provide nations with a set of values and principles for sustainable development.

[17] Personal communication with Andrei C. Marcu, Manager, Institutional Relations, Ontario Hydro, March 1997.

Earth Summit. Their background report to the Rio+5 Forum offers to "establish GEO as a credible observer of the world energy and sustainable development scene."

One of their intended approaches which could be facilitated by the use of electronic information exchange is "to assess non-quantifiable impacts, GEO could call upon various qualitative approaches, opinion polls, . . . media information and other techniques used to take non-monetisable impacts and externalities into account" (GEO 1997: 14).

- Energy 21 is a non-profit NGO established in 1994 dedicated to promoting energy efficiency and renewable energy sources. Their "One Million Initiatives" was unveiled at the Rio+5 Forum in March of 1997. This ambitious campaign intends to mobilize, through action and education, one million initiatives to save energy by the year 2001. Informing and educating the public, as well as coordination among these initiatives, will require a substantial capacity for communication.[18]

All these recent initiatives have at least three things in common:

(1) a commitment to increasing public understanding of renewable (i.e., sustainable) energy technologies,

(2) an intent to foster the use of such technologies, and

(3) a need for information access, dissemination, and coordination.

3.7 Integrating Results

Below the constraints to implementing photovoltaics in rural areas of developing countries are presented in table form and broken into the categories of technological constraints, sociocultural constraints, institutional constraints, and financial constraints.

The tables demonstrate the complexities involved in the niche markets for photovoltaics. There are a wide range of factors which influence decision-making with regards to photovoltaic use, but there are also several opportunities for information technology to help tip the scales in favor of investment in photovoltaics. The first column of each table describes the constraints (according to each category) on PV dissemination; the second column describes the role of information and communications networks in eliminating some of these constraints.

[18] Energy 21 press conference, Rio + 5 Forum, Rio de Janiero, March 1997.

Table 3.1 Institutional Constraints and Opportunities for PV Implementation and Potential Roles for Communications Networks

Constraints on PV Implementation	Potential Role for Communication Networks
Absence of infrastructure for service and maintenance, and distribution of spare parts	Communications is a service itself. Easy access to training and educational materials can help local capabilities do their own repairs. Communications can also help establish distribution channels for new businesses that wish to provide parts and service.
Overlap among SRE initiatives causes complications and inefficiencies	A common communications link can (1) help prioritize and streamline actions, (2) reduce redundancies, and (3) keep all actors up-to-date on each other's knowledge and experience.
Lack of follow-through on system operation after initial installation	Documenting case studies on easily accessible database increases accountability of technology providers, and puts pressure on raising performance standards.
Questionable political determination of importance of PV programs	Communications can increase public participation for development; a more informed public on benefits and uses of PV will increase demand.
Lack of standardized components and systems*	Communications can facilitate cooperation in a region to define standard components, and reduce the costs of inventory.
Variability of government development/incentive programs*	An information network can rapidly deploy information on relevant policies and recommended practices.
Opportunities for PV Implementation	**Potential Role for Communication Networks**
The opportunity for technology leapfrogging	Documentation of successful practices and pitfalls to avoid.
Research and development on renewables	Both government and non-government sponsored research can be better coordinated as users of a common communications network.

Table 3.2 Technical Constraints on PV Implementation and Potential Roles for Communications Networks

Constraints on PV Implementation	Potential Role for Communication Networks
Unsuitable for certain energy requirements	"Best practices" case studies can document viable markets.
Implementation in one market may not be replicable in others	Same as above.
Insufficient solar resource	Remote monitoring data would identify if insolation is sufficient in a region before investment in PV technology.
Incomplete knowledge of site-specific solar resource*	Communications technologies can record insolation data and support a database of insolation per location.

Table 3.3 Sociocultural Constraints on PV Implementation and Potential Roles for Communications Networks

Constraints on PV Implementation	Potential Role for Communication Networks
PV use not "mainstream"	Sharing information and research on overcoming barriers to implementation will help commercialize PV.
Questionable credibility of "new" technology	Monitoring of PV projects and making the information widely available will increase transparency and therefore credibility of the technology.
Lack of awareness of usefulness and possibilities of PVs	Using PV to power telecommunications equipment is a living example of its usefulness; educational information can be spread on PV benefits over traditional fuels.
Appropriateness of PVs for a particular region is uncertain	Communications facilitates two-way information sharing. This makes it easier for two parties to communicate on interests and complementary skills to cooperate on utilization of PV technology.
Market barriers to PV use are in place (i.e., taxes on BOS components)	Information content can reveal true economic costs (including externalities) of energy options.
Non-market mechanisms are underutilized	Communications can help foster non-market mechanisms such as accountability, moral persuasion, targeted information and tracking of voluntary agreements.
Sustainable Rural Electrification is a long-term objective, but decisions are made in the short-term	Access to information is generally a short-term objective. When IT and PV go hand-in-hand, this co-capacity building may speed up the implementation of SRE.
Movement of rural population to urban areas; solar systems are not as well adapted to concentrated urban areas*	The information revolution in the developed world may lead to more distributed energy use.
Consumer expectations raised beyond reasonable limits	Public education and factual presentation on the potential of PVs.
Need for individual awareness of environmental protection	Promote general information exchange on energy and natural resource conservation.
Limited knowledge/experience by local professionals	Communications technology can promote training and technology transfer.

Table 3.4 Financial Constraints on and Opportunities for PV Implementation and Potential Roles for Communications Development

Constraints on PV Implementation	Potential Role for Communication Development
Credit unavailable to low-income potential users/investors	Access to communications channels can help increase credibility and chances of getting a loan.
Competition from subsidized fossil fuel sources	Educational information can be made available on higher lifecycle cost of fuel engines.
Regarded as high risk investment	Communications can help organize consortia and partnerships which can cooperate to spread the risk out.
Use of highly inefficient end-use equipment (bulbs, refrigerators, TVs) increases costs of supplying electricity	Communications can help educate the public on lifecycle costs of appliance choices, and help establish distribution channels for supply of more energy efficient appliances.
Lack of information on potential demand increases perceived risk	Information could be made available.
Expensive to travel for on-site training	Information technology precludes expensive travel for training sessions.
Expense of site-specific system analysis compared to value of energy*	Information technology can help train local professionals on computer techniques, and provide handbooks of experience in good design practice.

*N.B. Constraints and possible solutions designated with * are adopted from WEC (1993).*

3.8 Co-capacity Building for Rural Areas

The motivations declared behind the energy initiatives in Section 3.6, and the role of communications presented in Tables 3.1 - 3.4 support the proposition that an information network is useful for facilitating the progress and monitoring of sustainable energy practices. The usefulness of PVs to power telecommunications equipment has also been demonstrated in this chapter. There is one other aspect to the main hypothesis yet to be demonstrated: that information networking is useful for sustainable development, and sustainable energy practices in particular for *rural* areas of developing countries.

One simple example of the cross-fertilization between information networking and sustainable development is that of a public call box or satellite groundstation located by or within a health center[19] several days' walk to the nearest town. With the ability to communicate with outside experts on health matters, the center can provide much-needed health services for the community (including remote diagnoses), and provide communications service as needed for other sustainable development problems. We can take that one step further and imagine this public call box powered by photovoltaics. This is not a big stretch of the imagination - it can be a viable commercial endeavor, as discussed in Section 4.4.

Rapid information exchange can even be an opportunity for competitive advantage. Recalling Volunteers in Technical Assistance (Section 2.2), VITA's communications networks designed for outreach to remote areas can help open new markets for PV exports. On the one hand, remote communications equipment can be powered by photovoltaics. On the other hand, PV projects could use the communications support. Skott Sklar of the U.S. Export Council for Renewable Energy claims "It's hard to compete when you're marketing to developing countries, or you can't maintain products because reliable communications aren't possible. VITASat is a solution to our problems, and can even give us a competitive edge. That's why we support this satellite system."[20] Far from being implemented in practice on a large-scale, claims such as this show more enthusiasm for the "world that could be" as opposed to real situations. Nevertheless, the potential for mutual benefits is recognized by experts from the telecommunications industry and the PV industry alike.

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[19] This example in support of the hypothesis presumes human health is subsumed under sustainable development. The author considers the provision of health services a basic human need necessary for the progression of sustainable development; this is an assumption which will not be further probed.

[20] VITA, "Renewable Energy," unpublished document, circa 1995.

The sustainable development communications network is yet another added capability which would add credibility and backing to any loan-seekers. In what one nonprofit development association calls "micro-entrepreneurship,"[21] sustainable development projects encourage the formation of businesses, thereby increasing the local standard of living. Enersol has found that renewable energy efforts in developing countries can be advanced through a national network of energy enterprises. Such enterprise networks could more effectively spread their financial and human resource base with the added capacity of efficient information sharing via SUCCESS.

[21] Personal communication with Julie Smith, Enersol Associates, November 1996.

Chapter 4
Communications Networking Strategy

4.1 SUCCESS

The role of a communications network in supporting sustainable development and photovoltaics in particular has been presented. This chapter turns to a discussion of the characteristics of the proposed network. The idea behind Sustainability Using Communications and Community-based Environmental Strategies (SUCCESS) is quite simple: combine the most appropriate technologies for connectivity with and among rural areas in developing countries, with access to the latest sources of quality information, in order to take full advantage of the capacity-building opportunities the network enables. More specifically, SUCCESS proposes to:

- Increase connectivity by **following the SDNP model**, to enable both horizontal and vertical information-sharing. The specifics on the actual information sharing process down to the individual level will vary depending on the needs, abilities, and existing infrastructure of the region. The objective of this connectivity is outreach into low-income communities in rural areas of developing countries. An efficient link can then be made between any actor with a need for information on sustainable development, and an organization which can provide the relevant information (either from their own sources or by access to the internet).

- Improve content by **using GSSD as a fulcrum for information exchange** among organizations with access to the World Wide Web. The conferencing capabilities intended to be incorporated into GSSD and its information base can accommodate just about any dialogue in electronic format — from real-time discourse between experts on an area of sustainable development, to asynchronous communication among stakeholders, to a simple retrieval of data from a server.[1]

[1] Conferencing capabilities are not a part of the GSSD system at this time. Through collaborative research and development among MIT's Department of Political Science, the Artificial Intelligence Laboratory, the Laboratory of

- Build capacity, where possible, by **powering telecommunications equipment in remote areas by photovoltaics**, inviting the co-capacity building of the combination.

A visual conception of SUCCESS is Figure 4.1. The legend explains how elements of SDNP, GSSD, and the use of photovoltaics contribute to the overall structure.

Computer Science and the Center for International Studies, such capabilities will be incorporated as the technologies and resources become available.

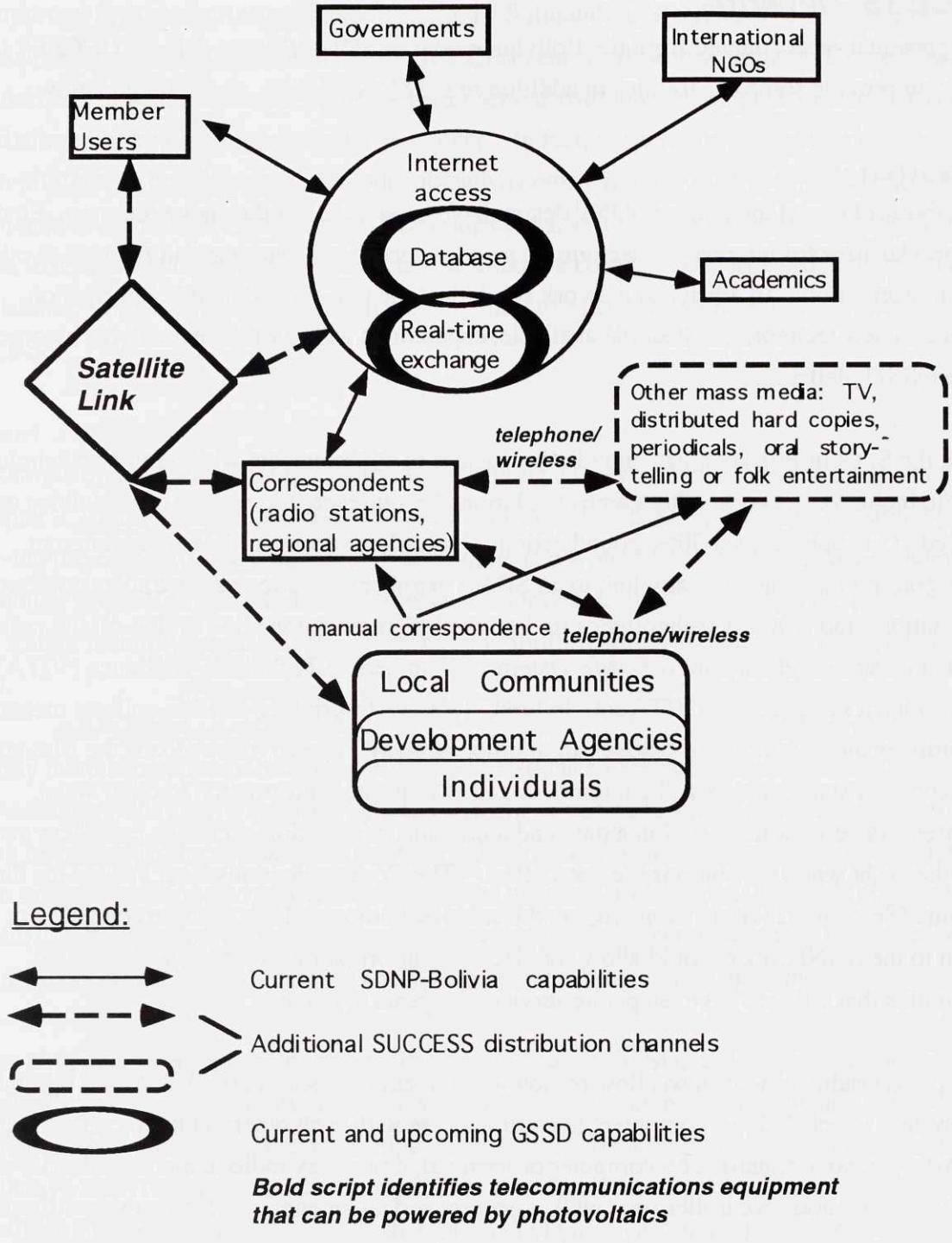

Figure 4.1 Sustainability Using Communications and Community-based Environmental Strategies

SUCCESS Network

This representation is adapted from the Bolivian model of SDNP (Figure 2.1). SUCCESS is intended to provide some capabilities in addition to the SDNP design, as discussed below.

Connectivity

Connectivities beyond the current SDNP design have been added in the above diagram. First, the SDNP model aims for internet connectivity to provide access to a database and pointers to other relevant information. An advanced network would include real-time, dynamic information exchange as new technologies become available, capabilities which will eventually be incorporated into the GSSD platform.

Second, the SDN in Bolivia relies on radio broadcasts to communicate with remote stakeholders. In a more inclusive network, other creative solutions for outreach into remote communities can be employed. One option is satellite groundstations with only a secondary link to the internet. Remote communities far from any link to an SDNP member institution can use solar powered groundstations and wireless technologies (in lieu of modem/telephone line or line-of-site radio transfer) in a store-and-forward message system. Volunteers in Technical Assistance (VITA) employs such a system called VITASat. In brief, a low-earth-orbiting satellite collects messages and continues on its orbit until it passes an internet gateway. There, it downloads the files and VITA technical staff can access the internet or gather requested information in other ways. Responses can be forwarded within a day, and automatic information exchange can occur even during the night when the stations are not staffed.[2] The Communications Boat Project for the Amazonia (Section 2.2) could even employ the same technology. Thus satellite connectivity in addition to the SDNP model could allow for electronic information exchange with isolated communities that will not have telephone services for years to come.

Digital packet radio systems also allow for low-cost electronic messaging. VITAPac[3] is another VITA system which "allows computers to communicate with each other via radios. Each station in a VITAPac network consists of a computer or terminal, a two-way radio, a modem-like device called a terminal node controller (or TNC), a printer, and an antenna . . . Transmission distance between stations may be increased through the use of intermediate relays, called digipeaters. Remote stations can be linked to form a network that can be connected to other networks."

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[2] Personal communication with Gary Garriot, VITA, November 1996.
[3] gopher://gopher.vita.org:70/00/intl/vita/vcomm.txt

It is important to note that the structure of SUCCESS (including SDNP and/or GSSD) does not preclude other communications initiatives. SUCCESS can work well with the initiatives described in Section 2.2; a wider audience would be better served with links among the various networks instead of merely by running parallel to each other. In fact, cooperation can further the objectives of each program. The Bellagio multimedia objective considered this in 1995. "Given the coincidence of the United Nations (UN) SDN objectives, World Bank objectives, and those of Agenda 21 Helsinki Group, the present database initiative could be seen as a product hosted and administered" on one of the network connectivity initiatives currently underway - or even SUCCESS.

Content

The example of a peasant sending a query and receiving a reply by radio broadcast was described in Chapter 2. In the same situation, an enhancement over the SDNP approach is possible by improving the *content* of the response. This example is not intended to point out any deficiencies in the ability of the Bolivian Ministry of Sustainable Development to respond to the problem at hand. Rather it simply points out the additional possibilities with a combination of SDNP and GSSD.

Currently there is no coherent tracking of SDNP questions and responses. A database hosted by GSSD could provide such a service. One can imagine a web page which posts the question, inviting responses from experts in the relevant fields: water resources management, fisheries and aquatic sciences, mining and construction, etc. The question itself can be "flagged" according to the field, to target the appropriate audience. So far the original anecdote changes little: as far as the peasant is concerned, the end result of a response by radio broadcast is the same.

Besides targeting the appropriate experts who have access to GSSD, use of the database[4] opens up the possibility of a continuous asynchronous dialogue, which can be tracked by any GSSD user. GSSD's ability to cross-reference these inputs to other problems, solutions and conditions also helps build a solid foundation of knowledge tailored to the needs of particular users. Recall from the Bolivian SDNP survey (Section 2.3) that this is the kind of information gap sorely noticed by some of the members and users.

[4] The author would like to thank Clarissa Hidalgo at MIT (MS '97) for an enlightnening discussion on user-database interface possibilities.

The national coordinator for the Bolivian SDN, Mr. Javier Orlandini[5] envisions that GSSD will be most helpful for creating an intelligent, interactive database to house information on Latin American development issues. The Bolivian SDN server currently hosts the web pages of several organizations, with no coherent structure. As development organizations provide the SDN with more and more data, the information can be strategically placed within the framework of GSSD rather than haphazardly on unlinked web pages.

4.2 Network Services

In the future, SUCCESS is envisioned as a communications network which will evolve to provide the following services.

Database Access

A combination of the SDNP network and GSSD content and capabilities would be able to provide almost any user in a developing country (indirect or direct) access to a database which could include:

- Directories of volunteers and assistance organizations
- Working papers and project proposals that could affect local communities
- An electronic bulletin-board service for announcements or asynchronous dialogue on events and issues
- Enforcement guidelines and monitoring activities.

Authorization hierarchy

By requiring users to log in and/or assigning passwords, different levels of speed and security of data exchange can be designated for different uses and users. For example, certain dial-up lines could be dedicated only to authorized persons, to expedite exchange of important or time-sensitive information. To control content, GSSD currently has three levels of security:

> "*Access* users will use GSSD as a mechanism for research or as a news source. Such users . . . do not add, revise, insert, or invent.

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[5] The author would like to thank Javier Orlandini, National Coordinator SDN-Bolivia, for his time in discussing the Bolivian program.

> "*Input* users are people or organizations using GSSD to modify the existing material on GSSD or to provide information to the system. The input user will build GSSD to an operational level and will maintain its growth.
>
> "*Networking* users, the third type of user, take advantage of the wide-area networking capabilities of GSSD. These users are able to communicate ideas, views, or concerns to 'experts' and others in the field and to elicit responses, in an exchange or conferencing paradigm" (Choucri and Baker, c.1996).

GSSD can therefore be tailored to the user-type; "only those components of GSSD to which an individual has access appear upon entry into the system."

Passwords can also be used to target audiences with specific information. "It may be necessary to reach different audiences even for different project objectives, with different messages, at different project stages and with different development communication or media channels" (Steinberg 1996: 576).

Search mechanism

Too wide of an on-line search for sustainable development-related information can be costly and take time to return too many bytes of data. In addition it clogs up the bandwidth, and wastes the user's time with irrelevant information. The intelligent search mechanism provided by GSSD returns pointers only to quality information.

Cross-referencing in GSSD includes pointers to cross-sectoral sources and consequences. There is a difference between a concept search and hits based on key words. A key word search is most useful for someone trying to find information on a very specific topic. The concept search returns a list of URLs pertaining to key words or phrases, as well as system connectivity, i.e., how they connect to GSSD concepts. This search option is useful for an overall understanding. A user could perhaps benefit from the GSSD framework in tracing the evolution of a problem and how it relates to current notions of sustainable development, and its policy implications. GSSD also includes a third type of search mechanism, a customized search. This allows the user to specify which slices, rings, and datatypes to search through.

Forum for public comment

A bulletin board service could be a forum for the public (or authorized users) to post comments. When project proposals and working papers during negotiations are posted on the database, public comment can formally be called, to be submitted by e-mail. This will make projects transparent, so that, for example, a proposal for building a road will be available for feedback from the affected communities. With proper follow-up on the correspondence, this operationalizes the idea of *two-way* communication and brings underrepresented stakeholders closer to the "virtual" negotiating table.

Real-time communication

SUCCESS will incorporate teleconferencing (as envisioned by the GSSD team), remote sensing (for data collection and project monitoring), and other services as new technologies become available. Thus the capability will exist for real-time feedback on development projects, eliminating a more lengthy trial-and-error process when the information and technology sharing is one-way.

Technology transfer 2-way

Technology transfer in the context of sustainable development often refers to environmental information and technologies transferred from industrially advanced countries to developing countries. Information involving environmental resources shared on the part of LDCs can be overlooked. With two-way communication, a network could facilitate the dissemination of indigenous knowledge.

Cooperation for Advanced Uses

SUCCESS can help streamline development activities, but it takes active participation by the users to identify how the communications network can best serve their needs. Below are some examples of the potential for SUCCESS capabilities which require more extensive effort and cooperation among actors.

Voting and asynchronous policy dialogue

Electronic collaboration can invite users throughout dispersed areas to participate in policy planning. One such system was developed at MIT for Vice President Al Gore's Open Meeting on the National Performance Review.[6] Several thousand Federal workers with access to e-mail and/or the WWW took part in "coherent, virtual conversations" to discuss proposals for bureaucratic

[6] This project is part of the Intelligent Information Infrastructure Project at MIT's Artificial Intelligence Laboratory. For more information see the URL http://www.ai.mit.edu/projects/iiip/doc/open-meeting/paper.html#introduction.

reforms. This type of research improves upon conventional technologies for on-line asynchronous discussion (i.e., mailing lists, newsgroups and electronic bulletin boards). With the proper security and user interface, eventually computer networks could allow remote inhabitants to participate in important referendums.

Decentralized data management

One of the powerful features of SUCCESS is that, using the internet as a backbone, any data stored on-line can be retrieved via the GSSD platform; GSSD itself does not house the information. Decentralized data can be added to GSSD at any time; a user need only request that a particular URL (Universal Resource Locator) be added to the system. The information in this URL is checked for quality and relevancy, and then placed appropriately within the GSSD framework. Multiple databases from different servers around the world can be searched with just one command. The more "input" users contribute to GSSD, the more powerful a tool it becomes.

One concept under consideration is designating different organizations to be "nodes" for specific types of information on GSSD. These "nodes" make available quality data to be placed within the GSSD framework. For example, an organization specializing in the energy sector could be in charge of the energy "slice." Whenever a user clicks on an icon in this slice , the information is retrieved from the external node, rather than the GSSD server computer.

Many organization implicitly recognize the need for expert nodes. Recall the Global Energy Observatory from Section 3.6: "GEO is being structured along geographic and expertise criteria, such that, as much as possible, every constituency is represented and every part of the world is handled by people from their own region" (Conner 1997). As more users gather information particular to their region, GSSD can be tailored according to usage characteristics. A GSSD "mirror site" would be set up to serve, for example, the South American countries, or users who prefer to navigate GSSD in Spanish. This mirror site would have the exact same user interface as the original GSSD, but would operate from a different computer server.

A mirror site could also serve as a "node" of information on the region. A user in the U.S. can search the GSSD database on the MIT server, request information on micro-irrigation schemes in the Bolivian altiplano, and retrieve the information from a web page on the Bolivian SDN server. As far as the user is concerned, the access to information is seamless. Dispersed nodes keep the data close to its source, allow it to be maintained by experts in the field, and reduce the demand on any one particular computer server.

Standardized communications protocols

A committee report from the Habitat conference in Istanbul, June 1996[7], states "The United Nations should foster the development of information standards and formats to enhance global access to information."[8] Through continued use, SUCCESS can evolve as the standard for international, national and regional information exchange pertaining to sustainable development. Since the SUCCESS framework includes a combination of many independent communications projects, the viability of these connectivity efforts will not be threatened.

Standardized project evaluation procedure

Project application, evaluation, implementation and monitoring forms could employ this same decentralized communications network. Directories of such information can be available via the on-line database. Methodologies for proposals sorted by region and by type (i.e., sustainable forestry, renewable energy, water management and so forth) could serve as templates. Project design and management, calculations for environmental impact assessments, stakeholder support, and financial information will then be presented in a standardized manner to facilitate the process of raising funds and technical and political support. With easily accessible project plans, the level of compliance can more easily be gauged by a wider audience. It will also be easier for stakeholders to witness environmental impacts over the long haul if monitoring information is posted as well.

4.3 Network Requirements

Some specifics for network requirements are provided in Appendix B.[9] The purpose of this thesis is to argue more for the qualitative architecture of SUCCESS, without espousing particular equipment and protocols. Appropriate linkages across communications networks are preferable to one inflexible standard network, or several disconnected systems. The details of current communications networks are sure to be quickly outdated, but new technologies will evolve and be able to fit into the framework of SUCCESS.

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[7] The Communications Dialogue Report of Committee II at the Second World Conference on Human Settlements, Istanbul, 1996.

[8] UN Doc: A/CONF.165/L.5.Add.8 12 Jun 96 p. 8 <www.undp.org/un/habitat/confdocs/16515a-8html> in Simms (1997).

[9] Appendix B contains information particular to SDNP-Bolivia. UNDP (1994) contains technical information on SDNP in general, also available in electronic format at the URL gopher://gopher.undp.org:70/11/undp/programme/seed/sdn

Above all, human requirements must first be met to ensure the continued contribution of SUCCESS to sustainable development. This means attention to serving the needs of its users, which can be checked by the feedback mechanisms inherent in the use of SUCCESS. For example, the number and type of users on GSSD can easily be tracked, as well as the information or services which are most in demand. Soliciting periodic updates from remote sites (i.e., the rural areas served by the low-tech "traditional" components of the SUCCESS network — radio broadcast, communications boat, satellite groundstations, etc.) will help keep track of the network's usefulness to these localities.

Human requirements also entail education and training on the use and upkeep of the system. Users should be aware of the availability and potential of information networking, and communications equipment must be properly maintained to ensure that the higher-technology communications mediums are reliable, and do not dissuade potential users.

4.4 Financing

Some of the issues involved in financing PV systems for general rural electricity requirements are discussed in Chapter 3. Here, the financing of a communications network is considered.

Costs

Connectivity

SDNP-Bolivia operates at an estimated cost of $3500 per month[10], but as pointed out in Chapter 2, this network is currently understaffed. The addition of two full time employee equivalents is anticipated to dramatically increase the outreach and usefulness of the network for remote users. Operating costs are highly variable according to each country. Bolivia's figure is bound to change with the advent of a new fee structure for the newly privatized telephone services. Until November of last year, data transfer by telephone was a flat rate charge. This year, local telephone service providers turned to per-minute charges.[11] The ability for users to afford full access to SUCCESS (i.e., full internet connectivity) is highly dependent on these external factors.

Other methods of network connectivity for low-income, rural communities may not involve the internet. The radio stations involved in the Bolivian SDN generally fund themselves. Being

[10] URL http://coord.rds.org.bo/engver.htm, cost estimate from 1996.
[11] Personal communication with Javier Orlandini, National Coordinator for SDN-Bolivia, April 1997.

network "correspondents" adds relatively little on the margin: the cost of a PC, and $20 per month for e-mail access or $35/month for full internet access.[12]

VITAPac (see Section 4.1) may prove to be appropriate and affordable. "Despite its level of technical sophistication, one TNC unit costs only about $300, and an entire VITAPac station, including computer, costs between $4,000 and $10,000 plus installation and training. Another advantage of VITAPac is that system computers may be used for other purposes when the network is not active."[13]

For public call boxes, a typical public telephone (with booth, coin collector unit, mast, and PV power supply, transceiver and antenna), which interfaces with the nearest town exchange, costs $5000 to $10,000 of which about 10-20% covers a solar (or wind) power system and battery (in 1989 dollars). Typically, it is only necessary to generate 30-60 minutes of traffic per day to break-even under commonly used telephone tariffs. Experience has indicated that, even in poor communities, once a reliable system has been established (so that people expect calls to be successful), a profitable level of traffic yielding a return on the investment may commonly be generated. The results are obviously fairly location-specific and individual surveys are needed to plan such investment (UN 1989: 203).

Building the infrastructure

Access to the Internet is largely seen as an inevitable objective for developing countries, and not an expense that would necessarily eat into the funding that goes towards sustainable development efforts. The proliferation of information technology is driven by the trends of decreasing hardware costs, smaller component sizes which increase portability, and increasing user-friendliness which circumvents the need for a technical education (Annis 1991).

The "leapfrogging" potential for information technologies in developing countries is a financial advantage. Communication via satellite does not require an expensive infrastructure - portable mobile stations weigh just a few pounds and can be used for transmission anywhere. Many commercial services already planned in developing countries will require minimal augmentation to be useful for SUCCESS. Inmarsat (Wright 1994) encourages all countries to add mobile satellite services (for communication in isolated areas) as a natural development to the growth in or extension to cellular services.

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[12] Ibid

[13] gopher://gopher.vita.org:70/00/intl/vita/vcomm.txt (April 1997)

Potential Revenues

Increased connectivity at a rate of 30% monthly growth (Bellagio 1995: 9) implies a growing customer base that sees value in internet connectivity. Increased demand, however, is accompanied by continuing falls in charges. "Thus the motivations behind pricing must change radically - to promote higher value added services rather than to optimize profits from the sale of basic connections" (Forge 1995: 4). It is the *service*, not the connectivity per se, that users value. A short answer to the cost-recovery problem is to eventually charge the user's willingness to pay for this service, assuming the service potential is recognized by the user.

This of course is easier said than done. *Any* fees assessed to the poorest of users in developing countries may be unreasonable in the absence of disposable income. The concept of the "rich" subsidizing the "poor" may be appropriate in these cases. For example, the Ford Foundation uses DAINET, a communications network in India for its own needs (i.e., for communications and coordination of their activities in the region). Their payment for these services effectively subsidizes public use of the network for sustainable development activities.[14]

We must also recognize that communication for sustainable development is a very small part of the whole telecommunications industry, which includes multichannel television and entertainment services. So costs for developing SUCCESS will not necessarily include the communications infrastructure of a region. SUCCESS assumes telecommunications companies will duke out the costs and details of providing access for a customer base wider than the users concerned with information on sustainable development.

Multilateral Financing

Multilateral financing is another lever for SUCCESS development. The UNDP provided seed money for the SDNP pilot program in Bolivia. There are also loan programs available with the help of the World Bank and the private sector which can finance telecommunications development in LDCs.[15] Some funding for SUCCESS will rely on such grants, loans, and any other donations. Multilateral financing can be thought of as a catalyst, with the understanding that the regional capacities will seek outside funding from the outset.

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[14] *Development Alternatives Newsletter*, March 1997, and personal communication with Ashok Khosla, March 1997.

[15] Personal communication with Terry Powers. For more information on these "B-Loan" programs administered by the International Finance Corporation (a member of the World Bank Group), please see the URL http://www.worldbank.org/html/fpd/harnessing/

Licensing

Licensing for bandwidth is a potential source of revenue. Governments can then choose to use some of the license revenues for financing sustainable development communications initiatives (i.e. SUCCESS). Licenses for commercial ventures could then be granted in a preferred manner if an agreement can be reached for SUCCESS to "piggy-back" on the technology.

Project match-making

Use of the SUCCESS network could reduce transaction costs and match-making expenses for joint implementation or other bilateral projects. Since the structure allows for two-way communication even to the most remote regions, the match can be made without hard leg-work on the part of project brokers or aid agencies. A well-designed database that can be scanned for potential matching will encourage these projects. Additional revenue for SUCCESS can come from a "participation" fee assessed to donor countries that end up embarking on a project thanks to using the communications network.

Fee Structure Options

User connectivity and content fees are another obvious revenue option. A fee structure should be designed to both provide incentives for organized data and incentives for its use. A fee per use assessed to a very poor end-user defeats the purpose. For some targeted socioeconomic groups, this information should either be free or heavily subsidized. Below are general categories for user tariff options.

Table 4.1 User Tariff Options

Tariff structure	Electronic Information Services
1. Connection charge plus periodic rental fee (fixed charges)	Internet services for organizations with direct access
2. Fixed charges plus duration (usage) charges	Online services which charge connect time. Internet services for users without direct access (e.g., dial-up)
3. Fixed charges plus content/ volume charges	Premium-rate information services offered via online services with direct access
4. Fixed charges plus usage charges plus content/volume charges	Premium-rate information services offered via online services with dial-up access
5. Usage charges or content/volume charges only (no fixed charges)	Public access to online services from multimedia kiosks via debit card or coinslot

Source: ITU (1995) Table 2.2

Different telecommunications services have attempted each method with varying success, and in the computer services industry there is little tradition that would favor one method over another. Option 1, connection charge plus rental fee, may be used if an umbrella organization (for example, the Ministry of Sustainable Development in the case of SDNP-Bolivia) could pay for the connection and fixed charge at the outset. Once the public perceives its value, a move to content/per-use charges can be made.

The benefits of a flat-rate are:

- predictable cost for consumer and revenue streams for provider
- simplified billing, making it easier to apply discounts and promotional pricing to attract new customers, and
- it encourages experimentation by users to discover what's to offer and to customize services for their own use (ITU 1995).

The downside to flat charges is the possible perception that if something costs nothing, it is worth nothing. Users unconcerned with metered charges could also quickly overload the system.

Since SUCCESS means different services to different users, cost recovery would depend on the specific application. We therefore must devise a menu of cost-recovery options from which to tap into. Without a doubt, trial-and-error will be necessary to balance cost recovery with demand.

"Piggy-backing"

SUCCESS in various manifestations may not necessarily happen on its own, but it could simply evolve when new development projects consider it from the outset of the endeavor. There may be opportunities for SUCCESS to "piggy-back" on other government programs, such as education or other public services. "In certain project contexts where permanent project assistance to beneficiaries is required to familiarize and guide them with certain low-cost self-help building techniques — with water consumption, with cleanliness and improved sanitation, with maintenance of drainage systems and a collaborative attitude towards communal solid-waste collection systems operating locally — this might represent an ideal leverage for DSC.[16] DSC could work through extension systems project field workers and technicians, eventually including training of community leaders and mass media support. Additionally, training and awareness-

[16] Development Support Communications

raising for local government technicians — who are working frequently in the field and are expected to perform an enabling role towards the project target groups — is an additional project task of high importance for DSC" (Steinberg 1996).

4.5 The "3 Cs" and Sustainable Development - Putting it all Together

A visualization of how SUCCESS can improve the "3 Cs" for rural communities expands on the simple 3 - axis diagram from Figure 1.1. The further a community is along the three axes, the more information content they will be able to access in order to address their development information needs. It is also relevant that the further along each axis a community is, the more information content they will *need* in order position themselves on a sustainable development trajectory. SUCCESS is a timely endeavor in the planning phases of development; its effectiveness is hampered when implemented in hindsight.

Before putting the connectivity, content, and capacity dimensions all together, Figures 4.2 and 4.3 decompose the connectivity and capacity axes. Figure 4.2 summarizes the levels of connectivity which can make up SUCCESS. Connectivity starts at the bottom, from existing traditional communications mediums all the way up to experimental and upcoming technologies. The axis in boldface type on the left hand side shows the progression from existing LDC infrastructure, to the potential for increased connectivity under certain conditions, up to experimental and upcoming technologies. There is no sharp delineation between these levels of infrastructure connectivity, hence the gradual shift towards increasing levels of sophistication following the arrow. The column in italics indicates the core features of the communications mediums described in the last column.

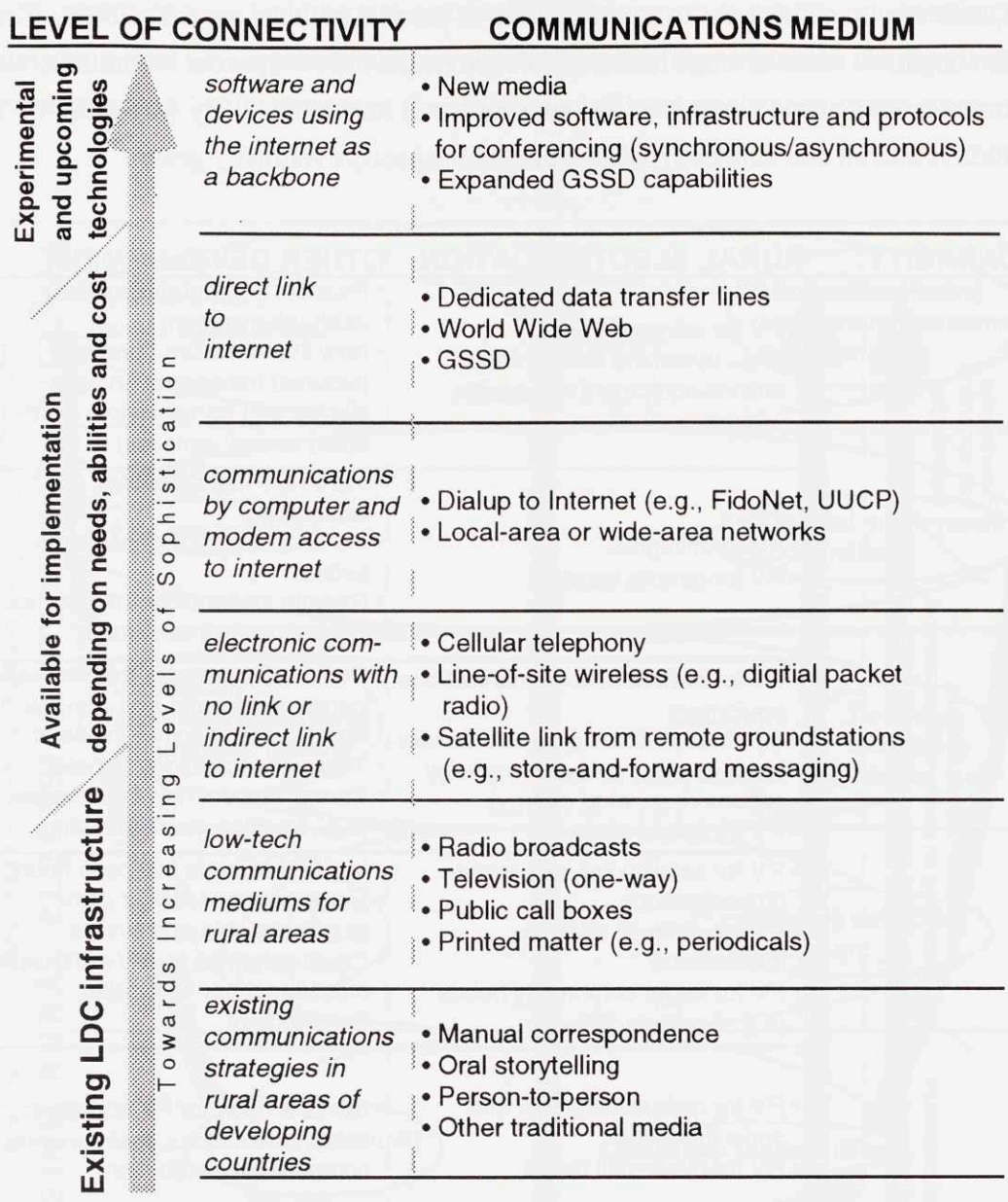

Figure 4.2 SUCCESS Connectivity Axis

Figure 4.3 uses the connectivity axis as a background, and highlights the capacity axis. The left column of the diagram summarizes the ways in which photovoltaics can be used for rural electrification needs, with a progression from household use through telecommunications applications, up to electric grid connection (i.e., from current capacities to potential future scenarios). The right side indicates development projects which start from simple awareness-building at the bottom, through enterprise development all the way up to new paradigms in infrastructure needs and demographics. These general development initiatives, like the PV

projects, start small and increase in sophistication in parallel with the spread of SRE. The *content* dimension begins to shine through here: as PVs are employed for specific community and telecommunications needs, the public becomes aware of its potential. By way of SUCCESS, this information is shared and connectivity, content, and capacity eventually grow.

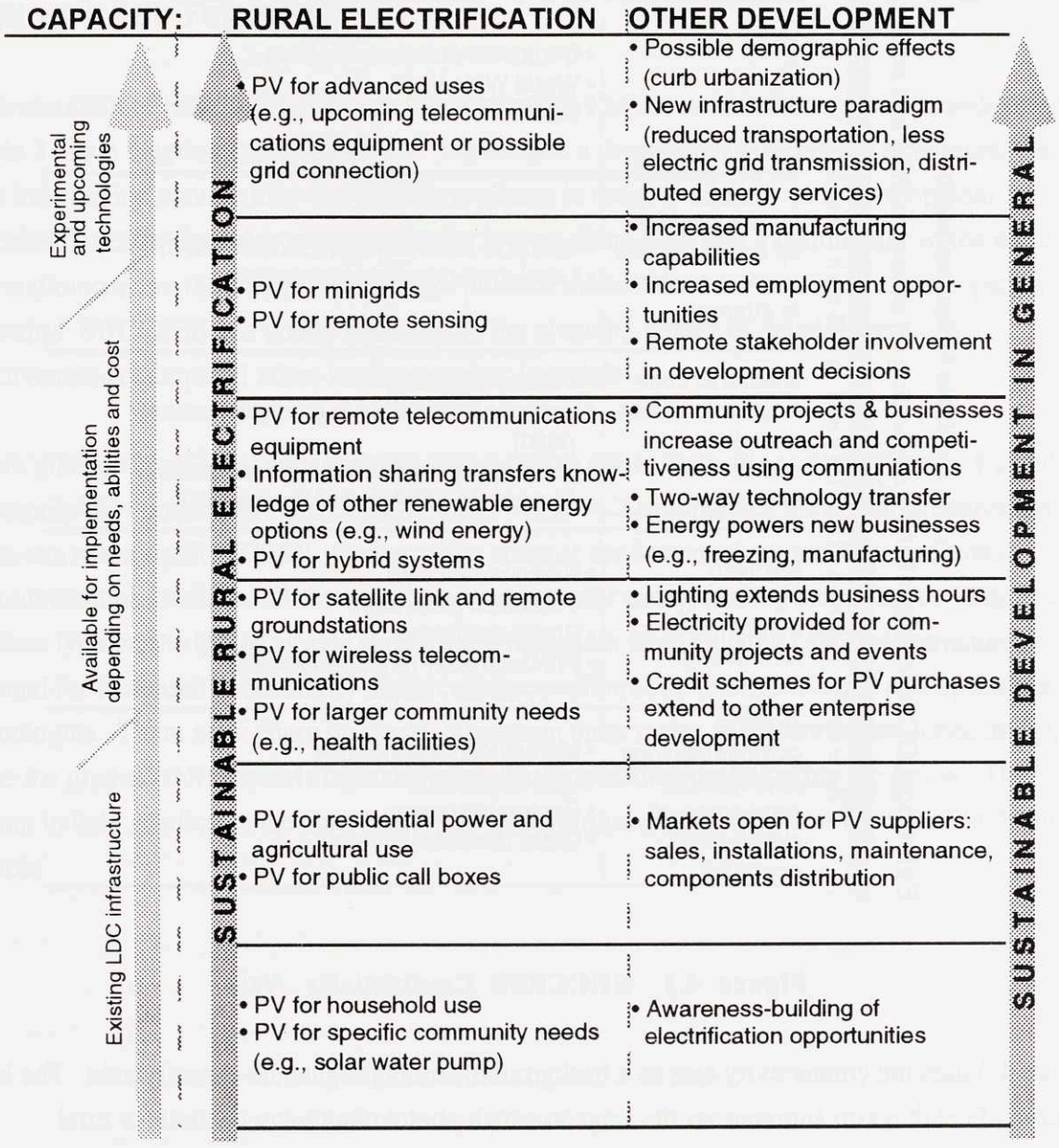

Figure 4.3 SUCCESS Capacity Axis

Figure 4.4 incorporates all the dimensions. Connectivity is shown as a simplified axis in the center of the diagram; essentially all of Figure 4.2 is subsumed in this center axis. Axes for sustainable

rural electrification capacity-building and sustainable development in general are on either side. Progression along each axis represents the level of community development. Content is depicted by the area mapped out by the ellipses in the center of each level of connectivity.

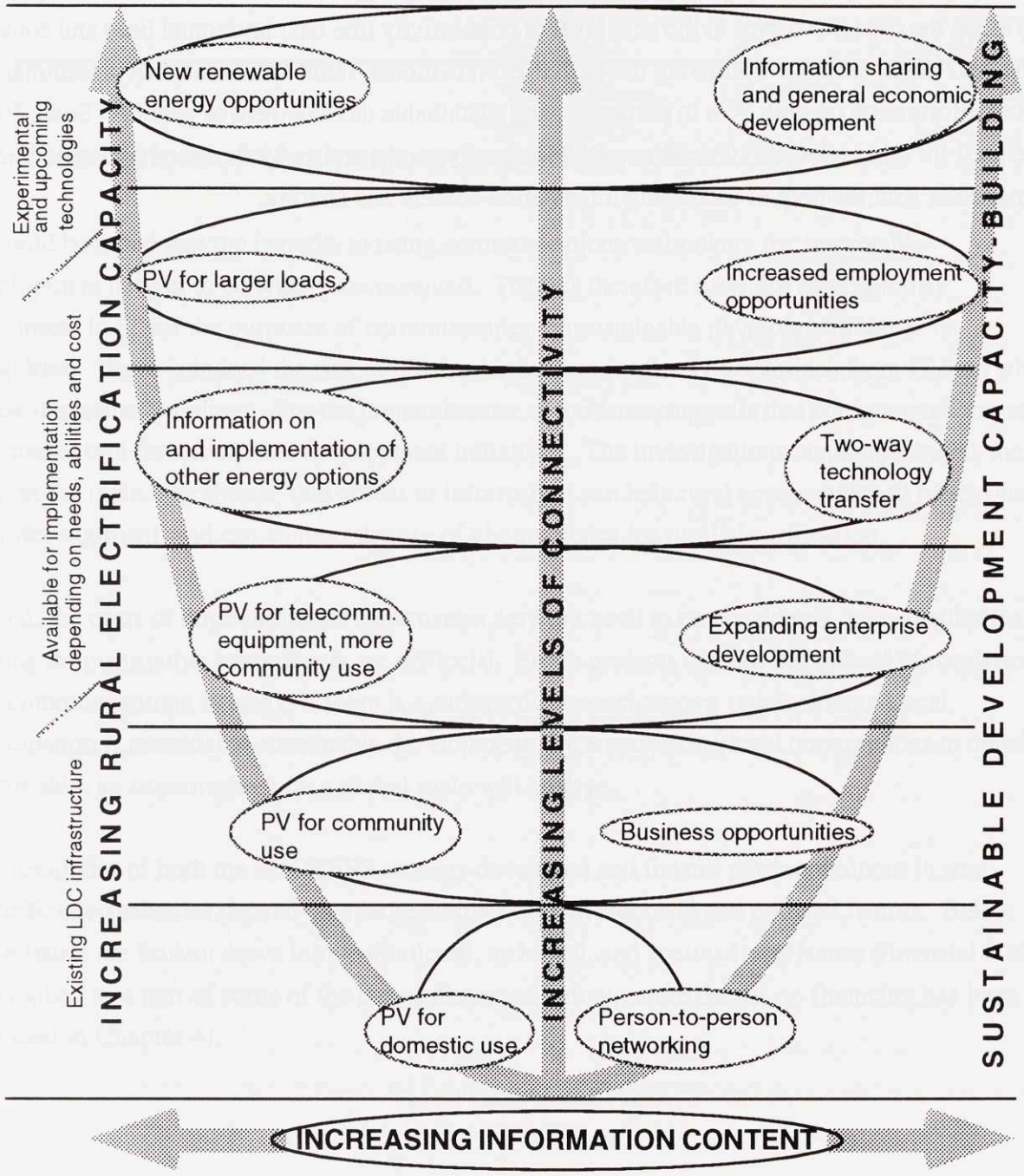

Figure 4.4 SUCCESS Connectivity, Capacity and Content Dimensions

One of the many idealized scenarios for community development with SUCCESS can be traced along the figure. The origin represents both the start of rural community planning for sustainable development, and the first manifestations of SUCCESS. We begin with manual correspondence, and isolated cases of PVs in the community for household use. Person-to-person communication spreads knowledge of PV capabilities for other community needs, and we trace this development up along the capacity curves to the next level of connectivity (the next horizontal line) and content (the next larger ellipse). Following the SDNP-Bolivia model, radio broadcasts can disseminate more information on both PVs in particular, and sustainable development in general. Soon, PVs are used for other telecommunications and community needs, and general economic development progresses with the help of increasing information content and sharing.

Chapter 5
Recommendations and Conclusions

5.1 Discussion of Uncertainty and Risks

It should be noted that the benefits to using communications technology for sustainable development has yet to be widely documented. There is therefore room for criticism that investment in IT for the purposes of communication on sustainable development issues is misguided. There is indeed the risk of placing higher expectations on solutions from IT than what its use can actually deliver. But the preponderance of evidence suggests that communications can be a useful tool for sustainable development initiatives. The investigations conducted in this thesis support the main hypothesis: that access to information can help rural communities to better plan their development, and can support the use of photovoltaics for rural electrification.

Indeed, the costs of not building an information network need to be considered (even qualitatively so long as quantitative assessments are difficult). Entire projects can fail because of the omission of a communications strategy, if there is a serious disconnect among stakeholders. Local participation is essential to sustainable development; by empowering local communities to develop sustainably, an improvement on a global scale will emerge.

The feasibility of both the SUCCESS strategy developed and the use of photovoltaics in rural electrification schemes depend on a large number of both technical and political factors. Below these issues are broken down into institutional, technical, and sociocultural issues (financial factors are implied as a part of some of the issues discussed below; more details on financing has been provided in Chapter 4).

Institutional Issues

Stifling diversity

Ashok Khosla writes "It is exceedingly important to allow for multiple efforts, even if they are seemingly similar in objective or strategy. The only hope for finding viable alternatives for specific development problems is to generate and test a variety of approaches undertaken with a variety of levels of competence. It is only from such diversity that the most viable ones can be selected for replication on a wider scale. The traditional fear of 'unnecessary duplication' is highly inimical to the generation of creative alternatives" (Khosla 1997a).

Mr. Khosla does point out the folly in the consensus that redundant activities are undesirable. Given the open architecture of SUCCESS, there is hardly a huge chance that SUCCESS will become an overarching strategy to dwarf all others. In fact, it can work in parallel with many other connectivity, content, and capacity efforts. This thesis recommends a model for each of the connectivity, content, and capacity parameters, but not to the exclusion of any other efforts to increase the "3 Cs."

Public/private expectations

There is often an interest in increasing public/private partnerships when considering finance for a public good. On the surface it may seem an enlightened concept, and potential for solid, mutually beneficial partnerships certainly exist. But there is a risk that any disagreement between a private donor and public service provider can have serious negative consequences. To paraphrase a participant in a panel discussion on "International Development in the Information Age,"[1] it's hard to create successful public/private partnerships because once they are committed, a dissatisfied private enterprise has an army of lawyers at their disposal that could essentially bury an NGO with time and expenses.

VITA has spent over one-half million dollars just in legal and engineering fees in order to meet the requirements for partnership with a commercial satellite firm. VITA's potential partner companies are those which deploy satellites for commercial applications, such as reading remote gas and pipeline meters, monitoring trucking fleets, etc. Since VITA's endeavors are not commercially viable, they must find a partner company which operates satellites that VITA can use for its store-and-forward messaging system. Ensuring that VITA's, their partner's, and the government's

[1] The 1997 Harvard International Development Conference, which took place in Cambridge, MA on February 21-22, 1997.

needs and requirements are met is a long bureaucratic process which takes "an incredible amount of time and money."[2]

Resistance to assistance

"Not long ago, if you wanted to seize political power in a country, you had merely to control the army and the police," writes Umberto Eco. Now power belongs to those that have privileged access to information. "The day after the fall of Khrushchev," Eco goes on, "the editors of *Pravda, Izvestiia,* the heads of the radio and television were replaced; the army wasn't called out" (Eco 1986: 135). Traditionally governments and private hands have had a stronghold on communications "merchandise." A fairer playing field in information access can begin to transfer that power to underprivileged groups, a shift that may not happen without some friction. Jessica T. Mathews, a Senior Fellow at the Council on Foreign Affairs argues in an article entitled *Power Shift:*[3]

> Widely accessible and affordable technology has broken governments' monopoly on the collection and management of large amounts of information and deprived governments of the deference they enjoyed because of it. In every sphere of activity, instantaneous access to information and the ability to put it to use multiplies the number of players who matter and reduces the number who command great authority. The effect on the loudest voice - which has been governments' - has been the greatest.

Besides issues of internal security, national resistance to building capacity for information access could stem from fear of competition, or simple bureaucratic lethargy (Wright 1994). In some areas, there may be a concern that local capacities — postal, telephone, and telegraph services (PTTs) — will get bypassed. Indeed, competition could force PTTs to crumble. PTTs that have been operating under the luxury of charging monopolistic rates are especially vulnerable. Care must be taken to undergo a smooth transition to a more competitive market, lest the capacity-building envisioned with SUCCESS inadvertently manifests as "capacity crumbling."

Lack of training

Another problem which arises from a variety of factors, misallocation of funding being one of them, is the potential for underestimating the importance of training on proper use of the network.

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[2] Quote and information from personal communication with Gary Garriot, VITA, November 1996.
[3] Mathews, Jessica T., "Power Shift," *Foreign Affairs*, Jan/Feb 1997 in Simms (1997).

Without training on even the most basic upkeep, the breakdown of a simple component or a bug in any software could render the entire computer system useless.

The seamless operation of telecommunications equipment, however, does not preclude futility. Information sharing is meaningless without quality control, as a random search on the WWW with a conventional search engine will reveal. The SUCCESS services proposed in this thesis include many distribution channels for quality information; it is up to the users to take full advantage of this potential, or risk losing important developmental information among the useless bits traveling in cyberspace.

Sociocultural Issues

Too complicated

Granted, the increased capacity for public outreach may overly complicate the playing field. If too many actors get involved, negotiation contentions can easily get compounded with so many interests at the table. But a more complicated playing field can nevertheless be a *fairer* playing field, if local interests are brought to the negotiating table. By facilitating communication both *with* and *among* NGOs and individuals in developing countries (which SUCCESS is designed to do), these interests can join forces. With clever coalescing, NGOs can then make sure they have at least one voice instead of many that are self-defeating.

The placebo effect

An "authorization hierarchy" is proposed in this thesis for security and quality-control purposes. This same feature creates the potential for subversive targeting of development information. Selective authorization for certain on-line "chat rooms," databases, or mailing lists, can parse the audience and essentially exclude stakeholders in the network - not by limiting connectivity, but by limiting information. A kind of "placebo effect" could take place, whereby certain interests are invited to "participate" in dialogues, with no follow-through on comments or requests.

Information on information

Consumers and providers seem to have a heavy preference for high bandwidth, real-time audio/visual exchange. This is very expensive compared to the data exchange necessary for scientific purposes (file transfer is a lot easier than talking to an engineer on the phone) - or what would be necessary for communications to support sustainable development. Decision-makers should be better educated on this issue, and informed on the potential of less-expensive (and often

more useful) asynchronous communications, to avoid wasting funds on inappropriate information technologies.[4]

Anthropomorphizing this . . . Thing

Using human terms to describe what computers do ("it's *thinking*") can imply a greater potential for useful results than what the machines can actually provide. Electronic information exchange occurs at very basic levels of abstraction[5]; many other visual, audio, cognitive and contextual cues are absent from simple data transfers. One must not forget that technologies for information dissemination are in many cases a poor substitute for traditional expression and communication.

At an SDNP workshop in Bombay (UNDP 1994: 33), a "balance between human and technical networking" was recommended. "Participants repeatedly noted the importance of the human network and it is concluded that the use of computer mediated communications or computer networks is first to enhance the human network and not an end in itself."

Language and culture

English appears to be the default language in world-wide information networking, as any "surfing" session on the WWW will reveal. Language translation software is facilitating more rapid deployment of information for non-English speakers, but rarer languages, and even indigenous languages with no written code, will not see a presence on the WWW in the near future. This widens the gap which SUCCESS is intended to bridge. Furthermore, the waves of popular culture (mostly American) emanating from the internet, TV and radio could create a cultural friction that might backlash and prevent widespread use of communications technologies.

Steinberg (1996) warns that "it is very relevant to consider the literary, language, cultural and age level of the target group. The general wisdom is that mass media will be utilized only for certain, easily identifiable target groups and for the dissemination of certain clear-cut information transfers. If more complex behavioral patters, beliefs, and feelings are addressed, it certainly demands a longer-term approach with an intensive person-to-person communication basis."

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[4] The author would like to thank Joe Sedlack, VITA, for his ideas on this subject. Personal communication, April 1997.

[5] The author would like to thank Professor John Williams (MIT), for an enlightening discussion on cognitive levels of abstraction and implications for information technology.

PVs are not the cure-all

Constraints to widespread PV dissemination in the developing world are summarized in Tables 3.1 to 3.4. These and other limitations render PVs and other renewable energy technologies quite problematic. It is likely that PVs will always have to be combined with more conventional energy sources in order to ensure maximum reliability and flexibility. As long as this limitation is recognized, the inability for PVs to be the backstop technology for all rural electrification schemes will not be seen as a failure and temper interest in its use.

A renewable energy source is certainly a step in the right direction towards sustainable rural electrification. But communities must not bask in the comfort of new energy sources without paying attention to energy end-use as well. For example, it is important to use energy-efficient appliances to avoid offsetting the gains in electricity availability.

Vandalism of PV systems might be a problem in some areas. Some preventative measures are: covering the modules with a tough plastic instead of glass, mounting them on a tall pole, and camouflaging the system or burying the balance of system components (Thomas *et al* 1994: 10).

Although implementation of distributed energy services is generally thought to reduce the inclination for rural to urban migration, there may in some cases be unexpected demographic consequences. "In areas of the Pacific Islands, the advent of electricity has led some family members to migrate to cities in search of jobs and cash in order to purchase these new electric services and appliances" (Shepperd and Richards 1993: 2).

Technical Issues

Fast train to the wrong station[6]

A risk that is easy to identify but much harder to minimize is the ability of the network to serve public needs. The temptation must be resisted to strive for state of the art equipment (when funding is available) even when cheaper, less sophisticated options will do. The danger here is misallocating funds on fancy equipment rather than education and training. An epitome of the problem is the not-uncommon example of network "users," NGOs or government employees, spending their time at work playing video games with the microcomputers or workstations on their desks.

[6] The author must credit the outspoken use of this phrase to Professor Robert N. Stavins of Harvard University.

This time of course could more wisely be spent on sustainable development activities - the whole point of the network. This presumes that there are people willing and able to make use of the information tool. If SUCCESS can provide a service to the rural peasant, the question is how to keep the rural peasants coming with the questions. Putting the SUCCESS network in place, no matter at what the level of sophistication, can be like a "fast train to the wrong station" if it serves too few people or even exacerbates information inequity by creating an "information elite" within a community. Just as problematic is the use of inappropriately sophisticated technologies which can cause delays, frustration, and other inefficiencies which reduce interest in the network.

Security

If SUCCESS is to be financially self-supporting, there must be people willing to pay for its service. If at least part of its service has monetary value, there's the possibility of hackers who might gain by unauthorized access to the product. Putting obstacles in the way of illegal access is especially important in the case of potentially sensitive information. Care must be taken to balance the trade-off between proper authorization (and its extra time and expense), with wide accessibility of sustainable development information, a key objective of SUCCESS.

Replicability

Solutions on a small scale, or under particular circumstances, do not necessarily scale-up or translate well under different conditions. In the case of the Bolivian SDN, Bolivia happened to have a terrestrial/radio infrastructure in place that is well-suited for sustainable development networking. Equipment and lifestyles in other countries may prove such a network impossible to replicate.

5.2 Policy Recommendations

Many policies which could encourage development of SUCCESS (or of any or all of the "3 Cs") would be in the spirit of voluntary agreements and cooperation rather than any binding national or international laws. For example, as mentioned in Section 4.3 (Network Services: Cooperation for Advanced Uses), voluntary contributions to content providers such as GSSD (in the form of a simple URL submission to the database) can populate the system with important information. Increased voluntary usage of content or connectivity platforms can spur awareness and demand and further allow capacity-building to grow.

Governments also play a large role in the feasibility of a communications network for sustainable development. Interestingly, among the responses to the survey sent to the SDNP-Bolivia members, no one indicated that political constraints were an obstacle to sharing information on sustainable development issues (Section 2.3). Lack of good sources of information was first place among the constraints; lack of finance, lack of education and training on the use of communications technologies, and technological constraints all tied for a close second.

It should first be noted that it is a government Ministry (the Ministry of Sustainable Development) which maintains the Bolivian SDN; users will not be likely to argue that the creators of the network and providers of the service are impeding its use. Second, governments inevitably either implicitly or explicitly influence the amount of resources (information, education, technology and funding) that can go to such an endeavor.

What governments must keep in mind concerning policies that can encourage SUCCESS is the implications for remote stakeholders in the development process. *Outreach* of the network must be emphasized in order to avoid a growing disparity in information and connectivity between urban and rural or remote populations. Governments can signal a strong commitment to sustainable development at the grassroots level by devoting even a fraction of their human, financial, and technical resources to information and education campaigns which extend beyond the top tiers of socioeconomic populations.

Governments can also prove a commitment to wider public access to information networking by "informatizing" their own functions. The International Telecommunications Union (1995) recommends that governments (1) electronically connect administrative offices; (2) maintain and provide computer-based documents and (3) develop methods of electronic democracy (see Section 4.3 for an example of electronic voting and asynchronous policy dialogue).

Policies which embrace "resistance to assistance" (Section 5.1) will prove to be myopic. Forward-looking developing countries will realize that both customers and the nation as a whole stand to benefit in the long run from international competition. First of all, computers and phone link networks are spreading so rapidly that the proliferation of information exchange appears inevitable. In addition, mobile groundstations for satellite communication are getting smaller and smaller, which means they'll be about as easy to control as the transborder use of briefcases. Consumers win because information sent over these electronic networks costs about one fourth of a fax transmission (WRI 1993: 231), less than a telephone call and is more convenient than regular postal "snail mail."

Instead of focusing effort on trying to build a fortress around a country's airspace, innovative ways of reaping social benefits from commercial communications applications should be considered. After all, only with a flow of foreign investment will many nations be able to develop a communications infrastructure. For communications mediums and development services that are not commercially viable at this time, public/private partnerships can be fostered. The burden of legal fees on small and fragile NGOs in the event of contention with a business partner was a risk discussed in Section 5.1. Reasonable and clear legal requirements for entering into such agreements must not perennially favor the private interest when it comes to petty, litigious disagreements.

Many nations (including the U.S.) collect licensing fees for the use of electromagnetic bandwidth. Part of these revenues could go towards funding portions of SUCCESS, including workshops to educate users and potential users on the use and maintenance of the network. Governments could also allocate (and enforce) certain bandwidths for the explicit use of communications for sustainable development activities. This is particularly helpful for terrestrial radio communication which uses short-wave frequencies that are clogged with use already (topography and sunspot cycles get in the way as well).[7]

It would also behoove governments to be aware of demand trends. "Demand for televized entertainment is taking off in developing countries. There are roughly twice as many television sets in use around the world as telephone lines. Viewers in developing countries have also shown a willingness to pay for subscription TV even though charges may be far higher than for basic telephone service. Data from Africa show subscribers paying up to seven times more for a pay TV service than for telephone service" (ITU 1995). The lesson here is that governments should pause to make intelligent decisions about communications infrastructure development. People of all income levels are willing to pay for a service when there is a perceived value; appropriate communications mediums and technologies must be deployed in order to meet this demand. It may be possible for SUCCESS services to "piggy-back" on the spread of communications for commercial entertainment services.

Keeping in mind the potential for co-capacity building with the combination of photovoltaics and telecommunications, governments can adopt policies which encourage the dissemination of PV technology where appropriate. This means a transition away from adverse market signals such as

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[7] Garry Garriot, Volunteers in Technical Assistance, *Personal Communication*, November 1996.

import duties or quotas on PV equipment and subsidies on fossil fuels. Financial incentives for utilities and entrepreneurs to invest in distributed energy systems could also catalyze sustainable rural electrification.

5.3 Conclusion

SUCCESS seeks to build capacity for grassroots efforts independent of the "top down" multilateral, international, or national development projects. The following table summarizes some of the differences discussed throughout this thesis between "top-down" efforts to achieve sustainable development, vs. small-scale independent efforts, as envisioned using SUCCESS.

Table 5.1 Characteristics of grassroots and top-down development initiatives

Grassroots	Top-down
Begins with individuals, families, and/or communities	Begins with governments
Technology transfer can be two-way	Technology transfer is one-way (ICs to LDCs)
Decision-makers at the community level	Decision-makers at the national level
Prioritizes community action	Prioritizes projects largely by political and economic attractiveness
Opportunity for real-time implementation	Large time lag for implementation

Networking is also inherent in almost any sustainable development activity, as expressed in the following diagram for the PV application example.

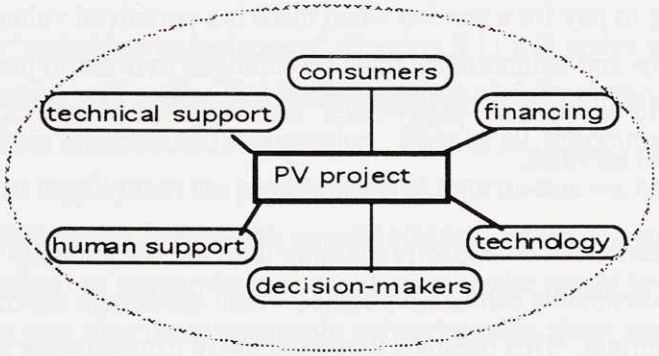


Figure 5.1 The PV Network

Figure 5.1 shows some of the actors and issues associated with installing a photovoltaic system. No matter what the scale of the project, there is involvement from consumers, who demand the electric service; decision-makers, community leaders or national interests who can either encourage or discourage the project; there are also issues concerning the technology itself, and that it requires technical support in the form of supplies and service; human support to provide maintenance and repairs; and financing to cover the high capital cost of the system. "Individually, each project needs sufficient resources to be able to carry through its tasks, and collectively they need to be able to communicate with, exchange and rely on information from others in the network. If appropriate technologies like woodstoves or solar pumps have failed, it is largely because of this factor" (Khosla 1997a).

The need for networking among all actors even for a simple application might imply hopeless complications. But these intricacies also afford opportunities. Once the technology is in place, we can see from the diagram that business opportunities may be created to provide technical support, the training needed by way of human support is an educational opportunity beyond the context of PV system support, and financial mechanisms to support PV capacity building schemes can extend to other business enterprises.

The SUCCESS concept starts in a very small and simple way; perhaps one PV module for household lighting along with word-of-mouth recognition of its usefulness. The first phases build connectivity and capacity by providing appropriate communications and electricity services. As the network expands, information for training, education, and economic development becomes more valuable. Information content evolves into a commodity as the network ripens into a financially self-sustaining venture. In this way a small, a grassroots seedling can spur more growth in sustainable rural electrification, sustainable development in general, and SUCCESS itself.

Appendix A
The Global System for Sustainable Development

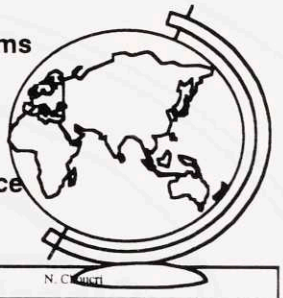
THE GLOBAL DILEMMA

HUMAN ACTIVITIES & CONDITIONS

reinforced by current

NORMS &VALUES

- **Threaten natural & social systems**
- **Undermine human aspirations**
- **Create social conflicts & violence**



WHAT CAN BE DONE?

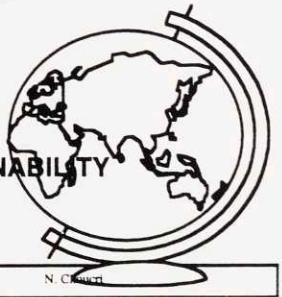
SOCIETIES MUST BECOME MORE SUSTAINABLE

therefore we must identify

"BEST STRATEGIES"

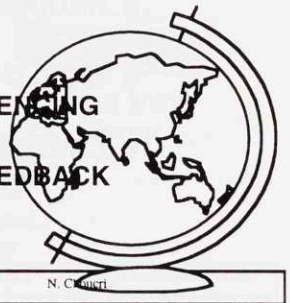
for

SECURITY, SURVIVAL & SUSTAINABILITY



WHAT ARE THE OBSTACLES?

- CONCEPTUAL AMBIGUITIES
- EXPLOSION OF INFORMATION
- OBSTACLES IN TRACKING
- ABSENCE OF GLOBAL CONFERENCING
- DISCONNECTS AND LIMITED FEEDBACK

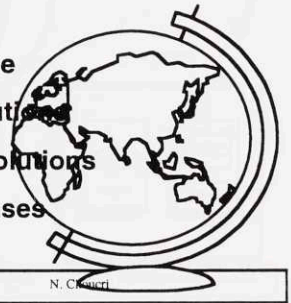


GLOBAL SYSTEM FOR SUSTAINABLE DEVELOPMENT

G.S.S.D.

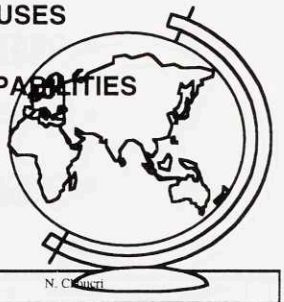
ADAPTIVE AGENT INTERFACE WITH FOCUS ON:

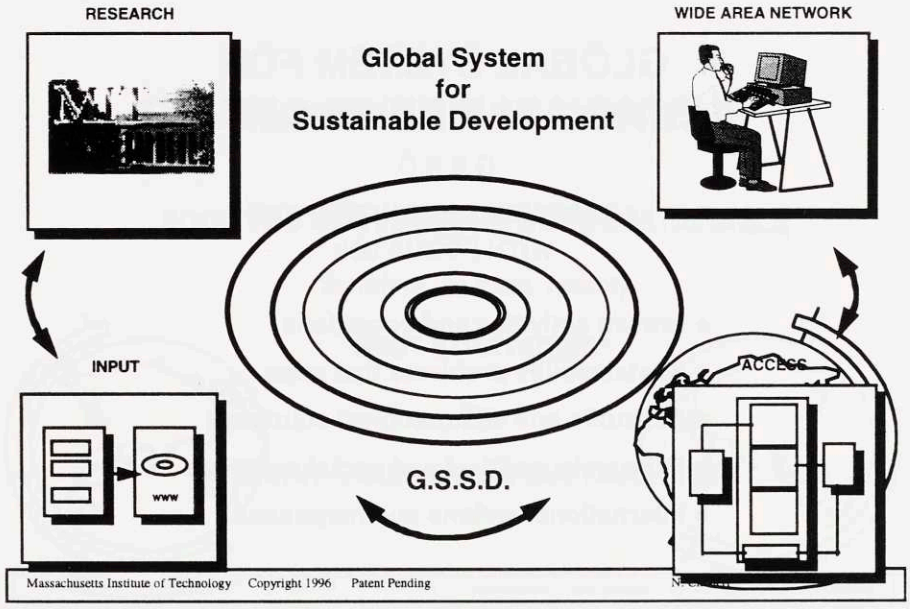
- Human activities and conditions
- Sustainability problems that arise
- Scientific and technological solutions
- Economic, political and social solutions
- International actions and responses

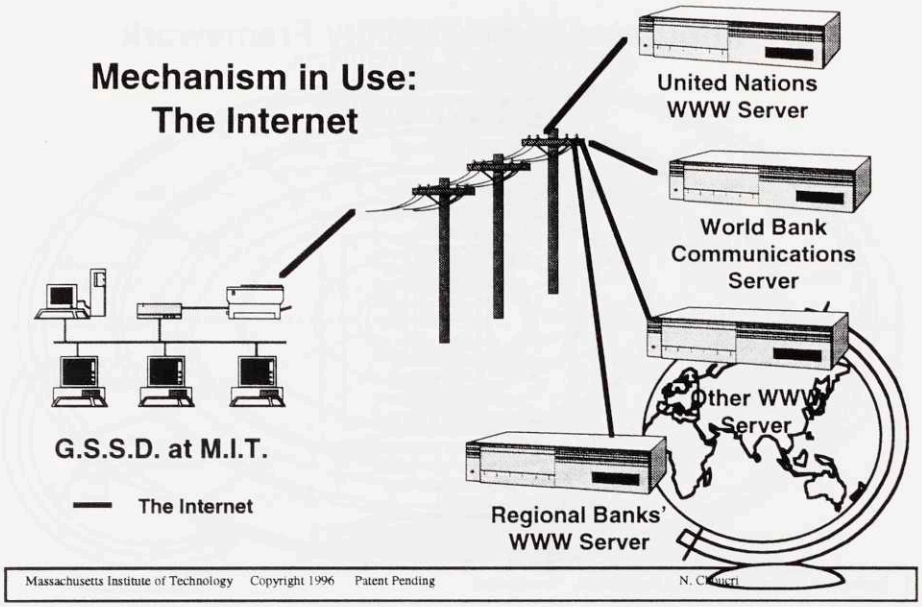


KEY FEATURES

- INTEGRATED APPROACH
- MECHANISM FOR TRACKING ADVANCES
- PROCEDURE FOR STREAMLINING USES
- WORLD-WIDE CONFERENCING CAPABILITIES
- CUSTOMIZED SEARCH ENGINES

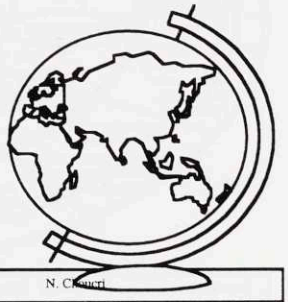




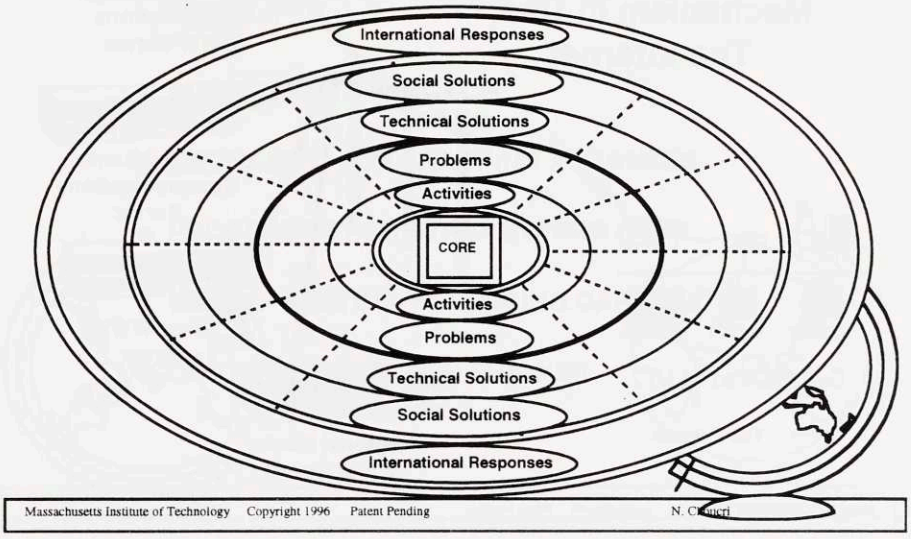


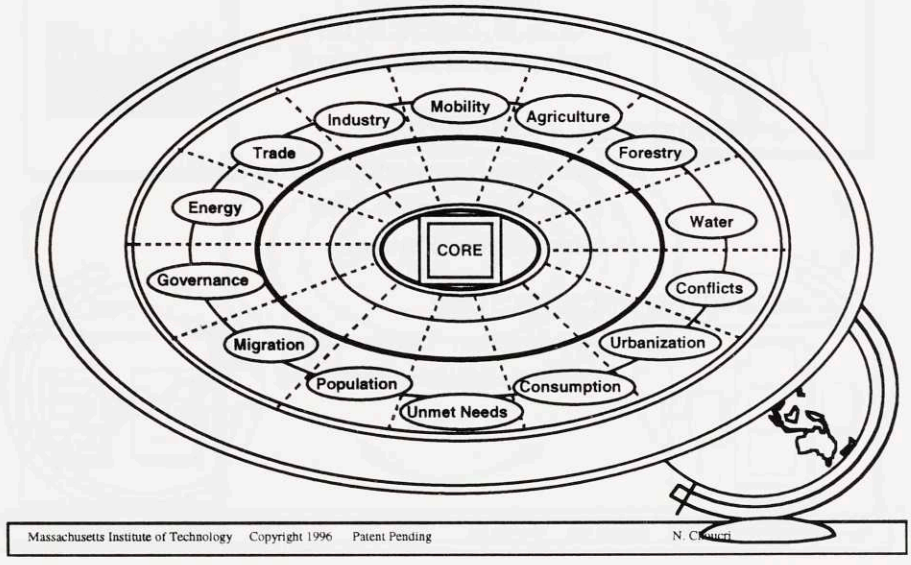
G.S.S.D. DESIGN

- **CONCEPTUAL FRAMEWORK**
  - Evolving Knowledge Representation
  - Multi-Dimensional View
  - Micro-Macro Linkages
- **SYSTEM ARCHITECTURE**
  - Application: Deliverables
  - Implementation: Methods

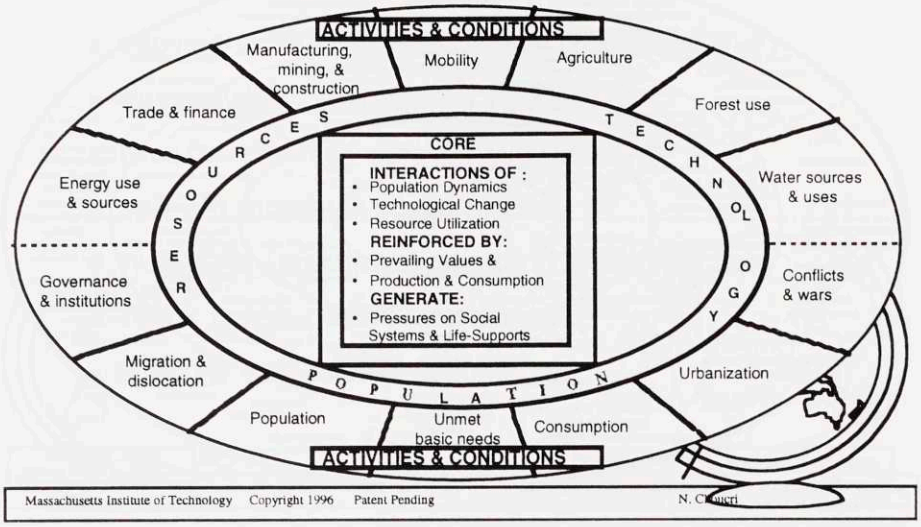


Integrated Sustainability Framework

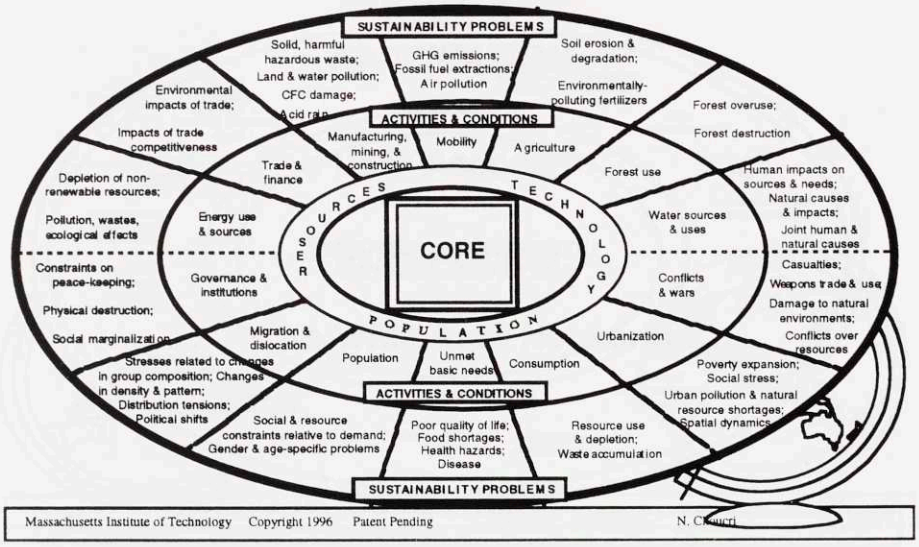




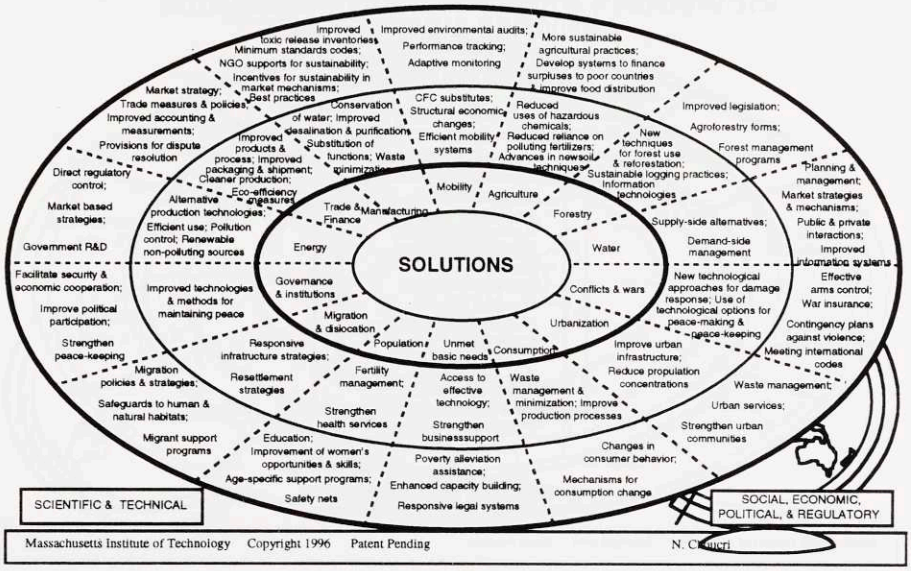
FROM CORE TO ACTIVITIES & CONDITIONS



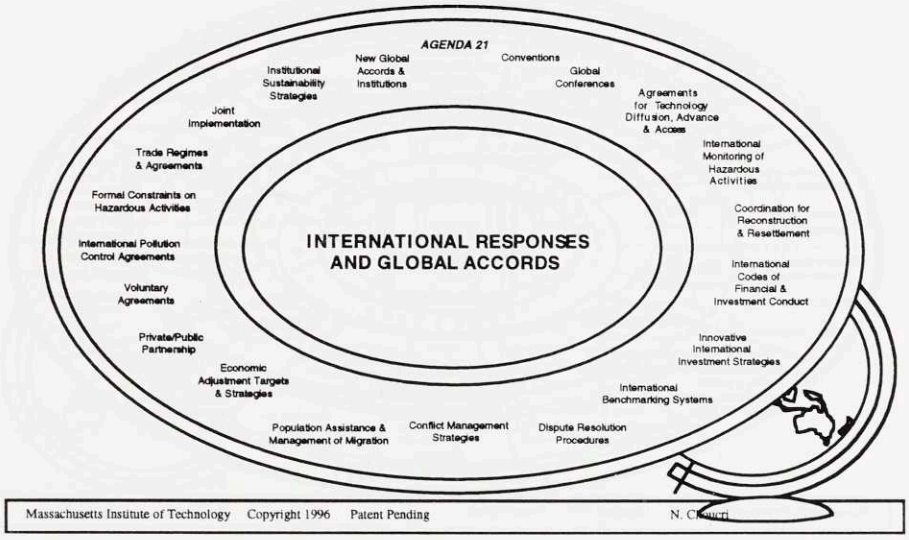
FROM ACTIVITIES & CONDITIONS TO SUSTAINABILITY PROBLEMS



TOWARD SOLUTION STRATEGIES

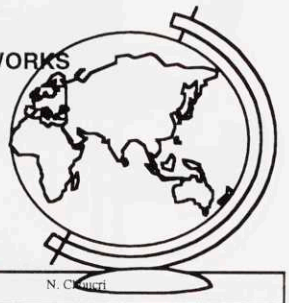


INTERNATIONAL STRATEGIES FOR SUSTAINABILITY



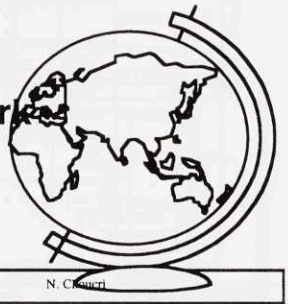
G.S.S.D. GOALS

- PROVIDE INTEGRATED APPROACHES TO SUSTAINABILITY
- CONTRIBUTE TO RESEARCH & EDUCATION
- FACILITATE ACCESS TO S & T KNOWLEDGE
- SUPPORT WIDE-AREA CONFERENCING
- FACILITATE LINKAGES TO AGENDA 21 NETWORKS
- TRACK INTERNATIONAL AGREEMENTS
- SUPPORT NEW GLOBAL ACCORDS

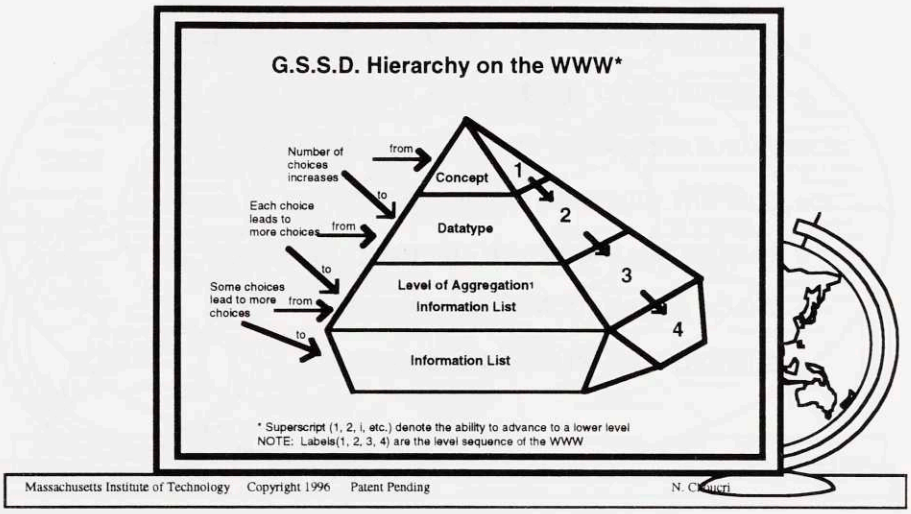


G.S.S.D. APPLICATION

- User Access
- System Input
- Wide Area Networks

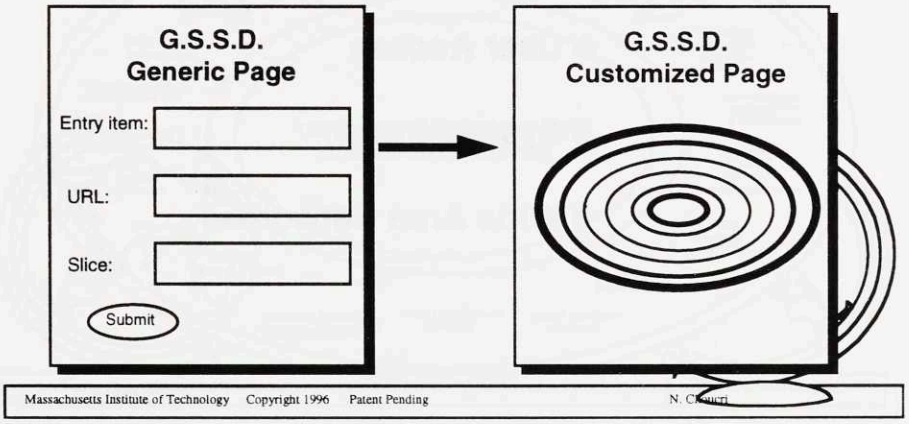


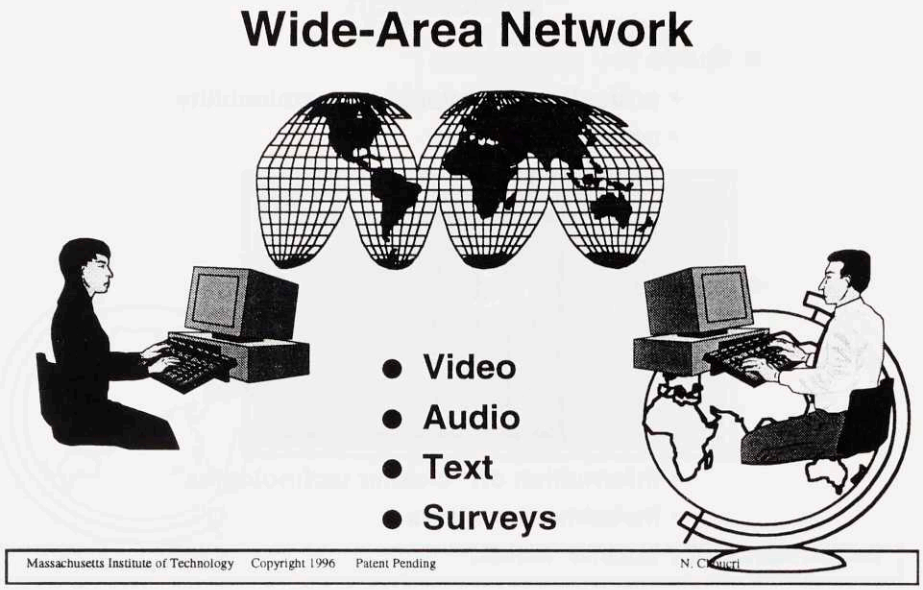
G.S.S.D. on the WWW
Access to Topics

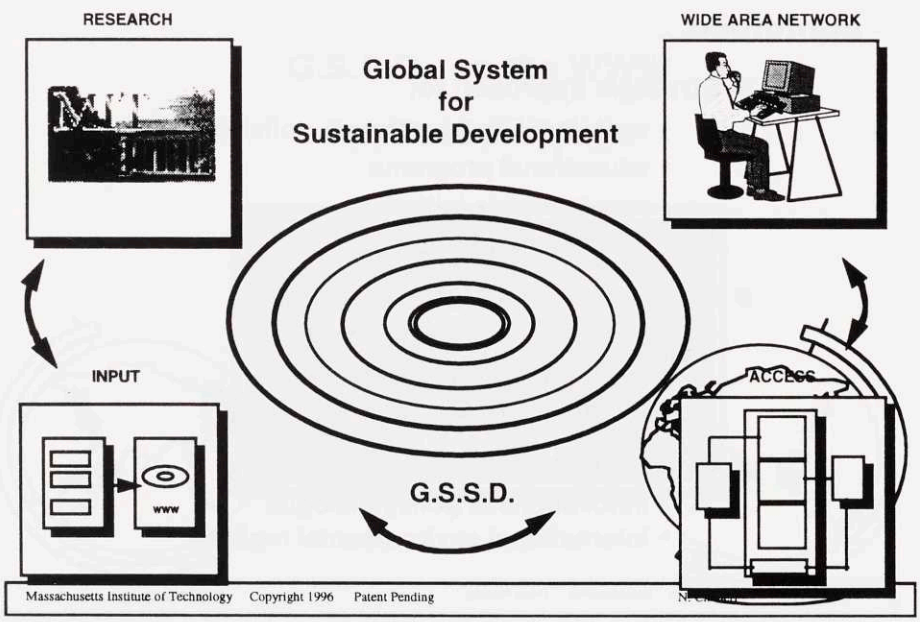


APPLICATION
System Input

Synthetic Strategy




Wide-Area Network
Video
Audio
Text
Surveys
Massachusetts Institute of Technology Copyright 1996 Patent Pending

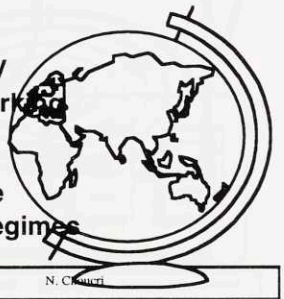

RESEARCH
WIDE AREA NETWORK
Global System
for
Sustainable Development
INPUT
ACCESS
www
G.S.S.D.
Massachusetts Institute of Technology Copyright 1996 Patent Pending

Conclusion

- Guide to:
  - critical issues related to sustainability
  - ongoing research
  - data banks
  - policy development
- Search algorithm for:
  - bibliographical purposes
  - modeling activities & initiatives
  - public policy records
  - international treaties & legislation
  - information on "cleaner technologies"
  - investment projects

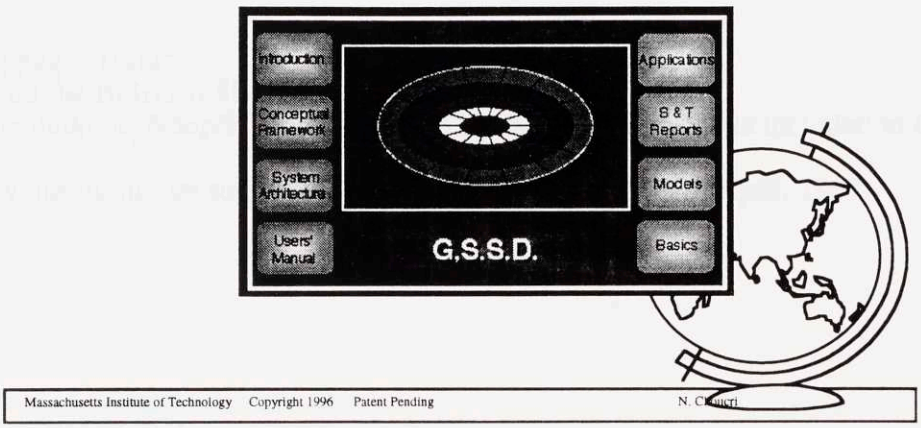
continued...

- Strategic approach to:
  - sustainability programs & policies
  - educational programs
  - new business initiatives
  - tracking performance
- Communication mechanism for:
  - international negotiations
  - conferencing on sustainability
  - international electronic networks
- Global map for:
  - innovations in policy dialogue
  - international environmental regimes



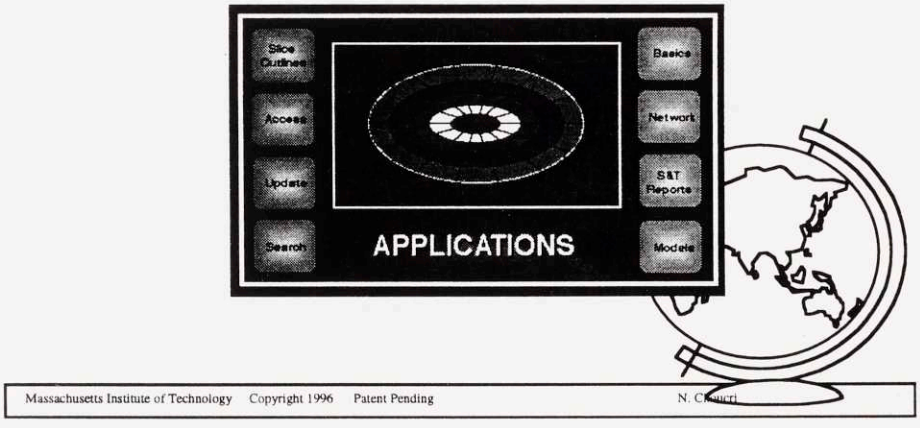
G.S.S.D. on the WWW

Home page



G.S.S.D. on the WWW

Applications page



Appendix B

Sustainable Development Networking Programme - Bolivia

The following pages show:

- 1995 data on the Bolivian SDNP, available from the URL http://www.undp.org/sdnp/la/boupdate.htm. Updated information is included in the body of the thesis.
- The survey questionnaire sent out to Bolivian SDNP members in April, 1997.

SDN Bolivia

Project Information and Personnel
Technical Information
Statistics
Organization Members
Information Resources
Activities

1. Project Info/Personnel

Project Name: Sustainable Development Networking Programme SDNP-BOLIVIA

Project Duration: 30 months, June 1993 - September 1995

Project Budget: June 1994 to December 1995: 161.895 $US

Project Phase: Phase three operational

Host Organization Name:

Ministerio de Desarrollo Sostenible y Medio Ambiente
P.O.Box 12814
Arce Ave. No. 2147 4to Flr.
E-mail: sdnp@coord.rds.org.bo
La Paz - Bolivia
phone: 591-2-317320
fax: 591-2-317320

Project personnel:

National Coordinator: Juan Pablo Arce
Technical Assistance: Javier Orlandini
Secretary: Selva Escalera de Mogro

2. Technical Information

Host computer:

Gateway 2000 P5-90
CPU: Pentium 90 Mhz
RAM: 16 MB
Hard Disk: 1GB
Operating System: Linux 1.1.59

Modems:

3 Modems Telebit T2500, 19.200 bps
1 Modem telebit Trial Blazer plus 19.200 bps

Number of phone lines connected to host:

Two phone lines (UUCP)
One phone line (SLIP)

Other equipment: One computer as a Router

CPU: 80486 20 Mhz
RAM: 4 MB
Hard Disk: 430MB

Operating System: DOS running KA9Q

Connectivity Type: Internet and UUCP

Connection Type: Leased line 19.200 bps (SLIP), Swiching Lines (UUCP)

Host software: Gopher, ftp, E-mail and Telnet

Client software supported: Pmail, Waffle, Winsock, FTP, Telnet and Gopher

Languages supported: English and Spanish

Year/Month Host started:

Pilot phase: started February 1993 to December 1993
Networking and operational phase: January 1994 to December 1994
Operational phase (with own internet access): started August 1995

Services provided: E-mail, Gopher, FTP and Telnet

System up 24 hours/day, 7 days/week?: Yes

3. Statistics

Number of users:

With e-mail: 81 (member of SDNP-BOLIVIA)
Without e-mail: 70 (member of SDNP-BOLIVIA)

Total number of messages/day:

From 1994 to May 1995 the SDNP-BOLIVIA was using the BolNet host to users of SDNP. In this sense the number of messages was increasingly each month according to new memberships. (see Table 1). From table 1 the average per day should be calculated, representing aproximately 3803.82 messages per month and 126.76 messages per day.

MENSAJES POR TIPO DE ORGANIZACION

MES	# MENSAJES	ONG	GUB	ACAD
Jan-94	720	360	288	72
Feb-94	790	379	316	95
Mar-94	1039	488	468	83
Apr-94	2496	1323	899	275
May-94	2763	1409	1078	276
Jun-94	3189	1754	957	478
Jul-94	2676	1525	856	294
Aug-94	3497	1958	1014	525
Sep-94	3070	1689	829	553
Oct-94	2121	1082	700	339
Nov-94	4822	2315	1688	820
Dec-94	4397	2199	1759	440
Jan-95	6564	3216	2363	985
Feb-95	5071	2941	1471	659
Mar-95	4721	2644	1275	803
Apr-95	7522	3911	2257	1354
May-95	9207	4972	2670	1565

Total daily bytes transacted:

During 1994 and part of 1995 the SDNP-BOLIVIA was using the BolNet host. In this sense the number of bytes transacted was increasingly each month according to new memberships. (see Table 2). From table 1 the average per day should be calculated, representing aproximately 16,081,182.9 bytes per month and 536,039.4 bytes per day.

A questionnaire was written in Spanish[1] and sent out to the Bolivian SDN members courtesy of Javier Orlandini, National Coordinator. Approximately 200 surveys were sent out by e-mail, 11 responses were received. The survey follows.

SDNP-Bolivia Member Survey

Estimados Miembros:

El Instituto Tecnologico de Massachusetts se encuentra evaluando a la RDS por favor les ruego responder el cuestionario y mandar las respuestas a la Sra. Karina Funk cuya direccion electronica es:

funkk@mit.edu

Agradesco de antemano su tiempo y colaboracion, atte.

Javier Orlandini
Coordinador Nal. a.i RDS-BOLIVIA

---

1) Nombre y ubicación de su organicacíon

2) [Pregunta opcional] Su nombre y empleo

3) Clase de organizacíon
   a) gubernamental
   b) no gubernamental
   c) académica
   d) institución privada
   e) institución científica
   f) otro

4) Qué medios de comunicacíon relacionados con su correspondencia sobre la RDS usa Ud.? Por favor, especifique los medios aplicables.
   a) radiodifución
   b) teléfono
   c) fax
   d) e-mail
   e) "World Wide Web"
   f) correspondencia manual
   g) intercambio de documentos electrónicos
   h) otros (por favor especifique)

5) En forma semanal, aproximadamente cuántas preguntas recibe Ud. por intermedio de la RDS?
   a) 0 - 5
   b) 5-10
   c) 10-20
   d) mas de 20

---

[1] With special thanks to Marina Funk for her proofreading.

6) Sobre estas preguntas, cuántas de ellas solicitan específicamente información sobre el desarrollo sostenible?

a) casi todas (más del 90%)
b) la mayoría (más del 50%)
c) pocas (20% - 50%)
d) casi ninguna (menos del 20%)

7) Aproximadamente cuántas respuestas con información específica sobre el desarrollo sostenible proporciona su organización? (Por favor indique cuántas)

8) Las preguntas que Ud. generalmente recibe sobre la RDS, a qué asuntos se refieren? (Por favor, indique las dos de mayor uso).

a) energía
b) finanzas
c) gobierno
d) migración
e) población
f) no poder hacer frente a las necesidades
g) consumo
h) urbanización
i) conflictos
j) usos y recursos de agua
k) agricultura
l) minería, construcción, o fabricación
f) silvicultura
g) transporte

9) Sobre las preguntas arriba mencionadas, cuáles considera Ud. que su organización tiene mayor experiencia?

10) De acuerdo a su criterio, cree Ud. que la RDS puede llegar a ser un método efectivo en potencia para poder intercambiar información sobre el desarollo sostenible?

a) si
b) no
c) no seguro

11) Consideraría Ud. que la RDS debería extender sus servicios más allá del desarollo sostenible? Si su respuesta es "si," qué otros servicios deberían ser proporcionados?

a) ayuda técnica sobre la agricultura
b) información sobre salud y medicina
c) información sobre actividades cívicas
d) otros (por favor especifique)

12) En su opinión, cuáles son los obstáculos más grandes que impiden el poder realizar un buen sistema para comunicación sobre el desarollo sostenible?

a) falta de fondos
b) falta de buenas fuentes de información
c) falta de usuarios - demanda insuficiente
d) restricciones tecnológicas
e) falta de instrucción sobre el uso de medios tecnológicos para la comunicación
f) restricciones políticas
g) otros (por favor especifique)

Muchas gracias por su participación. Cualquier otro comentario que Ud. desea incluir, será my bien recibido.

Bibliography

Annis, Sheldon, "Giving Voice to the Poor," *Foreign Policy* 84, 1994.

Barozzi, Leandro and Daniele Guidi, *Prospects for the Expansion of Solar PV Technology in the Developing World: Financial Mechanisms and Technology Transfer Optimization,* World Wildlife Fund Italy, Rome: 1993.

Benmouffok, Djilali and Tavinder Nijhawan, "Information and Communications for Sustainable Development: IDRC's Response to Agenda 21," IDRC: Ottowa February 1997, paper presented at Rio+5 Forum, Rio de Janiero, March 1997.

Bolivian Ministry of Sustainable Development and Environment (Bolivian MSD 1996), "Building Sustainable Development," country report presented at the Summit of the Americas on Sustainable Development, Santa Cruz de la Sierra, December 1996.

Bolivian Ministry of Sustainable Development and Environment (Bolivian MSD 1997), "Report on the Bolivian Consultation," presented at the Rio + 5 Forum, Rio de Janeiro, March 1997.

Boston Globe, "Solar Technology: ASE Americas cuts $8m Saudi Arabia Deal," Page C4, 5 March 1997.

Brundtland, G., "Report of the World Commission on Environment and Development," *Our Common Future*, Oxford and New York, Oxford University Press, 1987.

Burgos-Debray, Elizabeth, ed. *I Rigoberta Menchú: An Indian Woman in Guatemala*. Verso: New York, 1992.

Cader, Masud, "Opportunities for Establishing and Funding the Bellagio Audiovisual and New Media Database," Electronic Media Center, World Bank, Washington DC, 1995, World Wide Web version at URL http://www.worldbank.org/html/emc/documents/bellagio0895.html, May 1997.

Carr, Edward, "Power to the People: A Survey of Energy," *The Economist*, June 18 1994.

Choucri, Nazli, "Connectivity, Capacity, and Content: 3C's of Electronic Networking," short paper prepared for MIT meeting, Dec/Jan 1997.

Choucri, Nazli, ed., *Global Accord: Environmental Challenges and International Responses,* MIT Press: Cambridge, 1993.

Choucri, Nazli, and Wallace R. Baker, *Global System for Sustainable Development: Theory, Approach, Design and Policy* (tentative title), MIT Press: Cambridge, in preparation, referenced in thesis as (Choucri and Baker c.1996).

D'Orville, Hans, *Technology Revolution Study: Communications and Knowledge-Based Technologies for Sustainable Human Development*, United Nations Development Programme, New York: 1996.

E7 Group, "Summary: E7 Special Focus Report on Sustainable Energy Development," Submitted to Rio + 5 Organizing Committee, January 1997.

Eco, Umberto, "Towards a Semiological Guerrilla Warfare," Travels *in Hyper Reality: Essays.*, Harcourt Brace Jovanovich: London, 1986.

Enersol Associates, Inc., "Fondo Solar Leverages Local Financing for Honduran PVs," *Enersol News*, Winter 1994/95.

Forge, Simon, "The Consequences of Current Telecommunications Trends for the Competitiveness of Developing Countries," Information for Development Program, Industry and Energy Department, The World Bank, 1995, World Wide Web version at URL http://www.worldbank.org/html/fpd/infodev/forge.pdf

Global Earth Observatory (GEO), "Is Energy Currently Contributing to Sustainable Development?", Contribution to the Earth Council Rio + 5 Forum, Rio de Janeiro, March 1997.

Golub, Richard and Eric Brus, *The Almanac of Renewable Energy*, Henry Holt and Company, New York: 1993.

Greene, Owen, "Environmental Regimes: Effectiveness and implementation review," in *The Environment and International Relations,* edited by J. Vogler and M. Imber, Routeledge, New York: 1996.

Haas, Peter M. and Jan Sundgren, "Evolving International Environmental Law: Changing Practices of National Sovereignty," in *Global Accord: Environmental Challenges and International Responses*, edited by N. Choucri, MIT Press, Cambridge: 1993.

Hinrichs, Roger, *Energy: Its Use and the Environment*, Second Edition, Saunders College Publishing, New York: 1996.

Huacuz, Jorge M., J. Agredano, G. Munguia, R. Flores, "Los Sabinos PV Rural Electrification Project: Results After 30 Months of Operation," Conference Record of the . . . IEEE Photovoltaic Specialists Conference, Vol. 24, 1994.

Huacuz, Jorge M., R. Flores, J. Agredano, G. Munguia, "Field Performance of Lead-Acid Batteries in Photovoltaic Rural Electrification Kits," Solar Energy, Vol. 55 No. 4, 1995.

Imran, Mudassar and Philip Barnes, "Energy Demand in the Developing Countries: Prospects for the Future," World Bank Staff Commodity Working Paper Number 23, World Bank, Washington DC: 1990.

International Telecommunications Union (ITU), *World Telecommunication Development Report 1995*, World Wide Web version at http://www.itu.ch/WTDR95/, March 31, 1995.

Johansson, T.B. *et al*, *Renewable Energy: Sources for Fuels and Electricity*, Island Press, Washington D.C.: 1993.

Karshenas, Massoud, "Environment, Technology, and Employment: Towards a New Definition of Sustainable Development," *Development and Change.* 25(723-756) 1994.

Khosla, Ashok (Khosla 1997a) "The Limits of International Funding," *Development Alternatives Newsletter*, Vol. 7 No. 3, March 1997.

Khosla, Ashok (Khosla 1997b), "Lighting Up Areas of Darkness: Power for Rural Livelihood Enterprises," *Development Alternatives Newsletter*, Vol. 7 No. 3, March 1997.

Krasner, S., "Structural causes and regime consequences: regimes and intervening variables," (1983) in Krasner, S. (ed.) *International Regimes*, Cornell U.P., London: 1993.

Mathews, Jessica T., "Power Shift," *Foreign Affairs*, Jan/Feb 1997 p. 54.

Munasinghe, Mohan, *Energy Analysis and Policy,* Butterworths & Co. Ltd., London: 1990.

Oepen, M., "Appropriate Communication for the Development of Communities", in M. Oepen (ed.), *Development Support Communication in Indonesia*, Prisma, Jakarta, 1988, pp. 105-112.

Rogers, Adam, *The Earth Summit: A Planetary Reckoning*, Global View Press, LA: 1993.

Rockefeller Foundation, Global Environment Division, "Solar Energy Corporation: A Proposal to Stimulate Global Institutional Capacity for Solar-Based Energy Services Provision," December 1996 working paper presented at the Rio+5 Forum, Rio de Janeiro, March 1997.

Saadawi, Tarek N., M.H. Ammar and A. El Hakeem, *Fundamentals of Telecommunications Networks*, John Wiley and Sons, Inc., New York: 1994.

Sand, Peter, "Lessons Learned in Global Environmental Governance," *Environmental Affairs*, 18(213-277), 1994.

Shepperd, Lisa W. and Elizabeth H. Richards, "Solar Photovoltaics for Development Applications," Sandia National Laboratories Report SAND93-1642, August 1993.

Simms, William, "Special Focus Report: Information and Communications," report submitted to the Rio + 5 Forum, Rio de Janiero, March 1997.

Stevens, Yvette, "Photovoltaic Applications in Rural Areas of Developing Countries: a Survey of Evidence," *International Journal of Global Energy Issues*, Vol. 2 No. 1, 1990.

Steinberg, Florian, "Can Development Communication Improve Urban Management?," *Habitat International*, Vol. 20 No. 4, pp. 567-581, December 1996.

Susskind, Lawrence, *Environmental Diplomacy: Negotiating More Effective Global Agreements*, Oxford University Press, New York: 1994.

Thomas, Michael G., Harold Post, Anne Vanarsdall, "Photovoltaics Now: Photovoltaic Systems for Government Agencies," Sandia National Laboratories, U.S. Department of Energy, revised February 1994.

United Nations, Energy Issues and Options for Developing Countries, Taylor & Francis, New York: 1989.

United Nations Conference on Environment and Development (UNCED), *The Rio Declaration on Environment and Development*, Rio de Janeiro, 1992.

United Nations Development Programme (UNDP), "Energy After Rio: Prospects and Challenges Executive Summary," UNDP, New York: 1997.

United Nations Development Programme (UNDP 1994), "Sustainable Development Network: SDN Information Series," UNDP and the International Development Research Centre (IDRC), New York: 1994.

United Nations Development Programme (UNDP), "UNDP Initiative for Sustainable Energy," UNDP, New York: June 1996.

United Nations Development Programme (UNDP), "What is Capacity 21?" document from gopher mail server gopher@nywork3.undp.org, March 30, 1997.

Vicharangsan, Ta-noo, "Village Solar Well: Simple Solar Photovoltaic System as Power Source for Remote Villages," in Economic Commission for Europe, "Solar Power Systems," ECE Energy Series, No. 11, United Nations, New York: 1993.

Whiteley, Chris, "Bolivian Utilities Receive Training on Solar Water-Pumping," *Solar Industries Journal*, Second Quarter 1994, Volume 5 Issue 2 pp. 19.

World Energy Council (WEC), *Renewable Energy Resources: Opportunities and Constraints, 1990-2020*, World Energy Council, London: 1993.

World Resources Institute in collaboration with the United Nations Environment Program and the United Nations Development Program (WRI), *World Resources: A guide to the Global Environment,* Oxford University Press, New York: 1993.

Wright, David, "Mobile Satellite Communications in Developing Countries," *Telecommunications Policy*, 18(5-11), 1994.

Zweibel, Ken and Allen M. Marnett, "Polycrystalline Thin-Film Photovoltaics," in Johansson, T.B. et al, *Renewable Energy: Sources for Fuels and Electricity*, Island Press, Washington D.C.: 1993.

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