Sustainable Community Infrastructure:
The Case for Biological Waste Treatment in Yoff, Senegal

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Introduction

The abstractions of urbanization, sustainable development and the global environment translate into daily life experiences for people in Yoff, Senegal. "Drought" means no water during the day, long lines of women at the public standpipes, and minimal washing. "Desertification" is no longer having a vegetable garden unless you can afford the high cost of tap water for irrigation. "Inadequate infrastructure" means digging a hole in the street, emptying your septic pit waste into it, and waiting for the open cesspool to subside. "Pollution" is fisherman wading through solid wastes to bring the catch onto the beach. "Erosion" is watching homes wash into the sea. "Unemployment" is seeing educated young people hanging out on street corners. Moving between sustainable development theory and practice is not a matter of bringing the issues home. It is recognizing that they already are home and actively integrating that fact into project conceptualization, design, development, and implementation.

The meaning of sustainable development continues to evolve. Donor agencies consider sustainability as the potential for the endeavor to continue independently of outside funding. Environmentalists place resource conservation at the center of sustainability, focussing on the original conception that economic development not occur at the expense of the environment, and that current utilization of resources not compromise resource availability for subsequent generations. Sustainability from a broad ecosystem and human ecology perspective – emphasizing development -- integrates into the concept the entire ecosystem, including human, social, and cultural components, biological and natural systems, and economic structures and activities. All definitions implicate multiple levels of players and impacts, from the individual, to local, to global.

From the standpoint of practice and program implementation, most definitions of sustainable development require active assent and engagement at the individual and household levels. Ultimately, it is the individuals in the villages and cities who will or will not participate fully in development projects, and will or will not keep them going past the donor-support stage. People will adopt new practices, develop institutions, and agree to be bound by regulations, or not. People ‘develop’ or ‘enable’ themselves. Interventions, or sustainable development projects, therefore, must make sense to those on the ground by responding directly to perceived needs and priorities. At the same time, however, urgent common environmental, social, and cultural needs may not be identified or articulated by the community. Sustainable development requires that needs and potential impacts be examined and addressed with and within the community. At the same time, merging individual and community realities with national and international imperatives and policies, demands that needs and impacts also be analyzed at all levels .

Individuals, households, and communities are essential partners in sustainable development efforts. Building fundamental human and community capacity is, therefore, an integral part of sustainability. As communities are better able to identify and analyze problems, evolve strategies and solutions, interact with municipal authorities, and assume responsibility for implementation, they can do their share in the partnership working toward national, international, and global environmental sustainability. Given the interdependence of human capacity building with environmental sustainability, environmental issues and efforts cannot be abstracted from or allowed to preempt investment in human development. Widespread calls for community participation in sustainable development are grounded in the conviction that while participation may itself be problematic and cannot guarantee sustainability, without it, the potential for sustainability in any sense, at any level, is compromised (Mitlin and Thompson, 1995; Burgess et al, 1997; Hamdi and Goethert 1997; Pugh 1997). Increased recognition of the need to actively integrate participation into project planning and implementation was reflected in the 1992 United Nations Conference on Environment and Development. The Rio Declaration states specifically that environmental issues are best handled with participation of all concerned, and that states should promote community enablement for effective participation. The United Nations Conference on Human Settlements (Habitat II) in Istanbul, 1996, adopted the principles of enablement and participation as the most democratic and effective means of realizing their commitments. Who participates in what, how, with what roles, for what and whose purpose(s) and to what end(s), however, are the more difficult practical questions arising from calls for participation, enablement, and sustainability.

The Community Infrastructure Project in Yoff, Senegal, newly developed with CRESP Senegal and linked to CRESP's sustainable development program, is designed to respond to a network of community needs – social and cultural, physical and environmental. The concept of community infrastructure consciously merges traditional spatial and socio-cultural patterns with planning and development to meet urgent contemporary environmental challenges. Sustaining and expanding human and community capacities, and supporting local, self-determined cultural values, are seen as equally important in solving problems of waste as are the technical aspects. Unlike conventional conceptions of infrastructure as comprised of independently functioning built and mechanical elements, community infrastructure is conceived as also essentially encompassing human actions, assets, knowledge, abilities, and orientations. This article argues the need to evolve, design, and pilot a community infrastructure system based on decentralized biological waste treatment, within the context of culturally grounded site planning and the full utilization and development of local resources.

Fig. 1 Yoff – From Indigenous Fishing Village to Urban Commune of Dakar

Peninsula

Cap Vert Peninsula

Yoff, Senegal, is moving rapidly from ancient fishing village of the indigenous Lebou people of Cap Vert, to high-density Commune d'Arrondissement of Dakar, seriously straining environmental and social foundations.(see Fig.1) The urbanization of Yoff is characteristic of urbanization throughout much of Africa, with the pace of population growth outstripping the capacities of municipalities to provide services, aggravated by economic stagnation. In 1984, 40% of Senegal's population, or 2.5

million, lived in urban areas. By the year 2000, the urban population will more than double, to 5.2 million.

Dakar, like other African cities, is growing at an annual rate of close to 5% (Stren and White 1989). Located on the Cap Vert peninsula, the geographic direction of growth is limited, and the city has now engulfed its formerly outlying villages. From 1970 to 1992, Yoff tripled in area, and projections show the population doubling between 1988 and 2010 (Commune de Dakar 1993). With a 1994 population of 50,000, land pressure in Yoff is still intensifying. Within the traditional village, the Lebou extended family compounds have filled to capacity, and can no longer house their growing population. With the exception of a few small farms and gardens, and pockets of open space bordering Dakar's international airport, the fields surrounding the village have filled completely with unbroken expanses of new housing.

In 1983, after years of diligence and hard work, Yoff's village association, APECSY (Association pour la Promotion Economique, Culturelle et Sociale de Yoff) won back from government control 46 hectares (112 acres) of traditional village lands, referred to as the Extension.(see Fig .2)An area of approximately 25 hectares (63 acres) is designated as residential, intended to help house Yoff's exploding population. The sites and services plan developed for this residential area lays out a street-oriented grid, with approximately 1000 lots anticipated to house 11,000 to 12,000 people, at a density of approximately 183 persons per acre (460/ha). The plan well illustrates the interrelated nature of infrastructure, health, environmental, and social issues.

Based on western planning and engineering models, the rationale for the street grid is vehicular access, including emergency vehicles (Commune de Dakar 1993). Funds are not available, however, for paving the streets, and the amount of street length and cost of surfacing is greater in a grid plan than, for example, a cluster plan. The horizontal nature of the expansion plan further increases the costs, and decreases the probability, of new infrastructure installation.

The waste handling infrastructure in Yoff is inadequate. The sewage collection main that passes by the extension site is beyond capacity. Even if it were not, the pump on the main has been broken for years, spilling raw sewage onto a beach area fronted by new housing. Because the municipal sewage system cannot accommodate the new housing, each household will need to install a septic tank which will require periodic emptying by pump truck. In the old village, septic tanks are often connected to a secondary leach pit which allows effluent to percolate into the ground and extends the period between tank pumping. Such a system, however, is typically applicable where densities do not exceed 200 persons per hectare (Sinnatamby 1990). Density is twice that at the extension, and the site is over a shallow aquifer. Though soils are largely sandy, 1000 tanks with leach pits, spaced 10 meters apart and serving 12,000 people, will pose contamination and health problems. Where houses are closely spaced and streets and sidewalks paved over, it is difficult to construct or empty septic tanks. Leakages, tank failures, and informal 'street dumping' of tanks are additional public health concerns.

Open sewage pits are not an uncommon sight in the old village of Yoff, occurring where people are forced to empty the contents of their septic tank into a hole in the street because the pump truck cannot get access. In densely built areas, septic tanks are routinely located under the house itself. It is unclear what disposal practices or other septic related problems may develop at the extension. What is clear is that neither of the conventional alternatives, tanks with leach pits or municipal collection, is viable.

Even if the septic tank system were feasible from an engineering and capacity standpoint, pumping of the tanks generates associated environmental problems. The number of tanks and the frequency required for pumping will result in the pumping of six to eight tanks every day. Assuming trucks are available to provide the service, air pollution problems will be aggravated by the pumping activities. Not only must the trucks run their engines during pumping, but the exhaust of the leaded fumes occurs at ground level, posing the most serious health risks to children. Sewage sludge removed from the tanks will be trucked and dumped in the sea, adding to coastal pollution. Finally, it is important to note that while septic tanks and pumping deals with sewage – however poorly from an environmental standpoint – such a system does not address disposal of organic wastes or the ‘used’ or waste water from households.

The grid plan for the extension reflects little of traditional spatial arrangements and social life. The traditional village is webbed with winding pedestrian ways, circular compounds, and shared public spaces. Within compounds and groups of compounds, extended families share semi-private courtyards as centers of work, meals, and social exchange, and enclosed family shrines for private ceremonies. The irregular streetscape provides corners and nooks for small enterprises. Pedestrian networks allow children to play safely, without traffic, and under common surveillance, and allow easy circulation among households. Public, semi-private, and private open spaces were available for trees and plantings, which have cultural importance, moderate heat and noise, and affect soil and moisture retention, erosion, and the hydrologic cycle. Grid plans based on vehicular needs break down the spatial organization that at once reflects and supports the socio-cultural organization of Yoff, as well as its natural environment.

The fact that even planned areas such as the Yoff extension are or will be experiencing the problems of rapid urbanization is not unique to Yoff. Poor planning, and the related inability to provide necessary infrastructure, generate long-term problems. As the World Bank stated of Senegal, "The most dramatic consequence [of rapid urbanization] has been inadequate urban planning…which has led to…a chronically congested road network, and public health risks due to inadequate water supply, overflowing sewage, and accumulating garbage. Poor planning is creating environmentally unfit cities…with no green spaces…Even planned settlements suffer from lack of infrastructure and basic services" (World Bank 1994, 22-40).

Environmental Context: Interrelated Priorities

In 1990, as part of the Sustainable Cities Program of the UNEP, top priorities for Dakar and Senegal were identified as solid waste management, sanitary sewerage, and air pollution. Additionally, the nation is facing a crisis in water supply. Decreasing water supply is a global problem, and according to some experts, water is likely to become the most critical resource issue and most limiting input to food security and economic and social development in Africa. Dakar now consumes ¾ of the country's piped water, necessitating a major new infrastructure project piping water 200 km from the Lac de Guiers, which still will not meet demand. Water supply to Yoff (and Dakar) is routinely suspended during daylight hours, and occasionally for as long as one to two full days.

Although water supply was not given highest priority at the national policy level, at the household level, it is an extremely high priority. It has been found that given household choice, water provision will have a higher priority than sanitation provision (Cairncross et al 1990). This was confirmed in preliminary studies in Yoff in which respondents placed "regularization of water supply at the house" as a top priority. (It may be that the fact that water supply impinges most directly on the women's sphere and women's time renders it less evident at the policy levels. See Jordan 1990).

Inadequate quantity of water, as much as quality of water, is cited as a significant health problem in African cities (Cairncross et al 1990; Jordon 1993). In economically poor areas of Yoff, where water must be fetched from a significant distance, water consumption is approximately 40 l/p/day, below the 60 l/p/day considered sufficient for health purposes. As financial resources increase, and as water is brought within the compound or the household, water consumption increases several fold, to 70 l/p/d, and up to 130 l/p/d in the most wealthy households (Zeitlin and Diouf 1998). Yet, Stren and White (1989) document that already in Senegal water consumption has reached a level greater than the replacement capacity of the primary sources, to the point that the deficit is on the order of 23,000 cu/m/day in Dakar, and even greater outside of Dakar. Improving access to and supply of municipal water to meet basic health needs will therefore only exacerbate an already serious environmental problem, a contradiction whose resolution is at the heart of the Community Infrastructure Project.

Water shortages are intimately related to changes in the hydrologic cycle and desertification. The Cap Vert, or green cape, is now brown most of the year, and residents of Yoff remember green fields around the village from as recently as 25 years ago. Anecdotal reports support the documented rainfall data which show a decline in rainfall since 1968. The United Nations Statistical Office assessment of desertification shows that low and erratic rainfall, declining surface water levels, and depletion of groundwater reserves are major threats to sustainability throughout the Sudano-Sahelian zone of west Africa (Darkoh n.d.). Coupled with decreased water supplies is a lack of vegetation, aggravated by demand for wood for charcoal, which exposes the soil – another non-renewable resource – to severe wind erosion. In rural areas, environmental degradation intensifies the exodus from the countryside to urban areas, swelling the urban populations. Rapid, unplanned, or poorly planned urbanization removes more vegetation and increases erosion, and can launch the cycle of sedimentation of drainage canals, increasing runoff, increasing flooding potential, decreasing capacity to support vegetation, and decreasing rainfall. Water is at the heart of the complex of environmental and social degradations confronting the region.

At the same time that water is insufficient, sewage and waste handling and treatment are also insufficient. Only 12% of the population of Dakar is served by sewers (World Bank 1994), and much garbage and sewage does not reach a collection and transport system. Senegalese towns are, "…dirty with garbage strewn on roadsides and sidewalks.. and solid waste… dumped directly into gutters or canals," (ibid, 23). Waste collection rates across Africa are in the range of 40% - 50% , and transport vehicle immobilization rates in West Africa are as high as 70% (UNEP n.d). Even when successfully collected and transported, however, disposal creates problems. Dakar's sewage and waste waters are collected in 25 canals, most of which are open air. The canals discharge the waste into the ocean raw, to the point that Dakar effluent has already heavily polluted the surrounding waters. Sewage related diseases are evident in the Dakar region, where people living along the bays carry on average three infectious diseases (World Bank 1994). The combination of water scarcity, solid waste accumulation, inadequate handling of human wastes, and sporadic flooding, aggravate health problems including diarrhea, cholera, hepatitis, parasites, and respiratory ailments (Jordan 1993; Cairncross 1990).

Waste and Sanitation Conditions in Yoff

The environment which exerts the greatest and most immediate influence on the lives of people, their health, and well-being is the intimate environment of their home and neighborhood (Cairncross et al, 1990,19)

A study of sanitation conditions in Tonghor, (see Fig 3) a representative area of Yoff comprised of a modern, wealthier sector and a more traditional, economically poorer sector, was conducted by CRESP Senegal/EcoYoff in 1998 for ENDA-RUP (Zeitlin and Diouf 1998).

Fig. 3. YOFF

29% in the traditional, older sector, and 40% of the poorest economic group. Overall, 18% - 20% use the beach, the sea, or 'nature' for toileting purposes.

Water usage varies with income, from 40 l/p/day to 130 l/p/day. However, because municipal water mains are typically closed during the day, virtually all households stockpile water, often in open containers. Cups and buckets are used to scoop water from the containers to meet household needs. To supplement water supplies, households buy water from vendors, and 30% - 50% of households use sea water for certain purposes. Higher income, therefore, allows greater water use, but the health problems associated with unsanitary storage and handling of water, and the provision of water sources and breeding grounds for disease vectors, transcends income and is a community-wide problem.

In the modern quarter of Tonghor, 90% to 100% of bath, laundry, and cooking water goes down the drain and into the septic tank. In the traditional sector, 80% of households dump their laundry water on the beach, and a percentage dump 'in nature.' Significant amounts of water, therefore, are lost in ways associated with environmental problems in addition to the water loss itself. Water mixed with trash and dumped on the beach loses the water and adds to solid waste and coastal pollution. Trash and water poured into ditches discards the water and blocks the drainage ditches, simultaneously. Water flowing into septic tanks loses the water and results in more frequent tank pumping. Increased water availability and use addresses some problems, but without attention to water disposal and recuperation, it spawns others.

The population of Tonghor reflects differences in levels of formal education, unemployment, and skills, which relate directly to the development of a waste and sewage improvement project. Most (85%) household heads are male. Among the lowest and middle-income groups (the great majority), 42% - 39% of male heads of households, and 52% - 60% of the women (including wives of household heads), have no schooling. An additional 35% - 38% of men, and a similar percentage of women, are schooled only at the primary level. Only 0% - 3% of this population, male and female, have university-level education. In contrast, among the wealthier group, 47% of male household heads are university-educated. Forms of community participation, therefore, must be tailored to the schooling levels of the entire community population, and not only the more formally educated group. This is particularly critical in the area of waste and water handling and management, which is the domain of women. Even within the wealthier group, only 15% of the female managers of the household are university educated. Thirty percent have no schooling, and 30% have only primary school education. Television is widespread in Tonghor. Fifty to ninety percent of households have televisions, suggesting that this may be an excellent medium of communication for less-literate and less formally educated women.

Unemployment is high, especially among the youth, ranging from 25% - 35%. In one survey, youth unemployment was cited as the primary problem in Yoff. Despite unemployment, important skills are present in the community, and because of unemployment, people are available to work. There is a large cadre of skilled masons and laborers in Yoff, and the number of petty traders and shopkeepers is indicative of small-business awareness and abilities.

The Case for Biological Waste Treatment

Waste, sewage, and water are significant and interrelated problems in Yoff, Dakar, Senegal, and throughout much of the urban Third World. Biological waste treatment – using biological methods to treat wastes and recover the resources within it – coupled with an appropriate collection system for sewage, organic waste, and waste water, is an approach to meeting specific community needs while also furthering regional and national goals for environmental sustainability. Environmental conditions point to development of biological treatment technology as a potential substitute for conventional waste systems; technical, social and cultural considerations point to establishing biological treatment and waste collection facilities on a localized, decentralized basis.

Composting, biological water purification, and anaerobic digestion are the major forms of biological waste treatment that are just beginning to be piloted for use in Senegal. The Rodale Institute has established an experimental composting station in Thies, approximately 60 km from Yoff, and the US Peace Corps has small scale composting efforts underway in various locales. CERER is working with biogas digesters in the rural village of Khombole. A notable project was started in 1990 by ENDA-RUP in the city of Rufisque just outside Dakar (See Fig. 1.). Using participatory processes and community based financing, the Sanitation Scheme project established two stations to biologically treat sewage and purify the waste water from 360 households using a series of long water basins, or lagoons. Coupled with the sewage treatment is a collection system for household organic waste, with the waste transported to and composted at the purification station (Gaye and Diallo 1997).

From these efforts and from research in the area over the last thirty years, it is clear that no solution fits all conditions, and all have difficulties. Composting on a community basis requires a large amount of water. Not only is this physically difficult in arid conditions, but given worsening water supplies, it is not sustainable unless coupled with a water recovery project as at Rufisque. For composting, organic material must be separated either at the household level or at the composting site; if at the site, intensive garbage-picking labor is needed, which must be compensated. Waste must be transported to the site, and the space and labor (or machinery) needed for the operation is not insignificant. The labor demands for composting could potentially be an asset if markets were available for the compost, thereby creating paid employment, but lack of market has plagued composting operations everywhere (UNEP n.d.). A recent market study of the remaining farmers on Yoff land by the airport, however, shows that more of these farmers use manure than chemical fertilizer. Some use compost and more would like to do so if it were readily available (Sene et al, 1998). Price, access, transport, and the quantity farmers could absorb are open questions that suggest that more research into the potential for compost use in Yoff is warranted.

Water purification systems, such as that used in Rufisque, are promising, but have limitations. The system treats only sewage and some waste water, not household organic wastes, and requires very large ponds or basin areas for purification processes. In densely populated areas, the space requirement is a severe constraint. Odors from the initial basins and security considerations, in addition to the space demand, cause such systems to be located some distance from the participating households. Small diameter pipes effectively carry sewage to the system, but piping distances are long, and participants are separated from one of the most important by-products – the purified water and the greenery and agriculture it can support. A high level of labor for maintenance is also required. If funds are available to pay for labor, a high labor demand can be an asset of a system, but following the Rufisque project it is not clear that paid labor is financially sustainable.

Anaerobic digestion is another treatment system. Anaerobic digesters are sealed tanks that can be fed manure, crop residues, human waste, and organic waste. The material is broken down by bacteria to produce effluent suitable for agricultural purposes, methane gas used for fuel, and sludge, a high-quality fertilizer. Digesters have been widely and successfully used over the past 30 years, and the technology continues to evolve. In China, almost 7 million plants are operating in Sichaun, and anaerobic digesters have also been used in India, Thailand, and Nepal. In Africa, dissemination and success rates are spotty, with digesters built and operating, then failing after a few years. Construction and maintenance quality, lack of social acceptance, and poor project initiation and training have variously stymied the use of the technology in the Ivory Coast, Morocco, and Mali. However, as of 1994, there were 600 plants in operation in Tanzania, where the technology appears well established (GATE 1996).

The Community Infrastructure Project is working toward developing sustainable approaches to the interrelated social and environmental problems of urbanization, with sewage, water, and community at the core. The conventional collect-transport-dispose system of waste handling has broken down. Collection and transport are barely adequate, and are financially and environmentally costly. Inadequate disposal and disposal without treatment is environmentally undesirable, yet conventional treatment is prohibitively expensive. Parallel systems to treat sewage, organic waste, and waste water are also costly. Natural resources, including water, fuel, and soil, are scarce and in diminishing supply. Integrating biological waste treatment infrastructure with community planning and development merges what is typically viewed as a single, technical issue – waste handling –with an associated range of environmental and social needs.

Decentralized Anaerobic Digestion Systems

The matrix of needs identified at all levels points to developing a network of small scale anaerobic digestion stations on a decentralized, localized, public/private basis, within a framework of participation and community development. Digesters can potentially serve as a collection point for household waste, sewage, and waste water, while yielding the by-product of purified water for various household and agricultural uses. In so doing, digesters help address two of the most urgent problems cited by initial participants – sanitation and water supply. In addition, the methane gas produced by the digesters may be used in the household as a substitute for charcoal or gas. This substitution, while secondary to program participants, can be significant on broader environmental levels, as charcoal production is a major contributor to deforestation and desertification.

Localization and decentralization of the systems help address social, community, and household needs simultaneously. The public culture of social exchange and community networks requires multiple levels of community open space. This need, however, conflicts with the reality of land scarcity, population pressure, and high land prices. Building waste collection and treatment centers throughout the neighborhood can create open space while also providing conveniently located waste, water, and sewage collection points. Recovered water from the treatment can be used at the sites to make them green and park-like. If community spaces serve multiple purposes, the potential for them to remain as open space despite land pressure is improved. With collection and treatment at the same point, by-products of the system can be made more readily available to the users. Purified water can be obtained at the same site where women are depositing organic wastes and household water. Purified water could, potentially, be piped back to house reservoirs to use for toilet flushing or general cleaning. Biogas may be able to be piped back for cooking or lighting fuel. Fertilizing sludge can be used on site, at houses, in urban agriculture plots, or sold.

Working with the community to identify issues and priorities, pilot systems, trouble shoot designs, and to finance, site, and build neighborhood collection and treatment centers draws on local skills and knowledge, creates better systems, and develops understanding and ownership. Small systems that utilize local materials and skills, as do masonry digesters, support employment in construction activities and ongoing parts production and maintenance. Techniques required for construction of digesters will extend existing skills, potentially creating a cadre of specialists. While routine maintenance is relatively simple, some technicians will need to be trained for more advanced oversight. Establishing public-private partnerships can make participants actual owners and/or direct participants in maintaining, evaluating, and refining the systems.

Localized (and potentially community-owned) systems permit direct observation of operations, with problems and breakdowns quickly evident to those using the system. Problem solving can occur on a neighborhood level, rather than being left to an abstract, distant municipality to fix (or not). It is essential that women, who are the most direct participants in waste and water management at the household level, be involved in the project from the start. In so doing, the project has the potential to further women's skills and abilities in community development generally, using their own immediate issues – water supply and waste handling – as the starting point.

Biological waste treatment has important potential as the core of a multi-dimensional approach to the complex of human and environmental problems in urbanizing conditions, and can be seen to intersect with needs identified at all levels (table 1). It is important to emphasize, however, that at this time, the Community Infrastructure Project is pursuing anaerobic digestion technology not because it is ready-made for conditions in Yoff – it is not. Rather, existing biogas technology appears, in theory, to have the best potential for meeting more of the environmental and social goals than other solutions. The challenge is to develop the technology and the implementation methods together, to meet goals and needs in practice.

TABLE 1: Multi-level Analysis of Anaerobic Digestion

LEVEL	**Need/issue**	**Potential benefits of localized anaerobic digesters**
Individual	Employment	Creates construction and maintenance jobs; skilled technical jobs
& household	Water supply and cost	Provides affordable purified water on site for certain household and agricultural uses; helps regularize water supply; helps increase water supply at lower cost
	Health and sanitation	Provides affordable waste and sewage disposal systems
	Time demands	Saves time by having one central point for disposal of water, organic waste, sewage; reduces time needed for water collection and management
	Food supply	Provides water and fertilizer to support gardens and urban agriculture
	Fuel supply and cost	Substitutes biogas for some cooking and lighting fuels
	Climate in immediate environment	Provides water and fertilizer to support shade trees and plantings to moderate heat and reduce dust
Community and	Health and sanitation	Reduces waste in the environment; increases sewage handling and treatment capacity; reduces groundwater contamination
neighbor-hood	Diminishing open space	Creates community open spaces for treatment plants, which can become neighborhood gardens or parks
	Lack of green space	Uses recaptured water and fertilizer directly on site for plantings
	Community capacity building, enablement	Employs participatory processes for problem and solution analyses, system analyses, evaluation, and modification, and adoption, finance, and implementation strategies. Requires education for community problem-solving, and technical education for development, construction, and maintenance.
CITY	Waste handling costs	Potentially reduces costs through reduced collection and transport
	Water and air pollution	Reduces trucking and pumping, and reduces disposal of untreated wastes.

	Beachfront erosion	Water and fertilizer can be made directly available to support erosion control plantings
	Groundwater pollution	Substitutes for septic tank and leach pit system
REGIONAL	Deforestation	Provides water and fertilizer for reforestation; potentially substitutes biogas for some charcoal use.
	Decreasing water resources	Recaptures and recycles waste water, potentially slowing increases in water demand.
	Landfill over-capacity	Reduces quantity of waste transported to landfills.
NATIONAL	Decreasing fresh water supplies	Recaptures and recycles water, reducing demand on potable water stocks, and reduces potential for aquifer contamination.
	Water pollution	Reduces the quantity of untreated sewage disposal; reduces surface water and aquifer contamination.
	Fuel demands	Reduces electricity demands with biogas substitution; reduces fuel use for waste transport.
GLOBAL	Desertification	Provides water and fertilizer for reforestation / revegetation / habitat construction projects; provides organic soil amendments to control erosion; contributes to reducing fuelwood consumption through biogas substitution.
	Fossil fuel consumption	Decreases waste trucking
	Depletion of fresh water	Recaptures and recycles waste waters, and reduces water pollution.

Implementation

A starting point for practice is recognizing the appropriate context within which to place and work with a project activity. That is, while governmental ministries are concerned with desertification, soil erosion, the hydrologic cycle, and reforestation, individuals are more likely concerned with water in their houses and trees in the yard. At the point of community implementation, all environmental sustainability is local, and abstractions largely irrelevant. We would also argue that while sustainability is about the long term, at the practical stage of implementation, benefits must be immediate. Lives are difficult and personal and financial resources scarce. If people cannot see what a project will do for them now, and if it does not actually deliver it now, it is not likely to garner ongoing commitment. Theorists may, and should, talk of future generations, but in practice, the talk must address life now, reflecting Groucho Marx's comment, "What do I care for posterity? What has posterity ever done for me?"

While implementation demands local engagement, enablement, and immediacy, development projects must at the same time address sustainability on multiple, intersecting levels. Meeting a community's immediate needs for more charcoal simply by cutting more forests, for example, is not sustainable on regional, national, or global levels. The local need for cooking fuel remains urgent, however, requiring strategies for meeting that need without environmental destruction, and with due attention to associated needs of affordability, availability, ease of use, compatibility with cooking methods and customs, and the income needs of charcoal makers and sellers. Individual, household, community, regional, national, and global needs and issues form an interacting web that renders single-issue or one dimensional technical approaches to sustainability inappropriate, and likely ineffective.

The Community Infrastructure Project entails three overlapping start-up phases. In the first phase, initial participants provided their perspectives on priorities in the different areas of urban planning and interrelated urban issues, including water, sewage, traffic, erosion, housing, waste, and energy. This information was examined in the context of interviews, field observations, and demographic and social surveys conducted in Yoff by the Popular Urban Information System's Project, (SIUP in French) carried out by the EcoYoff Program of APECSY and the Commune of Yoff in 1997. With preliminary investigations pointing toward anaerobic digestion, site- and project–specific technical issues are being addressed by staff and engineers.

The second phase, which interacts with the first, expands participation to draw upon community residents to address various elements of the project, including social, cultural, technical, and financial components. As issues are raised and resolved, those decisions will inform project and technical designs. Analysis by women who would use the system, for example, will bring out potential difficulties, allow the women to work on possible solutions, and will point to the kinds of education and training needed. Financial analysis and planning with participants will affect the infrastructure design and construction, in concert with developing financing mechanisms. In the third phase, a pilot plant will be built, with structured, ongoing monitoring, review, and evaluation by community members. The evaluation will then direct modification of project elements and subsequent steps.

Biological waste treatment cannot, however, be seen as a perfect new solution to deliver to the community. Early indications are that biological waste treatment generally, and anaerobic digestion specifically, is an important route to pursue. Nevertheless, it remains the case that technical solutions developed by engineers – even engineers working closely with the community – cannot suffice. If human and community capacity building are not fully factored into all phases of the project, technical solutions cannot be sustainable. This reality requires that the planners, social scientists, engineers, and other technical experts involved, as well as community members, must be prepared for the unexpected, be prepared to share power and to respect various forms of knowledge, remain flexible, and allow the time that integrated, holistic and comprehensive sustainable development demands.

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